Present and future of the Mediterranean olive sector

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OPTIONS
méditerranéennes

SERIES A: Mediterranean Seminars
2013 – Number 106

CIHEAM

OPTIONS méditerranéennes

List of contents

Foreword 3

Prólogo 5

Avant-propos 7

Session 1: Challenges and trends in olive growing and processing

Evolution and sustainability of the olive production systems – *R. Fernández-Escobar, R. de la Rosa, L. Leon, J.A. Gómez, L. Testi, F. Orgaz, J.A. Gil-Ribes, E. Quesada-Moraga, A. Trapero, M. Msallem* 11

Pedo-environmental determination of olive oil quality. A case study – *A.P. Leone, R. d'Andria, G. Morelli, F. Fragnito, S. Purificato, M.G. Volpe, M. Nazzaro, A. Buondonno* 43

Olive oil processing technologies and investments – *M. Servili* 55

Table olive processing technologies – *S.I. Cillidag* 67

Case study of an integrated system for olive mill by-products management in Sfax region in central Tunisia – *K. Gargouri, B. Ben Rouina, A. Rhouma, M. Ayadi, M. Abichou, H. Bentaher* 75

Session 2: Marketing strategies

New global and local marketing strategies : Creation of added value through differentiation and high quality products – *M. Parras* 87

Turning food into a gastronomic experience: Olive oil tourism – *E.M. Murgado* 97

The case of Hojiblanca – *E.M. Carneros* 111

Electronic commerce development. Regulations and guarantees – *E. Bernal, A. Martínez* 117

Marketing organic olive oil: From fork to field – *R. Zanoli, S. Naspetti* 129

Session 3: Olive oil and olives, human health and nutrition

Nutrigenomics, cardiovascular diseases and the Mediterranean diet – *J.M. Ordovás, D. Corella* 143

Nutraceutical, cosmetic, health products derived from olive – *R. d'Andria, A. Di Salle, O. Petillo, G. Sorrentino, G. Peluso* 153

The genie in the bottle – *J. Barbacil* 163

Table olives – A natural source of health-promoting bioactive nutrients and probiotics – *C. Peres, C.M. Peres, L. Moreira, M. Alves, J. Maricato, F. Xavier Malcata* 171

The place of scientific information in the promotional activities of the International Olive Council. Olive oil and health: Consumers' perception – *M. Fernández* 179

Summary and conclusions 181

Resumen y conclusiones 187

Synthèse et conclusions 193

List of participants 199

Foreword

Olive cultivation constitutes a key element of the Mediterranean agricultural sector, and Mediterranean countries clearly dominate world olive oil and table olive production and consumption. Production has increased dramatically in the last decades, partly due to the development of production systems based on more intensive plantations using new technologies. Nevertheless, traditional olive production systems should not be forgotten, as these systems are multifunctional and they contribute to rural development and landscape conservation and protect the environment against erosion and desertification. Consumption of olive products has followed similar expansive patterns, and non-traditionally consuming countries are becoming important consumers and importers. The growth of these markets is the result of the gastronomic qualities of olive products and the nutritional and functional properties that make them healthy foods. There has also been an important improvement in post-harvest and processing in order to respond to the increasing demands for high quality standards.

In this context, the Mediterranean Agronomic Institute of Zaragoza (IAMZ-CIHEAM) and the International Olive Council (IOC) – two institutions that have recently celebrated their 50th anniversary, one serving agriculture in the Mediterranean region and the other the olive sector globally – organized the Seminar on "Present and future of the Mediterranean olive sector" from 26 to 28 November 2012 in Zaragoza (Spain). The aim of the Seminar was to promote debate on the following key questions challenging the olive sector: Are intensive production systems sustainable and will the future of olive development be based on them or should there still be an important role for traditional systems? Which key elements should be improved in processing technologies, especially to gain access to markets demanding high quality? In addition to the well-known nutritional and functional properties of olive products, what are the prospects of using them as a raw material base for the nutraceutical industry? What are the keys to open up new markets and to increase the share of consolidated markets?

The Seminar was organized in three scientific sessions with invited keynote speakers and oral presentations: "Challenges and trends in olive growing and processing", "Marketing strategies", and "Olive oil and olives, human health and nutrition". A round table on "Olive and olive oil development and promotion: policies and strategies" closed the seminar, which was attended by 102 experts from 18 countries: Albania, Algeria, Argentina, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Jordan, Lebanon, Morocco, Montenegro, Portugal, Spain, Tunisia and Turkey. The last day was devoted to a technical visit to the Bajo Aragon Designation of Origin in Alcañiz and to the agribusiness Hacienda Iber, both in the Aragon region.

This book publishes the proceedings of the Seminar and contains 14 articles and 1 abstract of the contributions presented. We would like to thank all the speakers and authors for contributing their expertise to shed light an encourage the debate on the wide and fascinating world of olive. We also acknowledge the panel of editors for their role in increasing the quality of this publication, and last but not least, Hacienda Iber and the Designation of Origin "Aceite del Bajo Aragón" for sharing their practical experience with the Seminar participants.

Ignacio Romagosa
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Prólogo

El cultivo del olivo es un elemento clave del sector agrícola mediterráneo y es evidente que los países de la cuenca del Mediterráneo destacan a escala mundial en la producción y consumo de aceite de oliva y de aceituna de mesa. La producción ha aumentado de manera notable en las últimas décadas, debido en parte al desarrollo de sistemas de producción basados en plantaciones más intensivas que hacen uso de nuevas técnicas. No obstante, no hay que olvidarse de los sistemas tradicionales de producción olivarera ya que estos sistemas son multifuncionales y contribuyen al desarrollo rural y la conservación del paisaje así como a proteger el medioambiente frente a procesos erosivos y la desertificación. El consumo de productos derivados del olivo ha seguido patrones similares de expansión, y los países que hasta ahora no habían sido consumidores tradicionales se están convirtiendo en importantes consumidores y productores. El crecimiento de estos mercados es fruto de las cualidades gastronómicas de los productos del olivo así como de las propiedades nutricionales y funcionales que los convierten en alimentos saludables. También se han conseguido importantes mejoras en las tecnologías de elaboración y poscosecha con el objeto de responder a la creciente demanda de normas de calidad más estrictas.

En este contexto, el Instituto Agronómico Mediterráneo de Zaragoza (IAMZ-CIHEAM) y el Consejo Oleícola Internacional (COI) – dos instituciones que han celebrado recientemente su 50 aniversario, una al servicio de la agricultura en el Mediterráneo y la otra al del sector olivarero a escala global – organizaron el Seminario sobre «Presente y futuro del sector olivarero Mediterráneo» del 26 al 28 noviembre de 2012 en Zaragoza (España). El objetivo del seminario fue impulsar el debate sobre los siguientes aspectos clave que suponen un reto para el sector olivarero: ¿Son sostenibles los sistemas de producción intensivos y se basará en ellos el desarrollo del sector en el futuro o los sistemas tradicionales todavía desempeñarán un papel importante? ¿Qué elementos clave deberían mejorarse en lo que se refiere a las tecnologías de elaboración, sobre todo para acceder a los mercados que requieren una gran calidad? Además de las conocidas propiedades funcionales y nutricionales de los productos derivados del olivo ¿Qué futuro tiene su uso como materia prima para la industria nutracéutica? ¿Cuáles son las claves para abrir nuevos mercados e incrementar la cuota de mercados consolidados?

El Seminario se estructuró en tres sesiones científicas que contaron con ponentes invitados e intervenciones orales: «Retos y tendencias en el cultivo y elaboración de aceitunas», «Estrategias de marketing», y «Aceite de oliva y aceitunas, salud y nutrición humanas». El Seminario se clausuró con una mesa redonda sobre el «desarrollo y promoción del aceite de oliva y las aceitunas: políticas y estrategias». El último día se realizó una visita técnica al Consejo Regulador de la Denominación de Origen «Aceite del Bajo Aragón» en Alcañiz y a la empresa «Hacienda Iber», también en Aragón. Asistieron al Seminario 102 expertos de 18 países: Albania, Argelia, Argentina, Croacia, Chipre, Egipto, España, Francia, Grecia, Israel, Italia, Jordania, Líbano, Marruecos, Montenegro, Portugal, Túnez y Turquía.

Este volumen publica las actas del Seminario y contiene 14 artículos y 1 resumen de las contribuciones presentadas. Queremos agradecer a los ponentes así como a los autores por haber compartido su experiencia y haber arrojado luz y animado al debate sobre el fascinante y vasto mundo del olivo. También queremos reconocer la gran labor que ha realizado el equipo de editores para mejorar la calidad de esta publicación, y por último a «Hacienda Iber» y la Denominación de Origen «Aceite del Bajo Aragón» por compartir su experiencia práctica con los asistentes al Seminario.

Ignacio Romagosa
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Avant-propos

La culture de l'olivier constitue un élément essentiel du secteur agricole méditerranéen, avec, à l'échelle mondiale, une nette domination des pays méditerranéens en matière de production et de consommation d'huile d'olive et d'olives de table. La production s'est accrue de façon spectaculaire sur les dernières décennies, ceci étant en partie attribuable à la mise en place d'une oliviculture intensive qui fait appel à de nouveaux systèmes de production. Néanmoins, il convient de ne pas oublier les systèmes traditionnels de production oléicole, car ces systèmes sont multifonctionnels et contribuent au développement rural et à la conservation du paysage, et protègent l'environnement contre l'érosion et la désertification. La consommation de produits de l'olivier a suivi des tendances de croissance telles que celles décrites précédemment, et certains pays qui traditionnellement ne connaissaient guère ces produits sont en train de devenir d'importants consommateurs et importateurs. L'expansion de ces marchés est le résultat des qualités gastronomiques des produits de l'olivier et des propriétés nutritionnelles et fonctionnelles qui en font des aliments favorables à la santé. D'importantes améliorations ont également eu lieu en post-récolte et en matière de transformation afin de répondre aux plus fortes exigences de normes de qualité.

Dans ce cadre, l'Institut Agronomique Méditerranéen de Zaragoza (IAMZ-CIHEAM) et le Conseil Oléicole International (COI) – deux institutions ayant célébré récemment leur cinquantième anniversaire, la première œuvrant pour l'agriculture dans la région méditerranéenne et la seconde pour le secteur de l'olivier à l'échelle mondiale – ont organisé le Séminaire portant sur « Présent et futur du secteur oléicole méditerranéen » du 26 au 28 novembre 2012 à Zaragoza (Espagne). Le propos du Séminaire était de promouvoir le débat pour faire le point sur les enjeux suivants concernant le secteur oléicole : Les systèmes de production intensive sont-ils durables et l'avenir du développement oléicole sera-t-il fondé sur ces systèmes, ou bien les systèmes traditionnels auront-ils encore un grand rôle à jouer dans ce domaine ? Quels sont les éléments décisifs à optimiser concernant les technologies de transformation, en particulier pour accéder à des marchés exigeant une forte qualité ? En plus de leurs propriétés nutritionnelles et fonctionnelles bien connues, quelles perspectives se présentent aux produits de l'olivier en tant que matières premières pour l'industrie nutraceutique ? Quels sont les éléments déterminants pour trouver de nouveaux débouchés et pour augmenter la part de ces produits sur les marchés déjà consolidés ?

Le Séminaire était articulé en trois sessions scientifiques comprenant conférences principales et présentations orales : « Défis et tendances de l'oliviculture et de la transformation des produits de l'olivier », « Stratégies de marketing », et « Huile d'olive et olives, santé humaine et nutrition ». Une table ronde portant sur « Développement et promotion de l'huile d'olive et des olives : politiques et stratégies », a clôturé le Séminaire, auquel ont participé 102 experts provenant de 18 pays : Albanie, Algérie, Argentine, Croatie, Chypre, Égypte, Espagne, France, Grèce, Israël, Italie, Jordanie, Liban, Maroc, Monténégro, Portugal, Tunisie et Turquie. Le dernier jour était consacré à une visite technique au siège de l'Appellation d'origine « Bajo Aragón » à Alcañiz et à l'exploitation « Hacienda Iber » tous deux au cœur de la région aragonaise.

Cet ouvrage présente les actes du Séminaire, constitués de 14 articles et d'une récapitulation des contributions présentées. Nous tenons à remercier ici tous les intervenants et auteurs, qui ont apporté leur expertise afin de mettre en lumière le vaste monde fascinant de l'olivier. Notre reconnaissance va aussi aux éditeurs pour leur rôle dans l'amélioration de la qualité de cette publication, et finalement mais non des moindres, à « Hacienda Iber » et à l'Appellation d'origine « Aceite del Bajo Aragón » pour avoir partagé leur temps et leur expérience pratique avec les participants au Séminaire.

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Session 1
Challenges and trends in olive growing and processing

Evolution and sustainability of the olive production systems

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Abstract. The olive tree counts among the most important oil-producing crops throughout the Mediterranean region. The century-long presence of olive trees in most producing countries can lead to misunderstanding as to the sustainability, hardiness, longevity and plasticity of their cultivation. At present, olive trees are planted in all regions of the globe between 30 and 45° latitude in the two hemispheres. Olive culture is a complex agrosystem with variability in production systems, cultivation techniques and genetic resources. The evolution of the olive growing sector over time revealed that until the 1950s, the olive culture expanded slowly. After that, traditional planting system have been transformed into more intensive groves. Since the 1990s the trend has been to reconvert traditional orchards into more intensive systems. In the new cultivated areas and in the new producers' countries, intensive and high density groves are proliferating with the objective of reducing both unproductive periods and costs. In many instances, these changes in the growing systems have been accompanied by irrational exploitation of natural resources and the introduction of new varieties. This report is a review of the different olive growing systems and the evolution from traditional to more intensive production systems.

Keywords. Genetic resources – Intensive orchards – Olive sustainable production – Mechanization – Pest and diseases control.

Évolution et durabilité des systèmes de production oléicole

Résumé. *La culture de l'olivier est l'une des principales spéculations agricoles pratiquées en Méditerranée. L'ancrage de cette culture depuis des siècles dans la plupart des pays avec des variantes climatiques et pédologiques est attribué aux caractéristiques : durabilité, rusticité, longévité et flexibilité. Actuellement, cet arbre est planté dans presque toutes les régions du globe situées entre les latitudes 30 et 45° des deux hémisphères. La culture présente une grande variabilité des systèmes de production, des techniques de plantation et d'entretien et une richesse génétique inouïe. Le suivi de l'évolution de cette culture dans le temps dévoile une progression lente jusqu'aux années 50 du siècle dernier. Par la suite, le système de conduite a évolué du mode traditionnel vers l'intensif. Depuis les années 90, il y a eu une tendance à la reconversion des vergers traditionnels vers l'intensif. Dans les nouvelles régions et dans les nouveaux pays producteurs, le mode intensif et hyper-intensif ont émergé dans l'objectif de réduire aussi bien la période improductive que les charges de production à travers la mécanisation de la cueillette. Ces mutations des systèmes de production sont accompagnées dans la majorité des cas par une exploitation irrationnelle des ressources naturelles avec l'introduction de nouvelles variétés. Le présent rapport décrit les différents systèmes de production et leur évolution du traditionnel à l'intensif.*

Mots-clés. *Durabilité – Intensif – Maladies et insectes – Mécanisation – Olivier – Ressources génétiques.*

I – Introduction

The presence of olives for centuries in most of the producing countries can mislead about the sustainability of its cultivation. Variability is a key concept in these lines. Although cultivated almost exclusively in Mediterranean clime conditions, olive orchards can be found under very different rainfall conditions, from the fringe of the dessert in very marginal areas to more humid climates. In the last few years olive oil and table olive production have increased because the development of modern orchards, intensification of the traditional ones and expansion into new crop producing areas. This has led a division between two types of olive farms: those that will survive (modern olive orchards producing at a lower cost than the market price) and that who could be extinguishing (traditional olive orchards unable to reduce costs below the market price). Given the longevity of olive orchards the majority of olive producing countries presents a mosaic of typology of olive orchards (Fig.1).

Fig. 1. Different types of olive orchards.

These lines are a brief review about some sustainability issues related to some major aspects of olive cultivation.

II – Evolution of the olive production systems

1. Traditional growing system

Olive has been traditionally grown on extensive dry farming, in orchards characterised with densities up to 100 trees/ha and poorly mechanised. Their profitability is normally low and, even in some cases, oil production cost could be higher than oil market price. Most of the olive orchards worldwide are currently grown in this system, located in ancient olive growing areas and using local cultivars (Fig. 2).

A significant part of those traditional olive orchards are located in marginal areas (Table 1), with significant slopes and where the chances of intensification are low. Under such conditions, few efforts have been made to mechanize, at least in part, the harvesting operations. In some cases, growers are looking for more incomes different from direct production, as landscape or social uses. Organic farming is proposed as other option to increase their benefit margin.

In other cases, where the traditional orchards are located in flat or low slope areas, there is a room for reconversion to more intensive systems with a high level of mechanization.

2. Intensive growing system

From the 70's, the development of irrigation, management and harvesting techniques has dramatically changed the new olive production systems. Plantations in new areas with higher water availability and better edaphoclimatic conditions have been performed. This has allowed an intensification of olive growing with an increase on tree density, up to 400 trees/ha, with final spacing determined by water availability, edaphoclimatic conditions, harvest system and cultivar. The development of irrigation infrastructures has been one of the main factors boosting intensification.

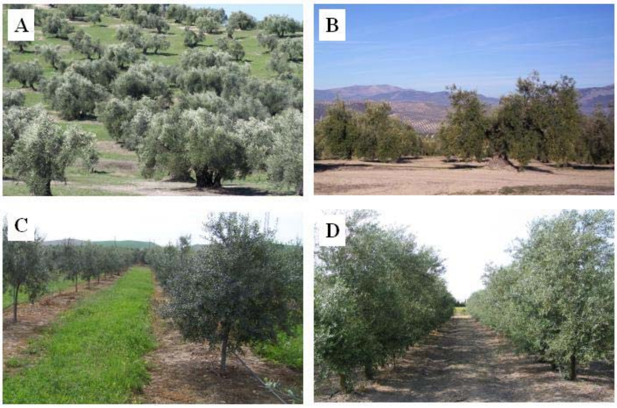

Fig. 2. Examples of different growing systems: traditional in marginal area (A), traditional able to be reconverted (B), intensive (C) and hedgerow (D).

Table 1. Percentage of the different growing systems in the world and in Spain

Growing system	World[1]	Spain[2]
Traditional marginal	20	24
Traditional able to mechanize	50	52
Intensive	29	22
Hedgerow	1	2

[1]According to Tous (2011); [2]According to AEMO (2012)

There is a strong tendency to mechanize the harvest in these intensive orchards with different type of shakers. For that purpose, trees are trained in a single trunk with the canopy developed at around 1m height. Continuous pruning from plantation up to the formation of the tree 5-6 year old is considered one of the key factors for having a well formed canopy. From that point, the main objective of the pruning is to keep the volume of the canopy within the limits to avoid excessive shading, which could depend on the cultivar and the edaphoclimatic conditions. The current trend is to have lower canopy volume per tree and increase density. The most efficient way to train the canopy seems to be a vase formed by two or three main branches, forming a structure able to efficiently transmit the shakers vibration through the branches in the tree. In plantations in new areas with reduce knowledge on olive growing, a proper pruning is one of the key factors to have a high an regular productivity. Most of the today existing olive cultivars could be grown in this system.

In the case of table olive, production systems are still very traditional. The low market prices in the last years in some countries have promoted the use of mechanical harvesting. The main problem for the mechanization of this system is the browning produced on the fruits but some strategies have been recently proposed to solve it. The success of this could lead on a change on the density and training of those orchards. New cultivars will also be needed for this intensification.

3. Hedgerow system

As a continuation of the intensification process, hedgerow orchards appeared in the early 90's as a system able to dramatically reduce the labour needed for harvesting. It was initially based in densities around 2,000 trees/ha and spacing of around 3.75 x 1.35 m, always with drip irrigation. Plants are trained in a monocone shape from the beginning of plantation. Three or four years after plantation, continuous hedgerows are formed on the tree lines. Straddle machines developed for vineyards with some modifications are used for harvesting, although, recently specific straddle machines for olive has been developed. The main advantages of this system are the low labour requirements at harvesting and the early entrance into commercial production, from three years after planting. Additionally, the faster and earlier harvesting could have a positive influence on the final olive oil quality. However, when large areas are planted with this system, enough milling capacity should be available to guarantee a good quality.

The large investment required by this planting system has promoted a reduction in tree density to around 1,200 trees/ha (4 x 2 m spacing). Other inconvenient is that the excessive vigour of the few cultivars currently used makes unpredictable the maintenance of long-term productive hedgerows with a convenient volume (De la Rosa *et al.*, 2007). In fact, many of the problems observed in the viability of those types of plantations are related to a deficient pruning, sometimes focused to have the maximum yield the first years after planting. On the contrary, the most convenient pruning strategy on hedgerow planting should be subjected to keep an adequate hedgerow size able to allow the straddle machine to harvest while maintaining a constant productivity at the same time. Therefore, pruning of hedgerow plantations is far different from vase-shaped trees of intensive orchards and labour should be specifically trained for that. Mechanical pruning has been proposed as another solution to reduce labour in both intensive and hedgerow systems and to keep the canopy volume within the convenient thresholds. However, some experiments performed advice to be complemented by selective manual pruning.

In the last years, irrigation management has been proposed as a convenient tool to control vigour in hedgerow olive. Other strategy to control the vigour is the development of new low vigour cultivars specifically designed for this growing system, as the case of 'Askal', 'Urano', 'Sikitita' or 'Tosca'. Also, dwarfing rootstocks could enlarge the number of varieties suitable to these systems. However, the vigour of a cultivar is largely influenced by environment, so specific trials should be developed to test the suitability of a given cultivar in a specific environment. This is especially important in those areas outside the Mediterranean Basin, where climatic conditions could dramatically affect vigour.

Some experiments of hedgerow orchards on dry farming at 7 x 2 m are currently under way with promising results. Again, this new strategy should be tested in several environments before it can be considered efficient.

4. Future prospects

Although the mentioned growing systems are the most popular up to now, new ones are appearing as a result of new harvesting solutions. This is the case of orchards with densities of around 500-700 trees/ha designed for a continuous mechanical harvesting by large straddle harvester machines in an over-the-row configuration (Ravetti and Robb, 2010). Trees are usually trained in an erected vase with two main branches formed perpendicularly to the hedgerow line. This constitutes an intermediate situation between intensive and hedgerow orchards. More cultivars could be adapted to this system, as the higher spacing between trees makes easy to maintain the hedgerow. As an inconvenient, the dimensions of the harvesting machine restrict its ability to move from one orchard to other and also to work on areas with high slopes. Other recently proposed harvesting solution, the lateral harvester could also have influence on the future growing systems and their pruning strategies.

Due to the current economic situation, new olive growing systems should not be devoted to last indefinitely or to maximize yield. The main objective should be to obtain high productivity at the minimum cost and to produce olive oil with added quality value to increase profitability. All solutions of intensification, from intensive to hedgerows of different densities, could be profitable. The decision from one or other would come from balance between pro and cons (Table 2). Labour availability, financial support and edaphoclimatic conditions could be critical for this decision. Therefore it is probable that in the coming decades all systems will coexist and the prevalence of one or other could depend on the development of new harvesting machines and new cultivars that could appear in the coming years.

Table 2. Comparison of vase-intensive and hedgerow olive systems. Advantage and inconvenients are relative from one system to other

Item	Vase intensive		Hedgerow	
	Advantages	Inconvenients	Advantages	Inconvenients
Planting cost	Lower			Higher
First crop		Later	Earlier	
Cultivars suitable	Many			Few
Need of labour at harvesting		Higher	Lower	
Need of pruning	Lower			Higher and specialized
Life span	Higher			Lower
Phytosanitary treatments	Lower			Higher
Invest recovery		Slower	Faster	

In many olive growing countries, there is a tendency to reconvert some of their traditional growing orchards to more intensive ones. Those efforts should be well planed, taking into account all the edaphoclimatic, economic and social aspects before being accomplished. For example, sufficient molturation capacity should be planned before large hedgerow plantings are designed and cultivar comparative trials should be performed before a foreign or new cultivar is used. Demonstration trials of the different growing systems accompanied with explanations of the pros and cons of any of them are the best advice that growers can have before deciding a new plantation. Additionally, growers' training is essential to impulse the accomplishment of this restructuring. One difficulty for the progress of restructuring olive orchards is the high amount of small farms (of less than 5 has) existing in many olive growing countries. Those farmers are not in good position to replant or install new infrastructures and, in many cases, they do not have skills for that. The average trees per ha, between 100-200 in many countries, indicate that the intensification of olive growing for a better management system is still in its early stages. In some cases, where olives are planted in marginal areas in very fragile environments, there is no possibility of reconversion, maybe only to optimize pruning. Organic farming could be a choice to increase profit on those cases. But in other cases, traditional extensive orchards are planted in areas where a shift to more efficient growing system could dramatically increase profit.

Special interest has the recent diffusion of olive growing in non-Mediterranean countries as Argentina, Chile, USA, Australia or South Africa. Growing systems in these areas must be based on high levels of mechanisation and low demand of manual labour, particularly due to the lack of tradition on olive growing. Although several problems of adaptation of olive to climatic conditions not exactly Mediterranean have been observed, the spreading of olive growing in new areas can have a significant influence on the olive oil market in the future due to their efficient productive systems.

In conclusion, a co-evolution of growing systems, mechanical harvesting solutions and new cultivars is expected in order to have more profitable olive orchards in the coming years.

III – Genetic resources

The genus *Olea* belongs to the *Oleaceae*, a family containing 29 genera and around 600 species of shrubs and trees. According to recent revisions of *Olea europaea* taxonomy, the species includes six sub-species based on morphology and geographical distribution (Green, 2002). Among them, the subsp. *europaea* is represented by two botanical varieties: cultivated olive (var. *europaea*) and wild olive (var. *sylvestris*), both present throughout the whole Mediterranean basin. Both wild and cultivated olives are diploid (2n=2x=46), predominantly allogamous and their genome size is about 2,200 Mb.

1. Traditional cultivars

Olive, along with grape, fig, date palm and pomegranate, belongs to the first group of domesticated fruit trees. All of them have in common their ability for vegetative propagation, initially by primitive methods requiring large propagules. The first olive growers selected individuals with better characters in wild olive forests, i.e. those showing higher fruit size and mesocarp proportion and higher oil content. Afterwards, with the spread of olive growing, this procedure might be repeated in the new growing areas leading to the first selected cultivars. In addition, these first cultivars could be enriched by the contribution of new genes (introgression) of local populations of wild olive, given the known interfertility between them. This domestication process probably occurred simultaneously at different places in the Mediterranean basin originating a large number of local cultivars which diffusion remained mainly restricted around its area of origin.

There have been efforts for cataloguing olive cultivars in most olive producing countries, although it is not exactly known yet the number and distribution of cultivars. Cultivar names difficult their correct cataloguing in many cases. Most cultivars, especially the most important, are known by different names depending on the area of cultivation (synonyms). In other cases the same name is given to cultivars that are actually different (homonyms). The identification of olive cultivars has been traditionally carried out by morphological descriptors. Besides, in the last years different molecular markers have been developed and applied for studying the variability of olive cultivars and their origin, providing a more powerful tool to guarantee varietal identification.

In Spain, a complete cataloguing work allowed the final identification of 262 different cultivars, classified in four categories (main, secondary, dispersed and local) according to their geographical distribution and economical importance. This high variability of cultivars is a common trait in all traditional olive-producing countries. A web data bank of the Olive Germoplasm developed by Bartolini *et al.* (http://www.oleadb.it) includes data on all the characters published extracted from 1,520 publications which have concerned about 1,250 cultivar denominations in 54 countries and conserved in over 100 collections.

2. Need for breeding

For many years, traditional olive orchard has been planted with the local cultivars above mentioned. However, in the last decades olive growing techniques have evolved considerably with new orchards designed to provide higher productivity and facilitate mechanical harvesting.

Tree shape, fruiting habit, fruit quality, production efficiency and resistance to diseases and pests should be improved for the future development of an economically viable industry adapted to modern agriculture.

In fact, changes in growing systems have been accompanied in many cases by the introduction of previously unknown varieties in these areas. The higher knowledge obtained in recent years about the agronomic characteristics of the most important cultivars have promoted that those cultivars having better performance (higher productivity, oil quality, mechanical harvesting aptitude, resistance to biotic and abiotic factors, etc.) replace traditional ones in many areas. As an example, in Andalusia, Southern Spain, according to nursery plant production data, over 90% of new plantations are being made by using only three cultivars ('Arbequina', 'Picual' and 'Hojiblanca'), which are spreading far from its traditional growing areas. The same situation applies for most olive producing countries. It should be noted that, in some cases, the introduction of cultivars has not been preceded by the experimentation to confirm their suitability to new areas, even though several studies show that the agronomic and quality characters of an olive cultivar can change dramatically depending on the area of cultivation. Comparative field trials are the most efficient way to determine the best suited cultivars in any specific area of cultivation. Unfortunately, the lack of previous experimentation has led in some cases to the commercial failure of new plantings.

High density hedgerow plantings represent a good example of the significant changes made in the olive grove in recent years. This planting system appeared in Spain in the mid-nineties based on high-density hedgerows (around 2,000 trees/ha compared to 200-400 trees/ha in standard olive orchards) collected by vineyard type straddle-harvesting machines, thus simplifying olive harvesting, the higher labor-demanding task in standard olive orchards (León *et al.*, 2007). However, unlike other fruit crops, in olive there are no specific low-vigor cultivars or dwarfing rootstocks adapted to this system. Due to the lack of specific cultivars for this system, very precocious cultivars such as ‘Arbequina’, ‘Arbosana’ or ‘Koroneiki’ have been mainly used, although they can not really be considered as low vigor cultivars (De la Rosa *et al.*, 2007). This could represent a problem particularly in very favorable growing conditions, since the hedgerow has to be kept under certain dimensions to allow the harvesting machine to pass over the top of the row.

Under these new planting systems, many of the traditional olive cultivars, which were empirically selected by growers centuries ago, display a number of undesirable traits for a sustainable modern olive industry. This situation has stimulated the development of breeding programs to obtain new cultivars that could increase the range of available cultivars adapted to modern olive growing systems.

3. Cross-breeding programs in the Mediterranean countries

Despite its importance, especially in the Mediterranean basin, breeding works in olive producing significant advances have not been carried out until the second half of the twentieth century. The long juvenile period (olive seedlings take more than 15 years before the first flowering under natural conditions) has been the main limitation for olive breeding. However, the development in the last years of simple methods to reduce this period by means of cultural techniques and adequate selection of parents has encouraged new olive breeding programs in many olive-producing countries.

Classical olive breeding programs are based in intraspecific cross-breeding between cultivars of known merit. Early bearing and high yield, increasing oil content and quality, tolerance to biotic and abiotic factors, suitability to different growing systems and mechanical harvesting aptitude are some of the main objectives. Initial works in these breeding programs were focused on the development of methodologies to shorten the juvenile period, the characterization of initial seedling progenies and the establishment of early selection criteria.

The selection procedure is carried out in several steps from the germination of seeds to the final registration of new cultivars (Fig.3). Promising genotypes are selected in the initial progenies populations and vegetatively propagated for further evaluation. Afterwards, new steps of selection are carried out in trials including a higher number of replications per genotype while the number of selected genotypes is reduced step by step. A final step of comparative field trial in several environments allows the final selection and registration of new cultivars.

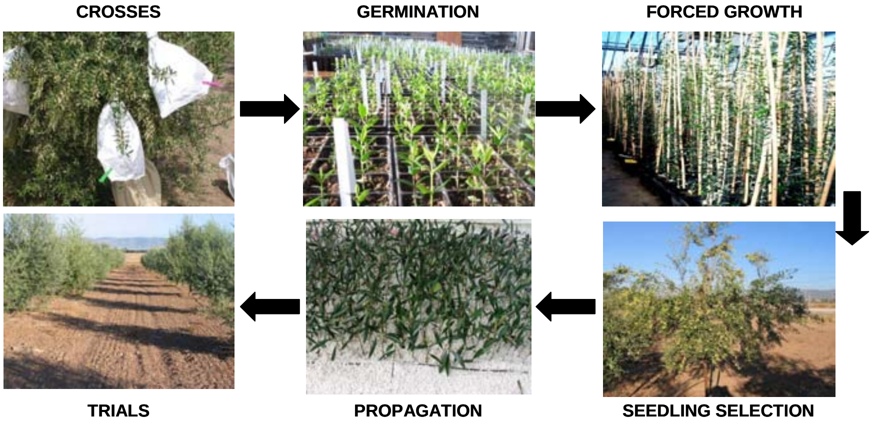

Fig. 3. Main steps in olive cross-breeding programs.

In the last years, breeding attempts have been initiated in several countries. However, due to the long period needed, only some of them have been able to complete the breeding process. As a consequence, several new cultivars and advanced selections, coming from different breeding programs, have been described.

4. New cultivars from breeding programs

Several new cultivars have been released in the last years as a consequence of breeding works (Table 3). However, only a few of them have been already marketed with relative success both in their countries of origin and abroad.

'Barnea' (Lavee *et al.*, 1986) originated from a mixed seedling population and was originally selected as part of an olive tree breeding program aimed to develop olive cultivars suitable for intensive conditions. It was characterized by its rapid and erect growth, early fruit bearing after planting and high yield under irrigated conditions. The oil is characterized by a medium content of oleic acid and polyphenols and its quality and taste is greatly appreciated. Since 1980, 'Barnea' has been planted in Israel as the major variety for the new intensive olive orchards for oil and also widespread in Australia, New Zealand, South America and USA.

'Fs17' (Fontanazza *et al.*, 1998) was selected in progenies from free pollination of 'Frantoio'. It was characterized as a new cultivar with early bearing, high and stable production and high oil content. With medium-low vigor, it was recommended for high density plantation or as a rootstock to reduce the vigor in high vigorous cultivars such as 'Giarraffa' or 'Ascolana tenera'. However, it should be noted that, in Spain, 'Fs-17' has shown lower productive performance than 'Arbequina', 'Arbosana' or 'Koroneiki' in high density hedgerow orchard trials. A high incidence of fruit rot caused by *Alternaria alternata* was also observed, a pathogen that is generally characterized as weakly virulent. These observations underline the importance of performing comparative field trials before the introduction of new cultivars in any specific area of cultivation.

‘Chiquitita’ / ’Sikitita’ (Rallo *et al.*, 2008) was obtained in a cross-breeding program in Córdoba, Spain derived from a cross carried out between ‘Picual’ and ‘Arbequina’. The results of the agronomical evaluation carried out in Córdoba allow the final selection of ‘Chiquitita’ as a new olive cultivar with early bearing, high oil content and yield efficiency. ‘Chiquitita’ showed a compact and weeping habit of growth, with dense canopy and branches trending downwards with crop so that canopy volume remains low. Its low vigor and natural trend to adopt a monocone shape with a central leader form make it particularly adapted to high density hedgerow orchards to ensure ease of management for a longer period.

Table 3. New olive cultivars released from breeding programmes

Cultivar	Origin	Country	Year
‘Kadesh’	F1 unknown	Israel	1978
‘Barnea’	F1 unknown	Israel	1984
‘Maalot’	F1 unknown	Israel	1995
‘Fs-17’	‘Frantoio’ free-pollination	Italy	1998
‘Arno’	‘Picholine’ x ‘Manzanilla’	Italy	2000
‘Tevere’	‘Picholine’ x ‘Manzanilla’	Italy	2000
‘Basento’	‘Picholine’ x ‘Manzanilla’	Italy	2000
‘Askal’	‘Barnea’ x ‘Manzanilla’	Israel	2003
‘Kadeshon’	‘Kadesh’ self-pollination	Israel	2004
‘Sepoka’	‘Kadesh’ self-pollination	Israel	2004
‘Masepo’	‘Manzanilla’ self-pollination	Israel	2004
‘Chiquitita’	‘Picual’ x ‘Arbequina’	Spain	2007
‘Tosca’	F1 unknown	Italy	2007

In the coming years, the continuation of breeding works with new crosses and continuous evaluation of the generated progenies will provide new olive cultivars obtained by genetic improvement that may change the current cultivar distribution in many countries.

5. Genomics tools

Recently developed genomic tools could be helpful to improve several aspects of olive growing. The most practical use of genomics nowadays is the authentication of plants in nursery. This consists on comparing a sample of the nursery plants to be used in a new orchard with a reference sample of the cultivar used. The comparison is made using molecular markers, mainly SSR (also called microsatellites), which analyze specific fragments of the DNA to test if the nursery plants are genetically identical to the reference sample. Reference sample are normally coming for cultivar collections existing in almost all olive growing countries (Bartolinie *et al.* Olea databases: http://www.oleadb.it/olivodb.html). Additionally there are three International Olive Germplasm Banks (in Córdoba, Spain, in Marrakech, Morocco and a third one scheduled to be set up in Turkey) hosting cultivars from all the Mediterranean Basin. As planting a new olive orchard is very costly, and errors on the cultivar used are only evident after 3-4 years of field growth, cultivar authentication is a very advisable operation, especially when foreign or not well known cultivars are used. Additionally, there are some molecular and serological tests to check if the nursery plants are carrying fungi (as *Verticillium dahliae*), bacteria or virus. Those test are also very convenient as, for example, the use of infected plants is considered as one of the ways of dissemination of *Verticillium* wilt. For these reasons, certification programmes are underway in several olive growing countries to offer to the growers nursery plants tested for cultivar trueness-to-type and free of diseases. However, up to now, there has been not a great demand of certified plants in most of the olive growing countries.

As mentioned above, molecular markers are also used in the management of Cultivar Collections in order to detect synonyms and homonyms. In this way, reference trees for the main cultivars could be identified. In the International Germplasm Banks molecular markers are also used to compare the authenticity of the foreign cultivars hosted with the country of origin. Microsatellite are again the marker of choice for those purposes, although high-throughput markers as DArTs and SNPs, recently developed for olive, are very promising for germplasm management in the future.

Apart from that, molecular markers and studies of expressed genes are being used to uncover the genetic basis of the most important olive agronomic traits as oil content and quality and resistances to biotic and abiotic stresses. In the future, these studies could significantly speed up the breeding programs as could greatly facilitate the selection process. However, marker assisted breeding is still far to be ready for use. One of the main reasons is that most of the agronomic traits of interest are quantitative and likely controlled by many genes. Additionally, the wide genetic base of the different breeding programs makes difficult transfer of marker-trait associations in the different crosses performed.

In the long term, transgenic olive is other challenge that could come to practice. In many countries, transgenic plants do not count on high popularity. Moreover, in olive, the concept "healthy", normally used in olive oil marketing would be difficult to link to "coming from transgenic plants". However, some intermediate solutions could be feasible in not so long term. For example, transgenic rootstocks resistant to diseases as *Verticillium* wilt could be of interest. In those cases, the olive oil from the scion will not come from transgenic plants and, in the future, it might be acceptable by the consumers. In other hand, cisgenesis (transformation with genes coming from other genotype of the same crop) is not considered as real transgenesis in some countries and could be an easy way to transfer genes from, for example, wild olives to high-yielding cultivars.

In conclusion, from identification to gene expression and transgenesis, different DNA analysis techniques could offer several tools very useful for the future olive growing.

IV – Sustainability and management in olives

1. Soil management and soil degradation

Soil degradation, most frequently soil erosion but also a decrease of soil nutrients and organic matter, and soil compaction, is systematically quoted as one of the major threats to sustainability of olive cultivation. Losses of top soil in areas characterized by shallow soils means a reduction of soil water storage capacity, which is critical for survival and productivity of rainfed olives (Fig. 4). They threaten olive cultivation rather by yield decrease or by the increasing production costs to compensate this degradation with additional inputs (e.g. fertilizers…). However the "off site", damages created by the runoff, sediment and agrochemicals transported downstream are what usually creates a major concern in the short term. Decrease of water quality in water courses by excess of sediment and agrochemicals has been noted as a major environmental problem in some olive growing areas. The high sediment load also increases the damage during floods and reduces the effective life of infrastructures (such as dam reservoirs due to silting).

Fig. 4. Examples of soil erosion in olive orchards.

Soil management in olive has been oriented for centuries to insure productivity and survival of the plantation under conditions of limited, and highly variable, rainfall using a combination of low plant density, limitation of tree canopy size by pruning and elimination of adventitious vegetation to limit competition for soil water. Traditional extensive systems in which weed control was pursued by tillage by animal traction were limited by available power (and the cost of tillage). This resulted in a mixed system in which the soil was covered by vegetation (or their stubble) during part of the year. Evaluation of similar systems today based on limited plowing (once a year or once every two years) suggests that this systems were subjected to moderate soil losses, specially if performed in a mosaic type of landscape where the orchards were surrounded by areas of natural vegetation or some retention structure. Topsoil in many of these orchards present values of some key soil properties within acceptable range and not far from those in undisturbed areas with natural vegetation. Traditional systems based in an integrated use of the orchard as intercropped with a field crop or with grazing at low density seemed to be in a similar situation with soil erosion rates not damaging sustainability in the medium term if performed at low intensity. However, erosion rates become higher and unsustainable when olive cultivation was pursued systematically on sloping areas and in a homogeneous, olive covered landscape. Van Walleghem *et al.* (2011) determined from field observations a cumulative loss of 450 mm of topsoil in old orchards during a period of 183 years, equivalent to 43 t ha/year.

The availability of tillage all year round due to mechanization combined, years later, with the availability of herbicides allowed a complete elimination of adventitious vegetation. This happened in a period of intensification with abandonment of other uses of the orchards. Measurements at small catchments also indicate high losses, ranging from 10 to 16 t ha/year (Taguas *et al.*, 2012), rates affecting quality of surface waters. The extrapolation from regional analysis or metanalysis to areas with similar conditions and soil managements indicates that this is a widespread problem around the Mediterranean basin, where most of the olive cultivation is still concentrated (Gomez *et al.*, 2008). The major effort during these decades regarding erosion control in olive orchards has been the development and expansion of the use of ground cover in the orchard lanes to prevent erosion and improve soil properties. Most of the change in soil management has been based on the introduction of cover crops that are sown along the lanes and are controlled by mowing or herbicides in late winter or spring to prevent competition for soil water with the olives. The cover crops can be sown every few years by the farmers (usually are cereals but leguminous are also been used) or are composed by adventitious vegetation naturally present at the farm. These cover crops have been studied for decades and their management and impact is relatively well understood in the more humid parts of the Mediterranean where it has been possible to achieve equilibrium between soil protection and competition for water, and their use has been incorporated into the environmental requirements of the Common Agricultural Policy of the European Union. However, even in these regions their effective use for erosion control in commercial farms is still achieving uneven results. In many farms, obtaining an effective ground cover remains a challenge due to the severity of soil degradation combined with the intensive traffic in the olive lanes, especially during harvesting. It also remains a relatively large uncertainty about the impact of the competition of the cover crop in areas different to those where the experimental studies with cover crops were performed, in years of limited rainfall (specially in spring), on orchards with different plant densities or under changing climate scenarios with higher temperatures and scarcer precipitation (Gucci and Caruso, 2011). Current research in Southern Europe seems to be focused on the development of new varieties better adapted to the role of cover crop in olive orchards, which can provide also additional benefits such as biological plague and disease control and increase of biodiversity; a comprehensive design of farm management to achieve an effective cover crop with limited risk of yield reduction (combining early harvest, controlled traffic and bands of cover crops of varying width and orientation) and the development of operational water balance models to predict the optimum date for cover crop killing in specific conditions. Related to water balance and the use of cover crops, the expansion of irrigation in olive growing areas provide a margin of safety to implement cover crop soil management without limiting significantly olive yield that does not seem to be completely explored. It has been also demonstrated the beneficial impact of a mulch of pruning residues, which had a similar effect to that of cover crops without the risk of water competition, although the amount of pruning residues to be prevent erosion can not be always achieve in the less productive orchards, and it also presents some limitations if some plagues and diseases are present. Overall, there is a need for a better understanding of the impact of these new uses of mulches and vegetation on pest and diseases in olives. There are some preliminary studies trying to use a biogenic crust of mosses, but their effectiveness or viability under the conditions (especially of machine traffic) of olive orchards is still to be demonstrated.

Little information is available on high density hedgerow orchards. These plantations occupy less sloping areas and provide an increased grown cover compared to traditional plantations, so it can be expected that this plantations might present a reduced erosion risk. Nevertheless, a comparison with systems that are conceptually similar (vineyards) suggests that if this plantations are implanted in areas with non-negligible slopes (e.g. >2 %) the erosion rates might be significant since they will present long lanes that will be probably compacted by the repeated pass of farming equipment. In these plantations, the use of mulch might be very efficient as an erosion control technique. Probably a mulch of pruning residues might be a viable option under these conditions.

The anthropization and simplification of the landscape that have resulted of the extension and intensification of olive orchards have also resulted, in some areas, in severe gully erosion (Fig. 4). This problem has severe consequences for the sustainability of olive cultivation. The techniques based on increasing ground cover to prevent erosion at hillslope scale are of little effect to prevent gully erosion. This is counterintuitive at first glance, but it can be easily grasped if we understand that mulches and cover crops are much more effective in reducing soil losses that in reducing runoff and that gully erosion results of concentration of overland flow (what will always happen in olive landscapes in the heavy rains that occurs periodically in Mediterranean climate) and the fragilization of the drainage network due to the elimination of vegetation that protects the stream sides. The use of vegetation at landscape for gully control, open the use of these measures as a tool to enhance biodiversity and landscape value in many olive growing areas.

2. Irrigation and sustainability

Irrigation can be considered a relatively recent practice in olive growing. Although some kind of irrigation has been traditionally applied to olives in very arid areas as an auxiliary practice, the most part of farm water supply was typically assigned to other less drought-tolerant crops. The appearance of drip irrigation in the 60's opened up the door for easily irrigating orchards on sloping terrains. The good response of olive yield to irrigation which, together with an increasing demand of olive oil, has made irrigation spread during the 80's and 90's. Of the 2.5 Mha of Spanish olive plantations, 0.52 (20%) are formally irrigated, and this share is almost certainly underestimated. New plantations –in Spain as in the rest of the world– are mostly irrigated, suggesting that the fraction of irrigated olive growing is very high worldwide and this fraction is increasing. One of the reasons that decreed the success of irrigated olive cultivation is that the tree yield responds strongly even to relatively small amounts of irrigation water. An evapotranspiration-yield function indicates an increase of 5 kg/ha of olive oil for each mm of water evapotranspirated during the season (Fig. 5). This is an average value, but the relationship is not linear. This means that the marginal productivity of water, i.e., the increment in yield for each incremental unit of water used by the crop, is higher under low water use and smaller when approaching the full water requirement of the tree. Olive is usually grown in arid and semiarid environments, where irrigation water supplied to the farmers is the main limiting factor to crop production; under these circumstances farmers naturally tend to apply less water than what needed for full production and to distribute it to the maximum surface, but trying to avoid water stress when the crop is more sensible (e.g. flowering or oil filling). This strategy is called "regulated deficit irrigation" or RDI.

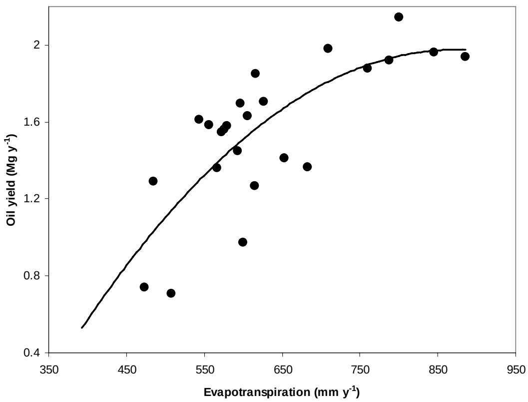

Fig. 5. Relationship between olive evapotranspiration and oil yield. Redrawn from Moriana *et al.* (2003).

Although irrigation of olive is profitable even under deficit supplies, the surface planted has nevertheless increased so much in the last decade that many olive growing areas are already unable to fit the water demand of olive groves. This is quite a big issue, as this situation is already drawing out non-renewable water resources. For example, in southern Spain some subterranean water bodies are depleting, many springs are disappearing or their flow has become discontinuous. The excess of water demand is a major risk associated to olive irrigation, as olive growing areas are located mainly in zones that are already at risk of desertification. The water requirements of olive growing areas must therefore be defined as precisely as possible; but olive orchards are very heterogeneous, in size, planting density, irrigation frequency, etc. which hindered the application of traditional calculation methods like the standard FAO Crop Coefficient technique. The problem has been addressed from a scientific point of view by measuring in various experiments all the sources of water evaporation from olive orchards (leaves, soil and wet soil spots under localised irrigation), which gave the possibility of developing a model of orchard ET (Testi *et al*., 2006), that was then used to simulate all the possible types of olive orchards and derive a calculation method to obtain the maximum evapotranspiration of a given orchard and site (Orgaz *et al.*, 2006). This method helps in both irrigation scheduling and in problems of dimensioning and balancing the area invested and its water assignment. Nevertheless, the information must be sided by good water policies at the right scale, with the object of assisting farmer's incomes while enforcing a sound environmental protection, by close monitoring of any environmental indicator involved.

The shift from rainfed to irrigated olive farming encompasses more than the implementation of irrigation. Removing water limitation means that olive production meets other constraints, more often the amount of radiation intercepted. Irrigated orchards find their optimum production under more dense systems to obtain the maximum potential from irrigation water the system requires more inputs and investments. Shifting from rainfed to irrigated olive groves entails intensification of the cropping system. If the target is making the best possible use of a limited resource (water) we should change the paradigm of olive growing: in marginal areas, where soils or climate are the main limiting factors, intensive input farming is spoiled. The maximum return from water investment can be found only routing it to the more productive environments, capable to support high-density, intensive and productive olive farming.

This change of paradigm should be taken with caution, as high input farming may carry environmental risks in vulnerable areas. The environmental risks associated with olive irrigation are more dependent on intensification of the cropping system rather than irrigation itself. One of the more common negative effects of irrigated agriculture is the contamination of water bodies due to pollutants (either fertilizers or pesticides) carried with runoff and percolation. Olive groves are less prone to leak out agrochemicals than many other crops, as new plantations are all drip irrigated (with minimise runoff even on sloping terrain) and irrigation in excess is found very rarely. A correct scheduling and calculation of the irrigation amount will reduce this risk to a minimum.

As many olive orchards are deficit irrigated and they typically occupy semi-arid zones, soil salinisation is often an environmental risk. This risk is further increased because the tree is salt tolerant, and farmers tend to use bad quality water under the pressure of increasing water scarcity; besides, drip irrigation also helps in reducing salt accumulation in the root zone. The use of saline water in olive irrigation is not necessarily detrimental for the environment, but the soil evolution must be closely monitored for sustainability. In very arid environments rainfall could be insufficient to remove salts through the natural soil flushing at the rate they are added by irrigation water; this could lead, in the long period, to push already vulnerable areas beyond the border of desertification.

Salinity effects on yield depend on the concentration but even though tolerance is a cultivar-dependent characteristic, most of the cultivars under semiarid conditions may develop well with no significant reduction of yield with an ECe in a range between 3 and 6 dS m^{-1}. Salt tolerance is mainly associated to salt exclusion mechanisms operating in the roots, preventing salt translocation rather than salt absorption. Olive trees are less sensitive to leaf Cl^- than Na^+, and Ca^{2+} play an important role in Na^+ exclusion and retention mechanisms. Results obtained from a long term experiment under field conditions (Melgar *et al.*, 2009) suggest that a proper management of saline water, supplying Ca^{2+} to the irrigation water to prevent Na^+ toxicity, using drip irrigation until winter rest and growing a tolerant cultivar, can allow using high saline irrigation water for a long time without affecting growth and yield in olive trees.

Irrigated olive growing is a new cropping system, with specific characteristics, that was mainly unknown only a short time ago. But new knowledge is required about the water use of high-density/hedgerow plantations, and the specific irrigation strategies for these high-investment orchards; the possibility of tailoring specific cultivars for specific irrigation/climate/management combinations through the new breeding programs launched recently; the modelling of the carbon dynamics of olive plantations linked to the water use, to explore new scenarios under the effects of changes in the water supply and climate.

3. Fertilization, crop quality and environment

Fertilization is a common practice in olive growing because it aims to satisfy the nutritional requirements of trees when the nutrients required for its growth are not provided in sufficient amounts by the soil. Since soils may differ in fertility, and nutrient requirements may vary among different olive orchards depending on tree age, variety and olive production system, it would be illogical to provide general recommendations for olive fertilization. The annual fertilization program may vary among orchards and among years within an orchard. However, repeated fertilization programmes are customary in many olive-growing areas.

A survey of olive fertilization practices in the Mediterranean region (Fernández-Escobar, 2008) revealed that in 77% of cases the fertilization programme was repeated every year and generally involves applying several mineral elements, which always included nitrogen, even when in most cases the nutritional status of the orchard was unknown. This approach tends to apply more mineral elements than necessary, some of which may already be available to the tree in sufficient amounts to guarantee a good crop, and, at the same time, it may cause mineral deficiencies if a specific element is not applied in sufficient amounts. The farmer attempts to return to the soil the nutrients removed by the crop in order to maintain soil fertility and provide a good nutritional status of the trees. However, this replacement fertilization did not always prove satisfactory since it did not take into account luxury consumption, the reuse of elements by the tree, the elements applied by irrigation water or rain, mineralization of the organic matter, tree reserves or nutrient dynamics in the soil exchange complex. Also, it has been proven that if an element is available in the soil in sufficient amount for the plant, there is no response to fertilization with this element. Accordingly, the excessive application of non-needed fertilizers increases growing costs, contributes unnecessary to soil and water pollution and may have a negative effect on the tree and crop quality. Today it is considerer that a rational fertilization tends to: (i) satisfy the nutritional needs of a orchard; (ii) minimize the environmental impact of fertilization; (iii) obtain a quality crop; and (iv) avoid systematic, excessive application of fertilizers.

Predicting the amount of fertilizers required annually to support optimum productivity is not simple. Under a rational point of view, a nutrient must be supplied only when there are proves that it is needed. For this purpose, leaf-nutrient analysis provides an indication of tree nutritional status and represents an important tool for determining fertilization requirements. Interpretation of the results of leaf analysis is based on the relationship between leaf nutrient concentration and growth or yield. Comparing actual leaf nutrient concentration to reference values allows the diagnosis of nutrient deficiency, sufficiency or excess. Optimum tree nutrition could be achieved combining this information with soil and environmental factors that affects tree growth and symptoms of nutrient deficiency or excess (Fernández-Escobar, 2007). Leaf analysis has proven useful as a guide to fertilizer management of olive trees, and may promote more environmentally responsible use of fertilizers. In a long-term experiment carried out in four olive orchards established on different types of soils, that compared the fertilization practice based on foliar diagnosis versus the current fertilization practice in the area based on the annual application of several nutrients, it was obtained that the current practice in the area increases in more than 10 times the cost of fertilization without an increase in yield or vegetative growth; on the contrary, this practice negatively affects oil quality due to a reduction of total polyphenols in olive oil. Despite that, recent studies indicate that leaf analysis is being underutilized in olive growing, since few growers perform leaf analysis annually.

Sixteen elements have been recognised as essential for plant growth: carbon (C), hydrogen (H), oxygen (0), nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg), calcium (Ca), sulphur (S), iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), molybdenum (Mo), boron (B) and chlorine (Cl). Nickel (Ni) is also considered essential for some authors. They are essential elements because the plant is unable to complete its life cycle without them; no element can substitute for another; and the element has a direct impact on growth or metabolism. The first three elements, C, H and O are non-mineral and represent approximately 95% of the dry weight of an olive tree. They are not added in fertilization because the tree can get them from the carbon dioxide (CO_2) present in the atmosphere and spread it to the leaves through the stomata, and from the water (H_2O) in the soil, taken up by the roots, whose combination by photosynthesis forms carbohydrates, the major plant nutritional component. The others are mineral elements and they are the reason why we fertilize. Together they only represent 5% approximately of the olive tree dry weight; therefore we can easily cause an excess of one of them. These elements are uptaken by the olive roots from the soil solution where they occur as ions. Perennial plants like the olive have nutrient storage organs to help them easily reuse nutrients. This is why nutrient needs of these plants are lower than annual plants.

Potassium deficiency is the major nutritional disorder in rainfed olives because the low soil moisture limits the spread of the potassium ion through the soil solution and prevents its absorption by the roots. It is worse when yields are high because is the element removed in largest amounts by the crop, around 4.5 g K/kg olives. Potassium deficiency is difficult to correct in olive orchards because the potassium fertilizer is uptaken in smaller amounts by trees suffering from a deficiency. Tentative doses for soil application in such cases are around 1 kg K/tree, provided that soil moisture is not a limiting factor. In rainfed olive orchards, between two and four leaf applications of 1%-2% K have given satisfactory results, although it is usually necessary to repeat the applications in following seasons until K reaches an adequate level in the leaves. Applications should be done in the spring because young leaves absorb more K than mature leaves.

In calcareous soils, iron and boron deficiency may occur in addition to potassium deficiency. Trees suffering from iron deficiency, known as *iron chlorosis*, display a characteristic series of symptoms such as yellow leaves, small shoot growth and lower yield. These symptoms are the means of diagnosing iron deficiency as leaf analysis is of no use in such cases because iron accumulates in the leaves even when deficiency occurs. Iron chlorosis is difficult and costly to correct. The best solution for new orchards is to choose a variety that tolerates this anomaly. In established orchards the remedy is to apply iron chelates to the soil, which makes iron available to the plant for a moderately long period in comparison with other products, or to inject iron solutions into the tree trunk. Olives are considered to have high boron requirements. Soil availability decreases under drought conditions and at higher soil pH values, particularly in calcareous soils. Boron deficiency can be remedied by applying boron to the ground at a rate of 25-40 g per tree. In calcareous soils with a pH>8 and in rainfed orchards, it is preferable to apply soluble products to the leaves at a concentration of 0.1% boron, prior to flowering.

Calcium deficiencies are to be expected in acidic soils. In these situations it is necessary to apply a limestone amendment, i.e. applying calcium carbonate or calcium oxide to neutralize the acidity. The amount required depends on the soil texture and pH, and has to be calculated on the basis of soil analysis results.

Finally, nitrogen is the mineral element required in the largest amounts by plants and consequently, it is commonly used in the fertilization programs of horticultural crops. Since it is lost easily through leaching, volatilization or denitrification, there is the perception that an increase in nitrogen fertilization always results in increased yield. However, long-term studies dealing with the optimization of nitrogen fertilization in olive orchards have demonstrated that annual applications of nitrogen fertilizers are not necessary to maintain high productivity and growth. On the contrary, this practice resulted in negative effects on the tree, on crop quality and on the environment (Fernández-Escobar, 2011). These studies recommend that the best strategy to optimize nitrogen fertilization in olive orchards, as well as other nutrients, is the application of nitrogen fertilizers only when the previous season's leaf analysis indicates that leaf nitrogen concentrations have dropped below the deficiency threshold.

These are the nutritional imbalances that can affect the majority of olive orchards and which it is advisable to monitor through testing. Nevertheless, it is unusual for these imbalances to coincide all at once in the same orchard. A good diagnosis of the nutritional status of olive orchards by leaf analysis, and good fertilizer application techniques can lead to a sustainable and responsible use of fertilizers. In this sense, fertigation and foliar fertilization -particularly in rainfed orchards-, may increase nutrient use efficiency. Also, since sufficient know-how is available in this cultural technique, we can conclude that more knowledge must be transferred to the olive sector in order to obtain safe, quality products.

V – Sustainable mechanical harvesting of olive orchards

The economic sustainability of olive production goes through reducing their production costs, which is only possible with integral mechanization. Harvesting can be up to 40% of the costs related to the crop. In each type of olive orchard it is possible to choose between several solutions for mechanization and none of them is completely generalized.

Planting systems have been completely transformed in recent years from traditional olive to high-density olive orchards thanks to advances in mechanization. In the Mediterranean area, the traditional olive orchard remains the most widespread crop system. However, in the new cultivated areas and in the new producer countries, intensive and high-density groves are proliferating due to their better adaptation to mechanization. The olive orchard typology determines the type of harvesting systems to be used and presents significant incidence on harvesting costs as shown in Table 4. This information suggests the need to convert the traditional olive orchards into modern ones. However, this change is very difficult for the high costs and the high risk in non-irrigated Mediterranean areas that represents and because it is not viable for olive orchards located in high slope areas.

Table 4. Costs of the olive oil harvesting systems used in the different type of olive plantations

Olive plantation typology	Yield (kg/ha)	Harvesting system	Harvesting cost (€/kg fruit)
Traditional orchards unable to mechanize	1.500-3.000	Branch shaker and manual harvesting with rods	0.15-0.25
Traditional orchards adapted for mechanization	4.000-6.000	Trunk shaker mounted in a tractor	0.14-0.19
Intensive olive orchards	5.000-10.000	Self propelled trunk shaker	0.09-0.12
High-density olive orchards	8.000-10.000	Straddle harvester	0.04-0.06

1. Mechanical harvesting of olive orchards located in high slope areas

Current advances made in olive harvesting systems have not focused on traditional olive orchards, despite its economic importance in the Mediterranean basin. This type of orchards, designed for manual harvesting, present several difficulties for integral mechanization due to the high slope where mechanization is not feasible. The harvesting systems used in this kind of plantation include manual aids such as branch shaker and combing machines that perform the removal of the fruit using flexible rods that combs the branches of the tree, and are carried by the operator.

The olive groves located in slope presents an additional problem, the risk of being crushed by tractor rollover or machinery for harvesting or other tasks. Another important factor of this type of olive that directly affects crop costs and environmental pollution is the misuse of pesticides application systems such as spray and treatment machines. There is a total disregard of the need to maintain and calibrate those equipments periodically for distribution of agrochemicals and know for certain minimum requirements covering manufacturing. The available equipments are not adapted to traditional olive orchards so in many cases application is not performed properly resulting in high product losses drifts (Fig. 6).

Fig. 6. Drift losses in traditional olive groves.

2. Mechanical harvesting of high yield traditional olive orchards by shaking

Vibrating systems have been and are the most common harvesting methods in olive oil orchards (Fig. 7). In olive oil orchards with high yields the current trend is to use trunk shakers for removing the olive fruits on canvas or nets placed under the trees. The removal fruit is manipulated by a group of workers who perform the loading and transport with the help of loaders and trailers. This harvesting system is the most versatile because it can be either used in traditional and in intensive olive orchards. However, harvesting efficiency in this kind of groves is reduced because their high trunk diameters, the number of trunk per tree, and the tree structure adapted to manual harvesting that strongly influence on transmission of vibration.

Fig. 7. Trunks shaker mounted on a tractor (left) and self-propelled trunk shaker (right).

Harvesting should be done as soon as possible to prevent the fall of the fruits on the soil. Although it is possible to remove the fruit on the soil and then sweep them, this practice is discouraged because the tendency is to get quality oils.

The olive harvest is very dependent on the use of labor for harvesting, manipulating, loading and unloading the fruit down by vibration that not only limit yields overall operation but the increase of costs. New trends in integral mechanical harvesting have to do with managing the removed fruit more than remove the fruit. In recent years, the Department of Rural Engineering of the University of Cordoba is making a great effort to modify and develop the integral mechanical harvesting of traditional olive orchards using canopy shakers. Oxbo 3210 canopy shaker (Fig. 8) designed for citrus harvesting has been tested on traditional olive orchards working in circles around the tree. The removal efficiency exceeded the 80% using the optimal work speed and beating frequency (1.5 km/h and 5 Hz). These first and good results were obtained without pruning adaptation and also suggest the possibility of incorporating a system for catching and loading the fruit, opening a promising way.

The broad tree separation of the traditional olive groves and the rounded shape of the canopy allow the continuous harvesting of fruit around the trees. Although there are olive harvesters that use this removal system, none of the commercial machines can be used in traditional olive. The development of such harvester would provide an alternative for integral mechanization for most of the traditional olive orchards.

Fig. 8. Canopy shaker and catch frame adapted for traditional olive.

One of the most important research lines in olive harvesting is to maximize the percentage of fruit removed. The harvesting efficiency in many cases is dictated by the operational parameters of the machines used and the tree adaptation to mechanical harvesting. The most important parameters are the duration, frequency, acceleration and amplitude of the vibration generated. In recent years, several studies have been performed to get new developments that allow increase harvesting efficiency and minimize damage to tree fruit (Gil-Ribes *et al.*, 2010). Frequency values between 1700-1800 rpm and acceleration values close to 200 m/s^2 are recommended using trunk shaker. The vibration time should not exceed 15 s to limit damage and maximize the removal fruit. Furthermore, it is essential to adapt the olive to mechanization with proper planting design, training and tree pruning, depending on the harvesting system chosen. It has been determined that moderate and severe pruning, leading to a lower canopy density, improve harvesting with trunk shaker because larger and better distributed fruits are obtained. Moreover, this kind of manage reduces olive potential yield, mainly in fertile and irrigated areas.

3. Integral mechanical harvesting of modern olive orchards

Olive integral mechanical harvesting includes three methods: trunks shaker with inverted umbrella, side by side trunk shaker and canopy shaker. The inverted umbrella trunk shaker is the most commonly used. The trees must be adapted with a vertical trunk with more than 1 m long to facilitate clamping and the use of the intercepting structure. Side by side trunk shaker are another alternative based on vibration and fruit interception (Fig. 9). This machine comprises two separate catch frames moving parallel to both sides of the row of trees and one trunk shaker mounted in one of them. This system is only valid for intensive orchards with a row separation higher than 6-7 meters. These systems incorporate continuous discharge on trailer or pallet containers for semiautomatic fruit handling.

Fig. 9. Inverted umbrella trunk shaker (left) and side by side trunk shaker (right) in intensive olive orchard.

Olive straddle harvesters are originated from the grape harvesters (Fig. 10). These machines are self-propelled with hydrostatic transmission and their structure cover the external surface of the trees. Fruit is removed by a number of beating heads formed by curved rods, radial arranged on one or several axes, which transmit the vibration directly to the fruit bearing branches with high frequency and low amplitude. The interception of the olives takes place in the bottom of the tunnel where the fruit is driven by a circulating conveyor with deformable mechanisms that allow folding and sealing with the tree trunk. They also have cleaning systems and storage hoppers.

Fig. 10. Straddle harvester for intensive (left) and high-density hedgerow (right) olive orchards.

The main advantage of the straddle harvester is that it develops a continuous operation with a speed of 0.4-3 km/h. The vibration parameters of these machines are very effective, obtaining greater fruit removal, with efficiencies ranging from 90 to 95% of the fruit production, even for small-fruited varieties and with high fruit retention forces. The small size of the tree canopy, not exceeding 2.0-3.5 m high and 0.80 to 1.20 m wide, is necessary for the use of this machines that move over the tree rods. This is one of the major problems posed by harvesters because it is difficult for many of the varieties to maintain this small size. Giant harvesters such as those used in intensive olive have not been successful in Europe. However, they are commonly used and widespread in the new modern olive groves located in Australia and Argentina. The results are promising, but its size and cost can only be used on large farms, without slope, and with low amounts of rain during the harvesting period.

The canopy shakers have been designed and adapted to various crops such as citrus and vineyard, and currently are being developed for intensive table olives. These systems allow continuous harvesting of the tree, applying vibration on the fruiting branches and reaching high harvesting efficiency levels. Table 5 summarizes the harvesting efficiencies and work yields for different harvesting methods and their application depending on the type of olive orchard.

Table 5. Harvesting efficiency of different harvesting methods according to the type of olive plantation typology

Harvesting method	Olive typology	Harvesting efficiency (%)	Work capacity
Hand harvesting	Traditional and intensive table olive	> 95	105-175 kg men/day
Hand harvesting with rods	Traditional olive	> 95	200-250 kg men/day
Branch shaker and shaker comb	Traditional and intensive olive	> 95	400-500 kg men/day
Trunk shaker mounted in a tractor	Traditional and intensive olive	80-90	0.12-0.20 ha/h
Side by side	Intensive olive	70-85	90-180 tree/day
Giant straddle harvester	Intensive olive	80-90	0.15-0.25 ha/h
Lateral canopy shaker	Traditional and intensive olive	70-80	0.30-0.40 ha/h
Straddle harvester for hedgerow	High-density olive	90	0.70-0.80 ha/h

Canopy shakers systems are based on the same operating principle as the hand harvesting with rods. They are formed by one or more drums rotating rigid horizontal or inclined shafts, radially arranged, which perform the removal by beating the branches. The rods partially penetrate and perpendicular to the tree, shaking branches by oscillatory horizontal motion with low frequency (3-5 Hz) and high amplitude (10-20 cm), sufficient not to break branches or cause serious damage to trees. The vibration is applied to the outer branches where olive production is concentrated resulting in high accelerations in the fruit capable of causing their detachment. The vibration generated parameters are crucial for a good result. Therefore, the shaking process must be adapted to the characteristics of the olive through the characteristics of the vibration generated by the adaptation and crop, mainly by pruning. The damage to branches and fruit are inevitable, but can be reduced by proper system design.

Integral harvesting mechanization necessarily involves adaptation, conversion or restructuring of the olive groves, as appropriate. Pruning is the second most expensive operation just after harvesting because basically is performed by personal equipments, so mechanization of pruning is another issue to resolve in order to ensure the future of this crop. Pruning tests have been performed to compare mechanical pruning against manual pruning, in terms of production and harvesting efficiency using trunk shakers. Dias *et al.* (2008) determined that production over a period of four years is not affected, but harvesting efficiency was reduced in the case of mechanical pruning. Although mechanical pruning is not a widespread practice, it is a future alternative to achieve integral mechanization and cost reduction of the crop. It indicates the importance of accompanying mechanical pruning with thinning of interior branches and dries every 3-4 years to prevent excessive density of the canopy and the accumulation of dead branches.

Among the new advances in research related to the integral mechanization highlights the introduction of new technologies of precision agriculture that has been almost unknown in this sector. These techniques include Global Positioning Systems (GPS), Geographic Information Systems (GIS), automatic control and remote control of the machine, that allow a real time tracking of equipment from a computer, PDA or Tablet connected to network (Perez-Ruiz *et al.*, 2011). Knowledge of the spatial and temporal variation of olive production, tree level, along with the properties of the plot and the distribution of inputs, will carry out a rational decision making to optimize available resources and economic returns olive farms. Fig. 11 shows the first yield mapping and a machinery tracking determined by agriculture precision techniques in traditional olive orchards. The machine tracked was the canopy shaker Oxbo 3210 with a catch frame working in circles around the trees. Through these techniques was possible to determine all olive production per tree and the position of the machine in every moment, obtaining the yield map.

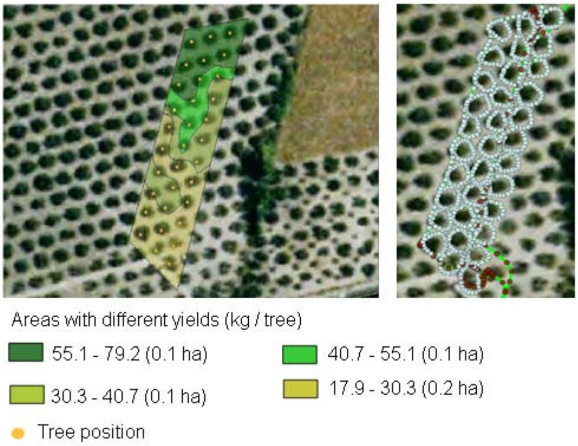

Fig. 11. Yield mapping (left) and machinery tracking (right) obtained using agriculture precision techniques in a traditional olive orchard.

Optimize the machine work is key factor to reducing costs. These technologies provide the ability to perform remote monitoring of equipment and know their real field capacities (Table 6).

Table 6. Work capacities and field efficiencies with the different harvesting systems determined by agriculture precision techniques

Harvesting method	Field capacity (ha/h)	Field efficiency †
Giant straddle harvester	0.15 – 0.20	0.55 – 0.65
Lateral canopy shaker without catch frame	0.35 – 0.40	0.80 – 0.90
Lateral canopy shaker with catch frame	0.30 – 0.40	0.65 – 0.75
Straddle harvester for hedgerow	0.70 – 0.85	0.60 – 0.75

†Useful work time.

4. Mechanical harvesting of table olives

Table olive crop presents specific limitations to mechanical harvesting due to the early time for harvesting in which fruit are harvested prior to coloration. The major impediments are the high incidence of bruising, the high fruit removal force and the risk of tree damage (barking). Also, table olive orchards show low adaptation to mechanical harvesting. Therefore, developing mechanical harvesting will require identifying a successful removal technology that allows at the same time fruit and tree damage reduction and increase of fruit removal.

Table olive crop presents specific limitations to mechanical harvesting due to damage to the tree by barking, because of its early time for harvesting and the damage to the fruit (bruise) that require specific developments adapted to their conditions: the low adaptation of the table varieties to mechanical harvesting and the greater retention force.

The percentages of table olives removed using the best commercial trunk shakers are between 70 and 75%. If the machine is adapted to the tree and vice versa, it is possible to achieve 85% of harvesting efficiency acting on the following aspects: (i) reducing the fruit retention force; and (ii) increasing the transmission of vibration from the trunk shaker to the fruit bearing branches by adjusting frequency, acceleration and vibration time required to maximize the amount of harvested fruit, and pruning adaptation to crop harvesting machinery.

There are several possible options to reduce the amount of fruit damaged by mechanical harvesting: (i) vibration less aggressive; reducing unjustified long vibration times; (ii) the employment-promoting fruit abscission, reducing the contact time of the fruit to the tree and therefore damage; (iii) eliminate or reduce the level of impact of the fruit using padded surfaces near the tree; and (iv) improving the management conditions of the fruit after mechanical harvesting: organization of activities, processing and transport at cold temperature, bruise retardants until processing in the industry.

VI – Olive pest and disease management

1. Olive pests and diseases: present status and future prospects

The olive is a woody crop representing a complex agroecosystem in which many organisms from different trophic levels are well balanced. Some of them are phytophagus or pathogens of the olive tree while some others are entomophagous, predators and parasitoids, antagonists of pathogens and even there are some species looking for shelter. The phytophagous or pathogen organisms that feed and/or develop on olive may determine to a great extend if olive can be grown economically in certain situations. Effective olive crop protection thus becomes essential to minimize the losses caused and to ensure that full benefit is drawn from other production inputs. Unfortunately, pest control operations may very often break off the above mentioned agroecosystem balance, giving rise to unsustainable olive farming.

The phytophagous invertebrates species, mainly insects and mites, known to feed and/or develop on the olive tree exceed one hundred, with a rather large group of them being composed of polyphagous or oligophagous species, each having many to a few host plants, respectively, in addition to olive. Some of them have evolved populations or strains adapted to olive so that in those areas olive is preferred to other hosts. A second, smaller group is composed of monophagous or oligophagous species closely associated with the olive tree, and with a few other Oleaceae of the Mediterranean Basin. The species from the first group are usually occasional pests whereas species from the second group that have either evolved on *Olea europaea*, or have populations that in recent times have adapted to olive, may cause economic losses comprising the smooth running of the crop and posing a serious risk for the annual yield. Table 7 gives most of the species from the second group and few from the first one. Most of the thousands of publications on olive insects around the Mediterranean basin concern fewer than a dozen species which are major pests, at least in those countries where olive growing is a key crop. Among them are the key pests, the olive fly *Bactrocera oleae* (Diptera: Tephritidae), the olive moth *Prays oleae* (Lepidoptera: Yponomeutidae), the black scale *Saissetia oleae* (Homoptera: Coccidae), and some secondary but sometimes also key pest such the oleander scale *Aspidiotus nerii* (Homoptera: Diaspididae), the two olive scolytids *Hylesinus oleiperda* and *Phloeotribus scarabaeoides* (Coleoptera: Scolytidae) and the olive pyralid moth *Euzophera pinguis* (Lepidoptera; Pyralidae).

Table 7. List of the most important phytophagous insect and mite species infesting olive tree

Order/ Subclass	Parts of the tree attacked				
	Roots	Stem and branches	Shoots	Inflorescences	Fruit
Hemiptera (Heteroptera - Homoptera)		*Stictocephala bisonia Kopp & Yonke* *Hysteropterum grylloides* (F.) *Saissetia oleae* (Olivier) *Hysteropterum grylloides* (F.) *Cicada barbara* Stalf. *Lepidosaphes ulmi* L. *Parlatoria oleae* Colvée	*Aleurolobus olivinus* Silvestri *Saissetia oleae* (Olivier) *Euphyllura olivina* (Costa) *Parlatoria oleae* Colvée *Cicada barbara* Stalf. *Aspidiotus nerii* Bouche	*Calocoris trivialis* Costa *Euphyllura olivina* (Costa)	*Parlatoria oleae* Colvée *Aspidiotus nerii* Bouche
Thysanoptera			*Liothrips oleae* (Costa)	*Liothrips oleae* (Costa)	
Coleoptera	*Vesperus xatarti* Mulsant *Anoxia villosa* F. *Melolonta papposa* Illiger *Ceramida cobosi* (Báguena)	*Phloeotribus scarabaeoides* (Bernard) *Hylesinus oleiperda* F. *Leperesinus varius F.= L. fraxini* Panzer *Sinoxylon sexdentatum* Olivier	*Otiorrhynchus cribricollis* (Gyllenhall)	*Anoxia villosa* F. *Rhinchites cribipennis* (Desbr.)	
Lepidoptera		*Euzophera pinguis* Haworth *Cossus cossus* L. *Zeuzera pyrina* L.	*Prays oleae* (Bernard) *Margaronia unionalis* (Huebner)	*Prays oleae* (Bernard)	*Prays oleae* Bern.
Diptera		*Resseliella oleisuga* (Targioni-Tozzetti)	*Dasineura oleae* (F. Loew)		*Bactrocera oleae* (Rossi)
Acarina			*Aceria (Eriophyes) oleae* Nalepa		

Olive pathogens also exceed one hundred, although only a few of them cause serious economical losses on olive groves. The main olive diseases described around the world and their relative importance in the Mediterranean basin are given in Table 8. One important group is the complex of fungal leaf and fruit diseases, mainly scab or peacock spot caused by *Fusicladium oleagineum*, anthracnose due to *Colletotrichum* spp. and cercosporiose due to *Pseudocercospora cladosporioides*. These three diseases cause heavy defoliation and weakening of olive trees, reduce plant productivity and quality of olive oil, and are responsible for regular fungicide treatments in the olive groves. Another important disease is *Verticillium* wilt caused by the vascular fungus *Verticillium dahliae*. This disease was unknown 30 years ago, and currently is considered the most serious disease and the main challenge for olive growing in some Mediterranean regions, such as in southern Spain. Other diseases having a moderate impact on olive groves in the Mediterranean basin are tuberculosis or olive knot caused by the bacterium *Pseudomonas savastanoi* pv. *savastanoi*, which is associated with wounds on leaves and branches, and a root and crown rot caused by several species of the oomycete genus *Phytophthora*, especially prevalent in water-logged soils (Trapero and Blanco, 2010).

These olive pests and diseases represent a clear restriction on olive oil production due to the reduction in yields and to the increase in total production costs. It is estimated that losses associated with the action of olive pests and diseases account for approximately 30% of the olive production, with 10% being allocated to the two major insect pests, *B. oleae* and *P. oleae*, and more than other 10% due to three diseases, peacock spot, *Verticillium* wilt and anthracnose. Accordingly to the International Olive Oil Council, approximately 30% of the olives produced in the Mediterranean region are lost to pests and diseases, with an annual control of pests and diseases of olive exceeding 200 million euro, 50% of which are for insecticides and fungicides, regardless of the cost of the side effects that these entail. Therefore, given the economic and social importance of this crop, olive-growing and olive protection practices should be carried out timely and under the criteria that encourage sustainability in agriculture.

Table 8. Major olive tree diseases

Disease	**Pathogen**	**Importance[1]**
FUNGAL AERIAL DISEASES		
Peacock spot	*Fusicladium oleagineum* (=*Cycloconium oleaginum, =Spilocaea oleagina*)	H
Anthracnose	*Colletotrichum acutatum* *C. gloeosporioides (=Gloeosporium olivarum)*	M
Cercosporiose	*Pseudocercospora cladosporioides* (=*Cercospora cladosporioides*)	M-L
Sooty molds	*Capnodium elaeophilum* *Botryosphaeria dothidea* *(= Camarosporium dalmaticum)*	L
Dalmatian disease	*Phlyctema vagabunda* *(=Gloeosporium olivae)*	L
Leprosy	*Alternaria, Aspergillus, Cladosporium, Diplodia*	L
Other fruit rots	*Geotrichum, Fusarium, Phomopsis,* etc.	W
Other leaf diseases	*Leveillula, Phyllactinia, Stictis panizzei,* etc.	W
Cankers	*Neofusicoccum mediterraneum* *Eutypa lata, Phoma incompta*	L
Wood decay	*Fomes, Fomitiporia, Phellinus* *Polyprous, Stereum,* etc	L
FUNGAL ROOT DISEASES		
Verticillium wilt	*Verticillium dahliae*	H
Woody root rots	*Armillaria mellea, Rosellinia necatrix* *Omphalotus olearius*	L
Fine root rots	*Phytophthora, Cylindrocarpon* *Fusarium, Pythium,* etc.	M-L
BACTERIAL DISEASES		
Tuberculosis or olive knot	*Pseudomonas savastanoi* pv. *savastanoi*	M
VIRUS AND PHYTOPLASMA DISEASES		
Foliar and fruit malformations	Unidentified virus and phytoplasma species	W
Latent infections, Yellowing	*Nepovirus, Cucumovirus*, *Oleavirus,* etc.	W
NEMATODE DISEASES		
Root knot, root lesion	*Meloidogyne, Pratylenchus,* etc.	W
PARASITIC PLANTS		
Mistletoes, Dodder	*Viscum, Cuscuta*	W
ABIOTIC		
Nutrient deficiencies	Boron, Iron, Potassium, etc.	M-L
Different damages	Frost, drought, soil water-logging, etc.	M-L

H = high; M = moderate; L = low; W = without general practical importance, although severe attacks have been observed occasionally.

One key issue in olive growing is the threat of new and/or emerging pests or pathogens which can potentially cause significant losses. The most predominant way is by invasion of alien species or pathogenic races which is usually related to human activities (i.e., trade) and/or natural migration, but in olive crops it is more commonly detected the emergence of new pests or pathogens due to the transformation of an indigenous species from an organism of minor significance to an important pest or disease. This could be related to various human activities affecting the established equilibrium in the olive agro-ecosystem, with emphasis in cultivation practices (high density plantations) or crop management practices (pruning, intensive application of insecticides, etc). Finally, it is not well known how the global warming could affect the incidence of the actual olive pest or pathogens and the emergence of new ones.

2. Olive growing and pest or pathogen incidence

In general, biodiversity tends to be high in traditionally managed olive plantations as their structural diversity (trees, under storey, patches of natural vegetation, dry-stone walls, etc.) provides a variety of habitats. The older trees support a high diversity and density of insects and microorganisms which, together with the tree's fruit, provide an abundant supply of food. The low level of pesticide use allows a rich flora and insect fauna to flourish which in turn provides a valuable food source for a variety of bird species. However, the intensive application of techniques for increasing production (especially frequent tillage and heavy herbicide and insecticide use) has a strongly detrimental effect on ground flora, microorganisms and on insect populations and results in a very considerable reduction in the diversity and total numbers of flora and fauna. Some of the agro-chemicals used in olive farming have been found to cause a dramatic reduction in a wide spectrum of insect species, including several which have a beneficial role in controlling pest species.

It is mandatory using **certified material** from officially licensed producers which is particularly important to avoid later problems associated with scales, mealybugs and other biting sucking insects. Certified material is crucial, not only with regards to the variety or quality of the plant, but also regarding its health. This is especially important in the case of pathogens that cause systemic infections (*V. dahliae*, viruses and phytoplasmas), as well as those remains associated to the plant material and cannot be easily detected, such as the epiphytic stage of *P. savastanoi*, the latent infections due to *F. oleagineum* and the infections caused by fungi or nematodes on roots. This is no rare that symptoms of some of these diseases appear months or years after planting the trees.

The incidence of **fertilization** on insect pests incidence is notorious in olive crops. It has been observed that excessive use of nitrogen fertilizer results in the emergence of many new shoots that facilitates a high percentage of neonate nymphs of *S. oleae* to find suitable settlement sites. Thus, regulation aims at reducing nitrogen fertilization as a measure to reduce the incidence *S. oleae*. Nonetheless, balanced mineral olive nutrition improves not only the nutritional status of the trees but also their defense mechanisms, avoiding those herbivores that develop easily on weakened trees such as *E. pinguis* or *H. oleiperda*. Likewise, it is accepted that the excess of nitrogen and the deficiency of potassium increases the susceptibility of olive trees to fungal foliar pathogens (mainly peacock spot) and verticillium wilt.

Irrigation may also exert influence both on olive vegetative state that promote the development of mites, scales and olive fly and on soil microclimate that may help *O. cribricollis* and white grubs incidence. With regard to diseases, irrigation increase activity of root pathogens (*V. dahliae*, *Phytophthora* spp., etc) causing more severe infections. Furthermore, irrigation water can contribute to pathogen dispersal. Both possibilities have been confirmed for the verticillium wilt of olive, so this disease is especially severe in irrigated olive groves.

Soil management system has been revealed to influence not only phytophagous populations and soil-borne pathogens but also the predator, parasitoids and antagonist ones. For this purpose, information of the effect of different olive soil management strategies such cover crops and organic amendments on pest and disease incidence and efficiency and abundance of natural enemies is scarce, although some well known effects of cover crops are the reduction of soil-borne inoculum of *V. dahliae* due to some crucifer species and the increase of leaf infection by *F. oleagineum* due to the higher humidity on the lower parts of tree canopy. Nonetheless, conservation of natural vegetation boundaries, hedges, isolated trees, edges, etc., is mandatory in the Spanish regulation.

Overall, conventional olive crop management has a negative impact on the abundance of canopy spiders and to a lesser extent on their diversity whereas they would benefit from an Integrated Pest Management (IPM) strategy. Likewise, cover crops also promote spider populations, whereas this effect is higher in the natural than in the planting ones. In general, plowing may help eliminating different stages of soil dwelling pests and reducing inoculum of pathogens that survive on fallen leaves, but also destroying nests of natural enemies that limits their beneficial action and favoring inoculum dispersal of some soil-borne pathogens such as *V. dahliae*.

Pruning is an agronomic practice with large impact on the incidence of pests and pathogens and even on their control. Its effect on phytophagous insects and aerial pathogens is due to the modification of the microclimate of the tree canopy and also to the reduction of inoculum after removing affected parts of olive tree. Favoring tree aeration through pruning reduces incidence of insects *S. oleae*, *P. oleae, L. ulmi* and the aerial pathogens *F. oleagineum*, *Colletotrichum*, *P. cladosporioides* and *P. savastanoi*. Besides, high pruning intensity may cause intense growth of tender shoots and finally promote olive scales activity. Avoiding pruning wounds will decrease the incidence of *E. pinguis* and wood decay fungi; for this purpose it is very important to protect wounds against pests and aerial pathogens.

Management of pruning remains is a far-reaching social practice that it is well regulated; they must be removed and destroyed prior to bark beetle emergence. Furthermore, control of the olive bark beetles *P. scarabaeoides* and *Hylesinus* spp and even the bark mosquito *R. oleisuga* can be accomplished by placing bait trunks that must be destroyed or treated with insecticides prior to adult emergence. Moreover, leaving water sprouts may prevent shoots against *O. cribicollis* attack as far as this species prefers the former.

Harvesting method and time may also influence the activity of certain insects and pathogens. It is known that wounds caused by beating promote *R. oleisuga, E. pinguis* and *P. savastanoi* activity. In general, it is recommended early harvesting to indirectly increase the olive oil quality by reducing olive fly activity and fruit rots caused by *Colletotrichum* spp. and other fruit rot fungi.

The **plantation density** of olive groves is determined by agronomic, climatic and economic criteria, but can have a great impact on the development of pests and diseases, especially in dense plantations, which favor shady areas between trees and therefore increase leaf wetness duration and infections by aerial pathogens (Trapero, 2007). Furthermore, in the current scenario of olive growing in Spain, one wonders whether considered secondary pests and diseases to conventional plantations, with occasional or local economic importance, may be become a problem in the new high density plantations. This kind of plantations possesses in most cases irrigation-related high soil humidity that might create a favorable environment to pests and pathogens due to high soil humidity and large fruits. Likewise, it has been demonstrated that irrespective of the 10 evaluated Spanish oil varieties, olive tree susceptibility to the olive fly *B. oleae* is higher under irrigated conditions that under rainfed conditions where the high relative humidity is favorable for its biology and the large olive fruits seems to be more attractive for oviposition (Santiago-Álvarez *et al.*, 2010). Besides, there are several reports on the need to perform control measures against new pests (i.e. *Margaronia unionalis*) and diseases (i.e. alternaria fruit rot) on such high density olive plantations (León *et al.*, 2007).

Pruning is a key operation in order to control the necessary tree vigor in such high density plantations, particularly in the hedgerow ones. Even if regular pruning following established codes of practice is performed, pruning wounds are targets for olive pyralid moth *E. pinguis* oviposition. Besides, this pyralid is becoming a serious pest of olive crops in Spain, Portugal, etc., and even in many areas it is becoming a key pest. Likewise, olive knot is becoming a key disease in the hedgerow systems that need to increase control measures due to increased wounds caused by harvesting and pruning.

Although there are more than 2000 olive tree varieties around the World, **genetic resistance** has not been used on purpose as a measure for the control of olive pests and diseases, because productivity and environmental adaptation criteria are taken into account when choosing a variety for planting. Now there is a great interest in the search for varieties better adapted for developing high density plantations. The most important criteria in the selections of the olive breeding programs to obtain new cultivars better adapted to such type of plantations are tree size and shape and resistance to *V. dahliae*. For this purpose, susceptibility of such new cultivars to key olive pests and diseases, such *B. oleae, F. oleagineum, Colletotrichum* spp. or *P. savastanoi*, should not be underestimated. Most olive high density plantations are based nowadays on the use of the available cultivars 'Arbequina' and 'Arbosana', followed by 'Koroneiki'. Providently, susceptibility of 'Arbequina', 'Arbosana' and 'Koroneiki' to olive fly attack is very low (Quesada-Moraga *et al.*, 2010). However, these cultivars are susceptible to the three pathogens above mentioned with the exception of 'Koroneiki' that is moderately resistant to *F. oleagineum* and *Colletotrichum* spp. Because of the relatively high soil moisture, low biodiversity and high productivity, high density olive plantations seem to be very prone to pests and diseases. For this purpose, it is essential to monitor many olive trees that are well distributed through the orchard and to follow the same inspection route throughout the season.

Choosing a tolerant cultivar makes integrated pest management easier and reduces production costs by reducing chemical inputs. On the other hand, a limited number of susceptible trees in the orchard could act as "traps" for monitoring or controlling pests. This practice, however, is not convenient for disease management because it increases inoculum of the pathogens in olive traps.

3. Sustainable olive pest control

Current olive pest and disease management strategies are still based on the use of chemical pesticides, either in traditional Mediterranean olive groves or intensively managed olive plantations. However, increasing public sensitivity towards environmental pollution in this key Mediterranean agro-system and problems derived from the side effects of these products has provided the impetus for the development of alternative, benign pesticides. Likewise, Regulation (EC) 848/2008 of the European Commission resulted in a drastic reduction in the number of authorized active ingredients for olive pest control and a more limited reduction in the authorized fungicides for disease control.

Further, the prevailing environmental awareness, and the high prevalence of Sustainable Agriculture as a guiding principle of EU agricultural policies has led to the European Parliament to the establishment of a framework for Community action to achieve a sustainable use of pesticides which under the shelter of the concept of Integrated Pest and Disease Management (IPDM or IPM), prioritize non-chemical methods of pest control. Accordingly, from January 1, 2014 in Europe will only accommodate the olive pest control according to the principles of IPM.

IPM strategy developed in the 1960s and 1970s is based on ecological principles. It encourages reduced reliance on pesticides through the use of a number of control strategies in a harmonious way to keep pests and diseases below the level causing economic injury. It came out of the realization that too heavy a reliance on pesticides (particularly those with broad-spectrum activity) can cause major problems, notably effects on human health and safety, environmental contamination, pesticide resistance in target and non-target organisms, resurgence of secondary pests, plant damage or yield loss (phytotoxicity), residues on fruit and products, with national and international consequences. There is also general community concern about the use of pesticides, particularly on foods.

IPM commonly utilizes or encourages biological control through natural enemies such as predators, parasites, insect pathogens and non-pathogenic antagonistic or competitive microorganisms. It also frequently involves cultural control strategies to minimize pest and disease entry and their spread in space and time. Cultural controls include protocols of entry to farms; manipulation of the field environment to discourage pests and diseases, such as opening crop canopies to increase air movement and reduce humidity; the elimination of alternative hosts for pests; or growing nectar and pollen-producing plants to encourage natural enemies. IPM may also involve the physical destruction of infested and infected materials and the use of tolerant or resistant plant species, where available. Chemical pesticides are used judiciously, and thus play a supportive role.

The major components of IPM systems are: (i) identification of pests, diseases and natural enemies; (ii) monitoring of pests, diseases, damage and natural enemies; (iii) selection of one or more management options on the basis of monitoring results and action thresholds, from a wide range of pesticide and non-pesticide options; and (iv) use of selective pesticides targeted at the pest or disease for instance, pesticides that will interfere least with natural enemies, targeted only at infested trees or parts of trees.

As an example, the Agricultural Entomology group of the University of Cordoba, Spain, has studied the susceptibility of 20 Spanish olive oil cultivars to the olive fly *B. oleae* under rainfed and irrigated conditions. We have found highly significant differences among oil and table varieties in their susceptibility to olive fly attack, with the most susceptible oil varieties being 'Nevadillo Blanco de Jaén', followed by either 'Picudo' and 'Lechin de Sevilla' and the least ones 'Arbequina' followed by 'Empeltre', while the most susceptible table varieties were ‘Ascolana Tenera’ and ‘Gordal Sevillana’ and the least ones ‘Callosina’ and ‘Kalamón‘. On the overall, for each cultivar, susceptibility to *B. oleae* was higher under irrigated conditions than under rainfed ones.

Currently, bioinsecticides are considered the most viable alternative for olive pest control. Nonetheless, not all entomopathogenic microorganisms invade susceptible hosts in the same way. While viruses, bacteria, and protozoa have to be ingested with food, entomopathogenic fungi (EF) enter via the exoskeleton, a mode of action by contact which makes them an attractive alternative to chemicals for the biological control of several olive pests. Besides, EF have a dual role as bioinsecticides as they may used both as microbial control agents and also as an unexplored source of new insecticide molecules of natural origin. Our work has revealed the elevated occurrence of the mitosporic ascomycetes *Beauveria bassiana* and *Metarhizium anisopliae* in the soil of olive crops but also in the olive and olive weeds phylloplane. Besides, it has been found *B. bassiana* as a natural biocontrol agent of the olive moth *Prays oleae* and the olive pyralid moth, *Euzophera pinguis*. It has been shown that these native isolates are in general well matched to the particular olive crop environmental conditions. Among them, there are several isolates that show potential to be used against medfly both in adult sprays and in soil treatments beneath the tree canopy for puparia control, and even one *B. bassiana* isolate obtained from an infected larva of *E. pinguis* with high biocontrol potential against this pyralid in stem and branch (pruning bounds) (Spanish Patent P201030539) (Quesada-Moraga and Santiago-Álvarez, 2008).

The demand for natural insecticidal compounds to be incorporated in pest control programs in IPM grows each day as they degrade more quickly and possess excellent ecotoxicological profile. Example of this is inclusion of spinosad, secondary metabolite produced from the fermentation of the actinomycete soil *Saccharopolyspora spinosa* in the regulation of organic farming. Among the microorganisms, entomopathogenic fungi which share the same ecological niche that phytophagous insects, fulfill all criteria of the "intelligent screening" in the search for new insecticidal compounds of natural origin. Secondary metabolites and macromolecules secreted in vitro by several *M. anisopliae* isolates from our strain collection have shown high insecticidal activity against adult tephritids that may be developed as new insecticide molecules of natural origin for medfly control (Quesada-Moraga and Santiago-Álvarez, 2008).

With regard to olive diseases, a big piece of research has been developed in the Department of Agronomy at the University of Córdoba during the last 20 years (Trapero and Blanco, 2010). Results have characterized the epidemics of main diseases, including the complex of fungal aerial diseases (peacock spot, anthracnose and cercosporiose), *Verticillium* wilt, phytophthora root rot and olive knot, as well as the epidemics of new diseases such as alternaria and botryosphaeria fruit rots and a branch canker caused by *Neofusicoccum mediterraneum*. This information together with results of research on different control methods (physical, cultural, biological, genetic resistance and chemical) are serving to define integrated control programs for each disease and implement a comprehensive strategy for integrated management of pests and diseases in commercial groves.

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Pedo-environmental determination of olive oil quality. A case study

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Abstract. This paper reports the preliminary results of a study regarding the influence of different pedo-environments of the Benevento province on the composition of olive oil from the 'Ortice' cultivar and the specific relationships among individual soil properties and olive oil compounds. Multivariate statistical analyses (Principal Component Analysis, PCA and Partial Least Squares Regression PLSR) were used for the investigation. Results from PCA showed a clear tendency of olive oil samples from the different pedo-environment to cluster, although the distance among clusters was not relevant. Results from PLSR showed some interesting relationships among several soil properties and olive oil compounds. These relationships were relevant when PLSR was applied separately to samples from individual pedo-environments, while it was less relevant when applied to the data set as a whole. Further investigations will enlarge the data set, also including other cultivars.

Keywords. Olive oil composition – Pedo-environment – Benevento province – CISIA project.

Détermination pédo-environnementale de la qualité de l'huile d'olive. Un cas d'étude

Résumé. *Cet article présente les résultats préliminaires d'une étude de l'influence des différents pédo-environnements de la province de Benevento sur la composition de l'huile d'olive de la variété 'Ortice' et les relations spécifiques entre les propriétés des sols et les composés individuels de l'huile d'olive. L'analyse statistique multivariée (Analyse en Composantes Principales, ACP et régression PLS, PLSR) a été utilisée pour l'enquête. Les résultats de l'ACP montraient une nette tendance de cluster pour les échantillons d'huile d'olive provenant des différents pédo-environnements, bien que la distance entre les clusters n'était pas pertinente. Les résultats de la PLSR ont montré certaines relations intéressantes entre les propriétés du sol et plusieurs composés de l'huile d'olive. Ces relations sont pertinentes lorsque la PLSR est appliquée séparément à des échantillons des différents pédo-environnements, mais elles sont moins importantes lorsqu'elle est appliquée aux données dans leur ensemble. D'autres enquêtes, déjà en cours, sont nécessaires pour évaluer plus en détail la détermination pédo-environnemental sur la composition de l'huile d'olive du cultivar 'Ortice' et d'autres cultivars importants de la province de Benevento.*

Mots-clés. *Composition de l'huile d'olive – Pédo-environnement – Province de Benevento – Projet CISIA.*

I – Introduction

It is well known that the quality of any agricultural product results from the combined effects of a number of factors, such as genetic, anthropogenic and physical-environmental. While the former factors widely vary, and can be modified too, the physical-environmental ones are substantially stable and poorly adjustable, so that they represent the crucial features, determining the specific characteristics and distinctiveness of crops.

It has long been agreed that soil and underlying geology, landform and climate are the main environmental factors governing the characteristics of agricultural production. All these factors establish the modern concept of agricultural "zonation". Such concept has largely and particularly been used in viticulture while it has so far been little applied to olive growing, despite the acknowledged influence of the nature and properties of soils, relief and climate on the physiology, growth and productivity of olive (Gucci, 2003; Rotundo *et al*., 2003; Saavedra, 2007).

In Italy, studies on olive growing zonation in the province of Siena have successfully been made by Franchini e Cimato (2006). More recently (2011), a study on this topic was started in the province of Benevento. In this province, the lack of any objective knowledge regarding the influence of pedo-environmental features on the quality of olive oil has long been one of the main causes that hampered the recognition of the Protected Designation of Origin (PDO).

The present paper reports some relevant preliminary results of the first year activity of the above mentioned activities. Specifically, it focuses on the discriminating effect of different pedo-environments on the characteristics of olive oil from the cultivar 'Ortice', the most important in the Benevento province, along with the cultivars 'Racioppella' and 'Ortolana'. Moreover, it explores the influence of specific soil properties on the 'Ortice' olive oil compostion.

II – Material and methods

1. Study area

The study area encompasses the province of Benevento (Fig. 1) NE of Campania region (southern Italy). The climate shows typical characteristics of the sub-umid Mediterranean environment, with a mean annual rainfall of 722 mm and a daily mean temperature generally increasing from 10-12 °C in April to 24-25 °C at the end of July, and decreasing to 18-20 °C in September. The yearly mean reference evaporation is about 1240 mm and values increase from about 3 mm day^{-1} in April to about 8 mm day^{-1} in July, starting to decrease in August. Agricultural land use is dominated by cereal crops, vineyards, olive orchards and woodlands (Regione Campania, 2009). Olive orchards cover about 18.000 ha (*i.e.* 38% of the study area), distributed on different pedo-environments (Fig. 2) (Fusco *et al*., 2006).

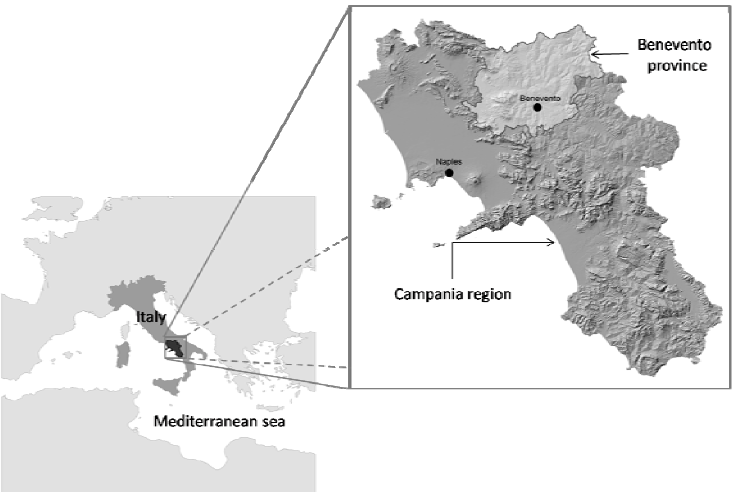


Fig. 1. Location of the study area (province of Benevento) within the regional (Campania), national (Italy) and Mediterranean context.

Fig. 2. Olive-growing area (in black) and limits of the landscape map units of the Benevento province over a Digital Elevation Models (DEM). Labels (S1 ÷ S27) refer to the landscape map units.

2. Olive and soil sampling and analyses

About 100 sampling sites were selected, in such a way to represent as much as possible the pedo-environments where the cultivar 'Ortice' is mostly cultivated (Fig. 3), namely: clay-marl and arenaceous-molasses deposits hills of Tammaro (S4), Fortore (S5) and Calore (S7); clay-marl hills of Titerno (S2); calcareous mountains of Taburno-Camposauro (S16); arenaceous-molasses deposits hills of Taburno-Camposauro (S1); clay-marl and calcareous hills of Calore (S13); alluvial plains (S19, S22, S24); sand-clayey hills of Benevento (S12). Soils associated with the above pedo-environmental units (di Gennaro, 2002) range from the weakly developed *Calcaric Regosols*, to the relatively better developed *Calcaric-Vertic* and *Calcaric Cambisols*, *Eutric* and *Calcic Vertisols*, to the well developed *Vitric* and *Molli-Vitric Andosols* and *Andic Luvisols*. Insights on the soil classification of olive orchards pedo-environments are in progress.

At each site, a sample of olive drupes was collected at the maturity stage of veraison, which varied largely from the beginning to the second decades of November forward, depending on the area microclimate. Drupes were frozen within a few hours after harvesting. Subsequently, they were carefully defrost, their pulp was separated from the core and gently minced for the extraction of oil. The latter was analyzed for the determination of total lipids, according to the method of Folch *et al*. (1957), fatty acids composition, by gas chromatography, polyphenols, according to Savarese *et al*. (2007), and antioxidant activity, according to Benzie and Strain (1996).

At each sampling site, a top-soil sample was also collected. Soil samples were air dried, grounded to pass a < 2 mm sieve, and then analysed in duplicate according to the Italian Official Methods for Soil Analysis (MIPAF, 2000). Samples were analysed for sand, silt and clay content, pH, electrical conductivity (EC), carbonates (as $CaCO_3$), organic carbon (OC), cation exchange capacity (CEC), exchangeable potassium (K^+), sodium (Na^+), calcium (Ca^{2+}), and magnesium (Mg^{2+}).

Fig. 3. Olive and soil sampling site (filled circles) and limits of the landscape map units of the Benevento province area over a Digital Elevation Models (DEM). Labels (S1 ÷ S27) refer to the landscape map units.

3. Statistical data analysis

Olive drupes and soil variables were described as minimum, maximum, mean and coefficient of variation % (CV). According to Ameyan (1984), a variable shows small, moderate, or large variability when CV is below 20%, between 20 and 50%, or above 50%, respectively. *Skewness* was then calculated as the cube root of the deviation from the mean.

Principal Component Analysis (PCA) (Webster and Oliver, 1990) was applied to explore the relationships among the olive oil samples from the different pedo-environments, in relation to the oil composition. Partial Least Squares Regression (PLSR) analysis (Tenenhaus, 1998) was used to explore relationships among the selected olive oil compounds and soil properties.

III – Results and discussion

Table 1 shows descriptive statistics for the selected olive oil characteristics. According to the current scientific literature (Poiana and Romeo, 2006; Rial and Falqué, 2003; Ünal and Nergiz, 2003; European Union Commission, 1991), all the compositional characteristics of the 'Ortice' olive oil samples fall within the range of reference values. The CV varied from low (pH, total lipids, palmitic, stearic, oleic, linoleic, α-linolenic acids and total polyphenols), to moderate (palmitoleic, arachidic, eicosenoic, behenic acids and antioxidant activity), to high (nervonic acid). Skewness exhibited always small values, thus indicating that the distribution of olive oil variables was close to the normal.

Table 2 shows the descriptive statistics for the selected soil properties. Looking at mean values, it is apparent that sand and silt were present in a comparable proportion (336.8 and 375.3 g kg^{-1}, respectively), while clay content was present in a slightly lower percentage (287,9 g kg^{-1}). As a consequence, the majority of soils under investigation was classified as clay loam and loam textured.

Table 1. Descriptive statistics of compositional characteristics of olive oil samples

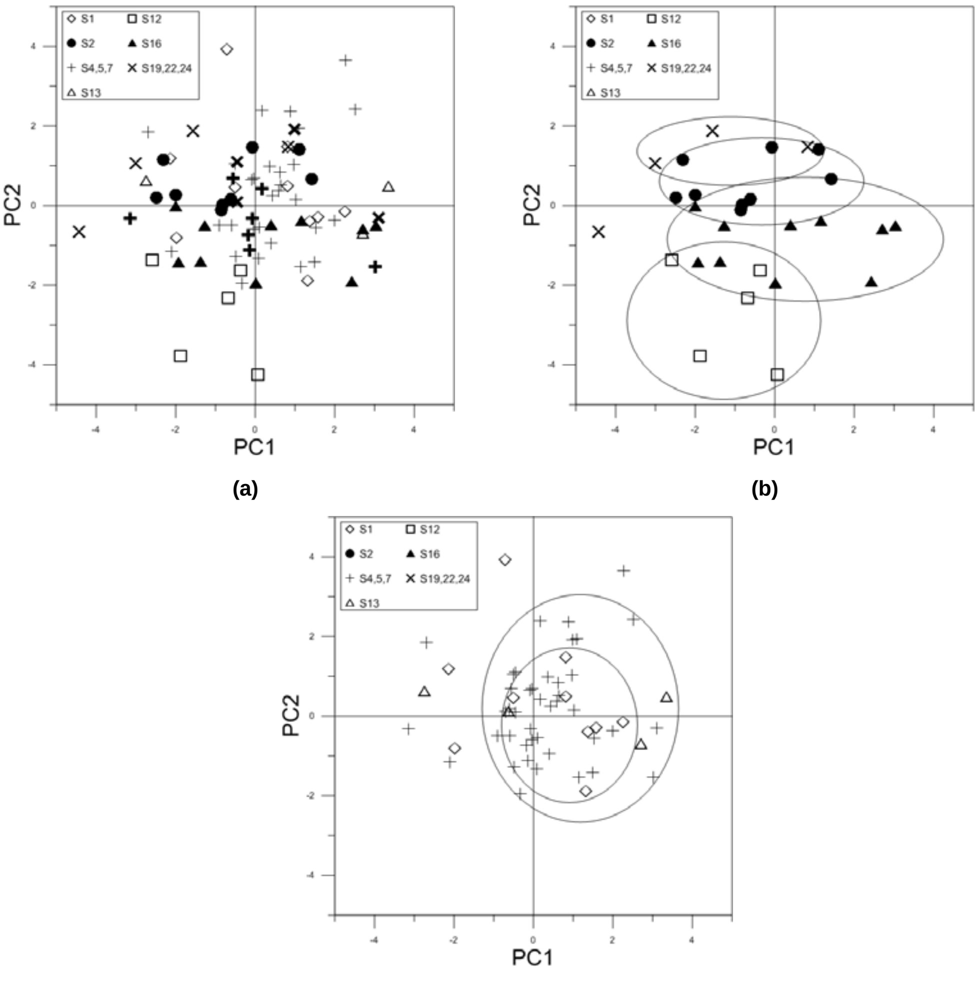
Variable	Min	Max	Mean	CV (%)	Skewness
pH	4.7	5.2	5.0	2.3	-0.3
Total lipids (g/100 g w.w.)	16.6	29.9	23.5	14.5	-0.3
Palmitic ac. C16:0 (%)	10.5	14.8	12.9	7.2	-0.3
Palmitoleic ac.C16:1 (%)	0.5	1.1	0.8	21.4	0.0
Stearic ac. C18:0 (%)	2.0	4.0	2.9	15.8	0.1
Oleic ac. C18:1 (%)	54.7	65.7	59.4	4.2	0.0
Linoleic ac. C18:2 (%)	9.3	12.6	10.8	6.9	0.0
α linolenic ac. C18:3 (%)	0.9	1.9	1.3	16.3	0.7
Arachidic ac. C20:0 (%)	0.1	0.4	0.3	29.1	-0.4
Eicosenoic ac. C20:1 (%)	0.0	0.3	0.1	36.8	-0.1
Behenic ac. C22:0 (%)	0.0	0.2	0.1	37.4	-0.1
Nervonic ac. C24:1 (%)	0.0	0.2	0.1	63.4	-0.6
Total Polyphenols (g GAE/100 w.w.)	0.3	1.7	1.0	18.9	-0.2
Antioxidant activity (mmol Fe(II) (kg w.w.)	27.5	146.8	89.0	23.7	0.1

Table 2. Descriptive statistics of soil samples

Variable	Min	Max	Mean	CV (%)	Skewness
pH	6.8	8.5	8.0	4.5	-1.4
EC (dS m^{-1})	0.3	2.5	0.5	53.8	5.5
P (mg kg^{-1})	3.1	358.3	43.8	140.5	3.2
Sand (g kg^{-1})	42.2	772.6	336.8	41.7	0.5
Silt (g kg^{-1})	130.7	621.8	375.3	23.3	0.1
Clay (g kg^{-1})	64.0	646.9	287.9	38.7	0.2
$CaCO_3$ (g kg^{-1})	14.0	681.0	155.6	80.1	1.5
OC (g kg^{-1})	5.6	51.8	17.0	40.9	1.6
CEC (cmol[+] kg^{-1})	10.9	42.7	24.9	28.5	0.3
Exch. Ca^{2+} (cmol[+] kg^{-1})	0.9	32.4	15.8	38.9	-0.3
Exch Mg^{2+} (cmol[+] kg^{-1})	0.3	4.9	1.9	48.6	1.1
Exch Na^{+} (cmol[+] kg^{-1})	2.3	11.6	3.0	40.3	5.4
Exch K^{+} (cmol[+] kg^{-1})	0.3	5.8	1.2	51.3	5.4

The OC content, averaging 17.0 g kg^{-1}, was moderately high. Soil reaction was on average slightly alkaline (pH = 8.0), ranging from pH = 6.8 to pH = 8.5. Mean value of cation exchange capacity (CEC) (24.9 cmol(+) kg^{-1}) was high. Mean value of $CaCO_3$ was very high (155.6 g kg^{-1}). According to carbonate content, exchangeable Ca^{2+} dominated the base exchangeable complex, showing a mean value (15.8 cmol(+) kg^{-1}) larger than Mg^{2+} (1.9 cmol(+) kg^{-1}), K^{+} (1.2 cmol(+) kg^{-1}), and Na^{+} (3.0 cmol(+) kg^{-1}). The EC was on average moderate, as 0.5 dS m^{-1}. The CV of the investigated soil properties varied mainly from moderate (sand, silt, clay, OC, CEC, and exchangeable Ca^{2+}, Mg^{2+} and Na^{+}) to high (EC, P, CaCO3, and exchangeable K^{+}). Only for pH the CV was low (4.5). Skewness exhibited relatively small values for sand, silt, clay, CEC, and exchangeable Ca^{2+}, thus indicating that also the distribution of such soil variables was close to the normal. Contrastingly, the skewness of the remaining soil variables exhibited larger values, thus denoting a significant deviation from the normal distribution, likely expressing a larger variability of factors depending on pedological features.

The results of PCA applied to olive oil characteristics revealed that the first two principal components account for more than half of the total variance in the original data set. Figure 4 reports the projection of the samples on the plane defined by the first two principal axes, providing substantial information on the relationships among the olive oil samples from the different pedo-environments.



(a) (b) (c)

Fig. 4. Scatterplot of the olive oil sampling sites projected on the plane of the first two Principal Components (PC): (a) all samples projected; (b) only samples from the S19,22,24, S2, S16 and S12 landscape units; (c) only samples from the S1, S4,5,7 and S13 landscape units. ***Legend: S19,22,24 = alluvial plains; S2 = clay-marl hills of Titerno; S16 = Calcareous mountains of Taburno-Camposauro; S12 = sand-clayey hills of Benevento; S1 = arenaceous-molasses deposits hills of Taburno-Camposauro; S4,5,7 = clay-marl and arenaceous-molasses deposits hills of Tammaro, Fortore and Calore; S13 = clay-marl and calcareous hills of Calore.***

Considering the distribution of all samples as a whole (Fig. 4.a), it would seem that there is no a relevant discrimination among samples from the different pedo-environments. However, if we split the samples into two clusters (Figs. 4.b and 4.c) in relation to their pedo-environmental origin, a trend of samples to group in relation to the specificity of pedo-environment appears.

In particular (Fig. 4.b), samples from the sand-clayey hills of Benevento, tend to cluster in the lower left quadrant, and are well separated from samples from the clay-marl hills of Titerno (S2) as well as from those coming from the alluvial plains (S19,22,24) (excluding the sample falling in the left size of the scatterplot, which should be considered as an outlier), which tend to cluster in the middle-upper part of the scatterplot. In turn samples from alluvial plains are well separated from those coming from the calcareous mountains of Taburno-Camposauro (S16). These latter, although evidently clustered in the middle-lower part of the scatterplot, partially overlap with samples from the S2 and S19,22,24 pedo-enviornment. It should be observed that the separation among the different clusters occurs mainly along the second PC axis. This axis is positively correlated (Fig. 5) with polyphenols and antioxidant activity and negatively with α-linolenic (C18:3) and palmitic (C16:0) acids, although the correlation with polyphenols and antioxidant activity is higher, in respect to that with α-linolenic and palmitic acids. In other words, all the above olive oil characteristics contribute to discriminate samples from the so-discussed pedo-environments. It should also be observed (Fig. 4.b) that samples from S19,22,24 are more or less equally distributed along the first and second principal axis. Contrastingly, samples from the remaining pedo-environments tend to be more distributed along the first principal axis which, in turn, is positively correlated (Fig. 5) with the palmitoleic (C16:1) acid and negatively with oleic acid (C18:1) and pH. Such a context, implies a quite relevant within-cluster variability of the above characteristics.

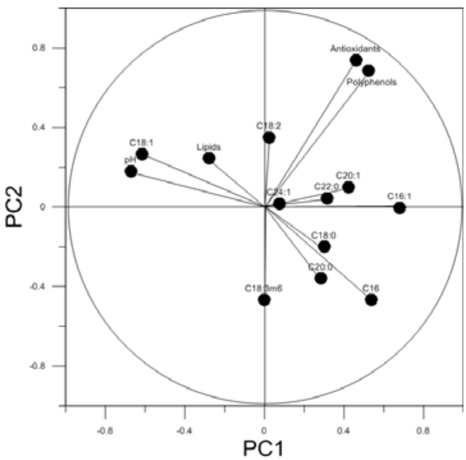


Fig. 5. Contribution of the olive oil components to the first two Principal Components.

Samples from the clay-marl and arenaceous-molasses deposits hills of Tammaro, Fortore and Calore (S4,5,7) (Fig. 4.c), excluding some outliers, tend to cluster mainly in the middle-right part of the PC1-PC2 scatterplot. Also samples from the arenaceous-molasses deposits hills of Taburno-Camposauro (S1) show a tendency to cluster, but within the previous cluster. Both clusters delimited in Fig. 4.c clearly overlap those previously delimited in Fig. 4.b. In other words, the composition of the 'Ortice' olive oil produced in the pedo-environments of the clay-marl and arenaceous-molasses deposits hills of Tammaro, Fortore and Calore and arenaceous-molasses deposits hills of Taburno-Camposauro, although relatively homogeneous, is not clearly distinguished from the composition of the 'Ortice' olive oil produced in the other pedo-environments (Fig. 4.b). Finally (Fig. 4.c) olive oil of samples from the clay-marl and calcareous hills of Calore (S16) shows no clear tendency to cluster. However, this statement must be made with caution, taking into account the small number of samples presently analysed.

Results of PLSR applied to olive oil and soil variables highlighted several significant relationships. In particular, we observed that the first two PLSR components explained together about 70% of the general variance on the initial data set. The first two components were then retained for further interpretation. This was done by plotting the correlation values among soil and olive variables on the factorial x,y planes defined by the first (t1) and second (t2) axes (Fig. 6.a).

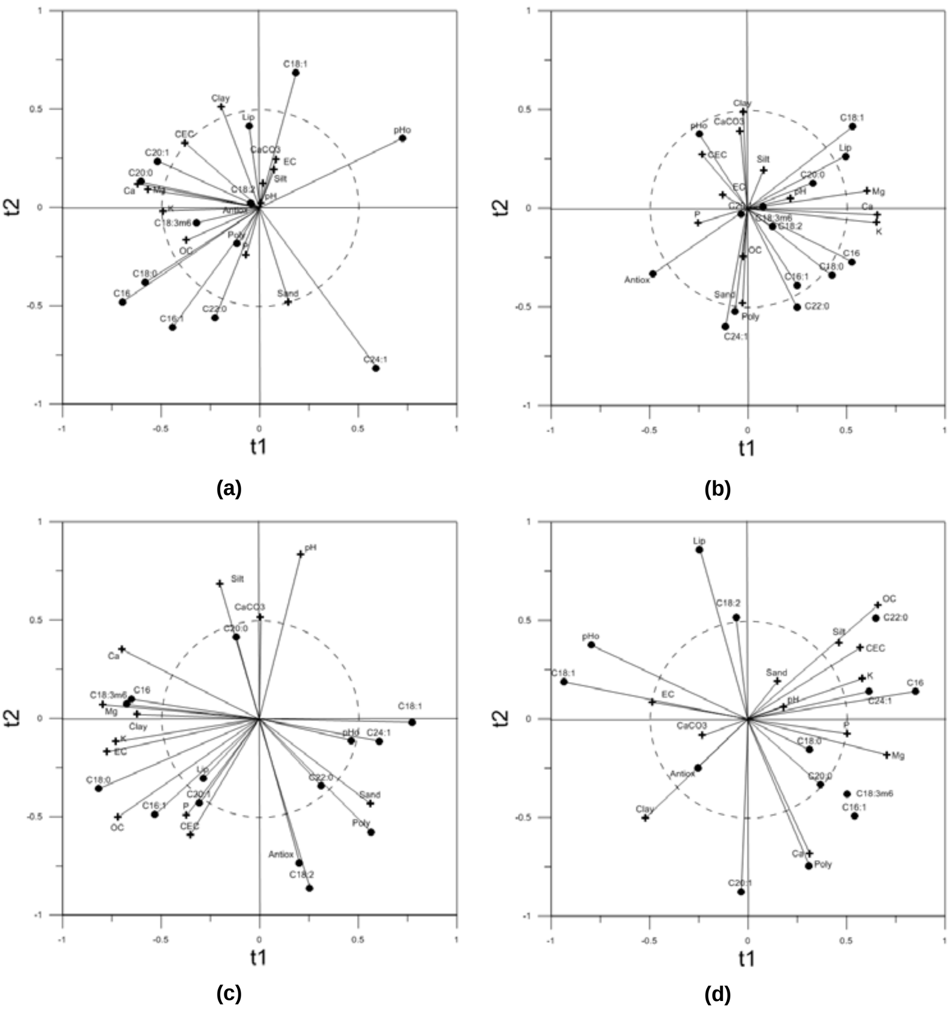


Fig. 6.1. Ordination of soil properties and olive oil components on the t1-t2 factorial plane resulting from the application of Partial Least Squares Regression (PLSR) analysis to: all olive oil and soil samples (a); only samples from landscape units S1 (b), S2 (c) and S3 (d). See captions to figure 4.

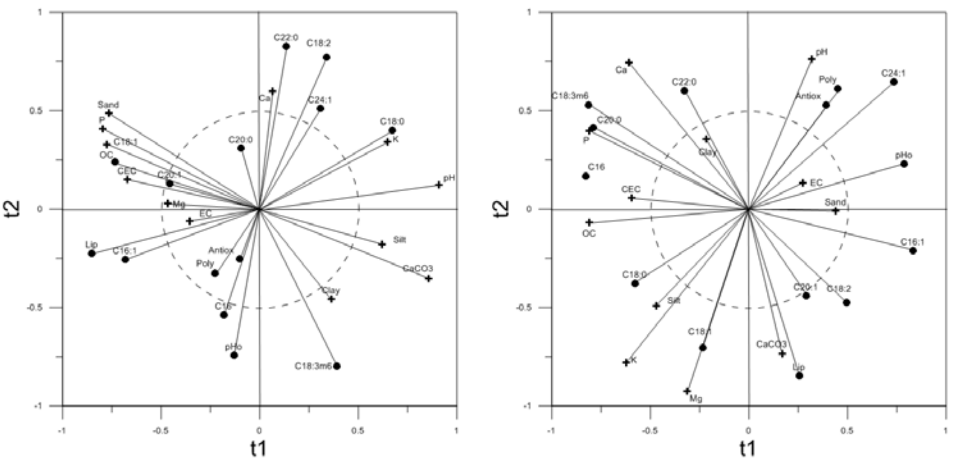
In the interpretation of the factorial plane, it was considered that when two variables are far from the centre, and concurrently close to each other, they are highly and positively correlated; if they are orthogonal, they are not correlated; if they are on the opposite side of the centre, they are highly and negatively correlated. When the variables are close to the centre, it means that some information is carried over on other axes, and that any interpretation might be hazardous. For the purposes of the present study only variables with a factorial value > 0.5 were considered for further interpretation.

The projection of soil and olive variables on the factorial plan defined by the first (t1) and second (t2) axes (Fig. 6.1.a) revealed that a certain number of variables are far from the centre and linked with either one or another of the axes.

In particular, the horizontal axis (t1) ordinates soil CEC, exchangeable Ca^{2+} and Mg^{2+} and olive oil variables C16:0 (palmitic acid) C18:0 (stearic acid), C20:0 (arachidic acid) C20:1 (eicosenoic acid) and pHo (= olive oil pH, to be distinguished by soil pH). This latter is negatively correlated with the remaining olive oil and soil variables. Furthermore CEC, exchangeable Ca^{2+} and Mg^{2+}, C20:0 (arachidic acid) and C20:1 (eicosenoic acid) tend to group together, thus denoting a high correlation each other, compared with the other variables linked to t1.

The vertical axis (t2) ordinates clay, C18:1 (oleic acid), C16:1 (palmitoleic acid), C22:0 (behenic acid) and C24:1 (nervonic acid). Both soil clay content and, particularly, C18:1 are positively correlated with the second axis, then between themselves, although the position of clay in not very far from the origin of axis. The remaining variables are negatively correlated with the second axis, then with clay and C18:1 (oleic acid).

It is interesting to note that, when PLSR is applied to the subset of data defined on the basis of their pedo-environmental origin (Figs. 6.1.b, c, d and 6.2.e, f), the general relationships among soil and olive oil variables tend to be more discriminating and significant. In other words, a better understanding of the influence of soil properties on olive oil composition can be achieved working within individual pedo-environments. Of course, the low number of cases (samples) available for certain pedo-environments can affect the results, although PLSR is a reliable multivariate technique also when the number of variables in low, in respect to the number of cases.



(e) (f)

Fig. 6.2. Ordination of soil properties and olive oil components on the t1-t2 factorial plane resulting from the application of Partial Least Squares Regression (PLSR) analysis to: only samples from the S19,22,24, S2, S16 and S12 landscape units (e); only samples from S4,5,7 and S13 landscape units (f). See captions to Fig. 4.

IV – Conclusions

The preliminary results of the present case study, based on a pedo-environmental approach and supported by multivariate statistical analysis, suggest that the combined geo-pedo-climatic features can affect the olive oil characteristics more than one can expect, beyond the well-known, relevant influence of genetic factors, as well as of production technologies. This is true at least for the investigated area, as Benevento province and for the cultivar 'Ortice'. Therefore, it is possible to assert that:

(i) Different 'Ortice' olive oils, in terms of composition –and then organoleptic features– can be produced in the different pedo-environments of the Benevento province; this aspect can be advantageously considered by producers, to characterise their olive oils on the basis of their pedo-environmental origin;

(ii) A general specificity of the 'Ortice' olive oil of the Benevento province exists, despite slight local (i.e., pedo-environmental) differences; this is important in view of the recognition of the Protected Designation of Origin (PDO).

It must be observed that the number of investigated sites, as well as of olive samples, used in this preliminary paper is still incomplete. A more detailed study will be carried out soon when the whole data set will be available. This will allow to better explore the pedo-environmetal specific relationships among soil and olive oil variables.

On the whole, our results are encouraging enough to delve further into the presented research, foreseeing the chance to widen up the set of data, considering also other relevant olive oils cultivars characterizing the province of Benevento, in addition to 'Ortice'.

Acknowledgments

The authors are grateful to the CISIA project of the Italian National Research Council for the financial support in this study. They wish to thanks Dr. Anna Di Cerbo (STAPA Ce.CEPICA, Regione Campania), Gen. Antonio De Blasio (Olivicola San Lupo), Mr. Antonio Parente (Olivicola del Titerno), Dr. Luigi Auriemma (Coldiretti, Benevento), Dr. Mauro Vella, Dr. Valentina Cusano, Dr. Luigi Martone, Mr. Giuseppe Di Carlo for their valuable contribution to the selection and location of sampling sites, their help in establishing contacts with olive growers and their direct support in the collection of soil and olive oil samples.

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Olive oil processing technologies and investments

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Abstract. The commercial quality of Extra virgin olive oil (EVOO) is defined by the European Legislation (EC 61/2011), International Olive Council (IOC) and the *Codex Alimentarius*; it includes parameters describing the alteration state and assures the oil genuineness, but does not take into account the markers related to the sensory and healthy quality of the product. These properties of EVOO are strongly related to the amount of monounsaturated fatty acids and phenolic compounds (which, in particular, act as natural antioxidants and may contribute to the prevention of several human diseases) and volatile compounds. The main antioxidants are the lipophilic and hydrophilic phenolic compounds. While lipophilic phenols can be found in vegetable oils from other species, the hydrophilic phenols, such as secoiridoids, are exclusive of oils from *Olea europaea*. Moreover, they give bittern and pungent EVOO sensory notes. The volatile compounds responsible for EVOO flavour are due to the lipoxygenase pathway (LOX) that catalyses the genesis of C_5 and C_6 saturated and unsaturated aldehydes, alcohols and esters. These compounds are correlated to the "cut grass" and "floral" sensory notes of EVOO. The concentration of fatty acids, phenols and volatile compounds is largely affected by agronomic factors and by oil extraction conditions during crushing, malaxation and EVOO separation. The malaxation conditions such as temperature and oxygen concentration of paste during process regulate the activities endogenous enzymes polyphenoloxidase (PPO), peroxidase (POD) and lipoxygenase (LOX), activated during crashing with a strong effect in the final concentration of hydrophilic phenols and volatile composition of EVOO. Moreover, new EVOO extraction technologies are also oriented towards the valorisation of their by-products.

Keywords. Extra virgin olive oil quality – Phenols – Volatile compounds – Technological conditions – Endogenous enzymes.

Processus technologiques et investissements pour l'huile d'olive

Résumé. *La qualité commerciale des huiles d'olive vierges extra (HOVE) est définie par la législation du secteur, elle inclut des paramètres décrivant l'état d'altération et assure de l'authenticité des huiles, mais ne prend pas en considération les marqueurs liés à la qualité sensorielle et salutaire du produit. Ces propriétés de l'HOVE sont liées à la quantité d'acides gras monoinsaturés, de composés phénoliques et de composés volatils. Les principaux antioxydants sont des composés phénoliques lipophiles et hydrophiles. Tandis que les phénols lipophiles peuvent être présents dans les huiles végétales, les phénols hydrophiles, tels que les sécoïridoïdes, dans l'HOVE sont exclusifs d'*Olea europaea*. En outre, ils donnent à l'HOVE des notes sensorielles amères et piquantes. Les composés volatils responsables de l'arôme de l'HOVE sont dus à la voie de la lipoxygénase (LOX) qui catalyse la genèse des aldéhydes, des alcools et des esters en* C_5 *et* C_6 *saturés et insaturés. Ces composés sont corrélés aux notes sensorielles d'"herbe coupée" et "florales" de l'HOVE. La concentration en acides gras, en phénols et en composés volatils est influencée par les facteurs agronomiques et par les conditions d'extraction de l'huile au cours du broyage, du malaxage et de la séparation de l'HOVE. Les conditions de malaxage telles que la température et la concentration en oxygène de la pâte pendant le processus peuvent réguler l'activité des enzymes endogènes polyphénoloxydase (PPO), peroxydase (POD) et lipoxygénase (LOX), avec un fort effet sur la concentration finale en phénols hydrophiles et la composition volatile de l'HOVE. En plus, les nouvelles technologies d'extraction de l'HOVE sont aussi orientées vers la valorisation de leurs sous-produits.*

Mots-clés. *Qualité des huiles d'olive vierges extra – Phénols – Composés volatils – Conditions technologiques – Enzymes endogènes.*

I – Introduction

The International Oil Council (IOC, 2010) and the European Community (EU Reg. 61/2011) establish the characteristics of different olive oils and define quality and authenticity criteria for a correct olive oil commercial classification. They have defined the marketable quality of virgin olive oil by dividing it into three different commercial categories [extra virgin (EVOO), virgin and lampante] on the basis of some analytical parameters evaluating the hydrolytic alteration (such as the free acidity) and the oxidation state [such as the peroxide value and the UV specific extinction coefficients (K232 and K270)]. On the other hand, in order to guarantee the genuineness of oil they take into account other analytical markers, such as waxes, sterols, aliphatic and triterpenic alcohols trans-isomers of fatty acids, fatty acids and triacylglycerols composition, stigmastadiens, etc. The sensory analysis integrates the analytical definition of the EVOO. This approach has been proposed by the International Olive Council (IOC, 1987) and accepted by the European Community (EC, 1989/2003). The first aim of this analysis is the control of the off-flavours' occurrence which are not admitted in the EVOO category. These sensory "defects" have been well defined by the International Olive Council (IOC) that also standardizes the procedure for the evaluation of the sensory *flavour* and *off-flavours* (IOC and Reg. EU 1989/03).

However, the current olive oil official regulations do not take into account analytical markers, like natural antioxidant compounds and monounsaturated oleic acid and squalene concentrations, for determining healthy and sensory properties of the EVOO although they are directly involved in conferring benefits to human health. In this respect, the current EVOO class does not mention any information concerning the above discussed parameters on the label and, therefore, it is not able to inform the consumer about the health properties of the product. In recent years, more and more attention has been given to a superior concept of EVOO quality that is based on the sensory, nutritional and healthy properties of this product. These aspects are due to its high content of monounsaturated oleic acid, squalene and natural antioxidant such as phenolic compounds, tocopherols and carotenoids (López-Miranda *et al.,* 2010; Bach-Faig *et al.,* 2011; Cicerale *et al.,* 2011), while the sensory properties (mainly aroma) of EVOO is the result of a complex mixture of volatile compounds, C_5 and C_6 saturated and unsaturated aldehydes, alcohols and esters responsible for some typical *flavour*, such as "cut grass", "haylike" and "floral", and also of hydrophilic phenols for bitter and pungent notes (Angerosa *et al.*, 2004; Servili *et al.*, 2004, 2009a). Moreover, these substances show a high antioxidant activity and play an important role in the prevention and/or reduction of chronic degenerative events based on inflammatory processes and chronic-degenerative diseases such as cardiovascular-cerebral diseases (EFSA, NDA, 2011) and cancer (Servili *et al.,* 2009a; Obied *et al.,* 2012).

The nutritional importance of EVOO is mainly attributed to its high content of monounsaturated fatty acids (oleic acid, in particular), but in the last decade it has been observed a significant variability in the EVOO oleic acid content, whose range traditionally was fixed between 54% and 82% of the overall fatty acids quantity. This strong variability is strictly related to the extensions of the olive growing in several new areas where the produced oils show a poor content of oleic acid, lower than 50%. It is a matter of fact that this aspect is in contrast with the health values of EVOO (Terés *et al*., 2008; Lopez-Huertas, 2010).

Moreover, the same variability has been assessed for EVOO tocopherols and hydophilic phenols. In particular, α-tocopherol is the main tocopherol evaluated and it shows a great variability in the EVOO marketable class. In fact, it has been found that its value ranged between 23 and 730 mg/kg on 430 analyzed samples. The same remarks can be made for hydrophilic phenols. The EVOO polyphenols represent a group of secondary plant metabolites not often present in other oils and fats. The hydrophilic phenols class is the most important one and includes phenolic alcohols and acids, flavonoids, lignans and secoiridoids (Servili *et al.,* 2004; Obied *et al.,* 2008): the latter, exclusively present in the Oleacease family plants of which the olive is the only edible fruit, are the most important fraction under a biological point of view.

Secoiridoids are in fact the most abundant polyphenols in EVOO. They are represented by the dialdehydic form of decarboxymethyl elenolic acid linked to 3,4-DHPEA or *p*-HPEA (3,4-DHPEA-EDA or *p*-HPEA-EDA), an isomer of oleuropein aglycone (3,4- DHPEA-EA) and the ligstroside aglycone (*p*-HPEA-EA) (De Marco *et al.,* 2007; Obied *et al.,* 2007, 2008; Servili *et al.*, 1999; 2004; 2009a). As discussed above with respect to the α-tocopherol, in EVOO the range of concentration variability of these compounds is very large. In fact, more than 500 EVOO samples were evaluated and the obtained results showed a variability between 50 and 900 mg/Kg. Therefore, it would be of fundamental importance to redefine the relationship between the EVOO marketable classification and its true quality.

The process innovation in the field of EVOO should follow a new approach towards the oil quality, which is strongly related to the content of phenolic and volatile compounds (which are the main responsible for the positive aroma). The qualitative and quantitative composition of both the volatile and the phenolic fractions is affected by several agronomic factors (such as cultivar, ripening stage, geographic and genetic origin of olive fruit, olive trees irrigation) as well as by technological aspects (Angerosa *et al.*, 2004; Servili *et al.,* 2004; 2009b; Inglese *et al*., 2011). In this respect, this new approach should take into account the effects of the temperature and of the oxygen control during the malaxation on phenolic and volatile compounds to improve the quality of the oil, thanks to the control on the enzymatic activities involved in the release and oxidation of phenols and in the biogenesis of flavor. In this context, the new challenge to the competiveness improvement of the virgin olive oil production has the following goals: (i) the optimization of the operative conditions to improve the virgin olive oil healthy and sensory properties; and (ii) the by-products' valorisation (stoned olive pomaces and vegetation waters).

II – EVOO mechanical extraction system and quality

The volatile and phenolic composition of virgin olive oil is strongly affected by agronomic factors (the genetic and geographical origin of the fruits) as well as by the enzymatic reactions such as polyphenoloxidase (PPO), peroxidase (POD) and lipoxygenase (LOX), occurring during the different phases of the mechanical extraction process of the oil (Di Giovacchino *et al.,* 1994; Caponio *et al.*, 1999; Servili *et al*., 2004). Some endogenous enzymes, crushing activated, play an important role to determine the amount of phenolic and volatile compounds in EVOO. After crushing, all endogenous enzymes are still active. The PPO and POD, catalyzing the oxidation of phenols, reduce their concentration in pastes and oils, and LOX, through a cascade pathway, produce of the C_5 and C_6 saturated and unsaturated aldehydes, alcohols and esters responsible for aromatic notes of "cut grass" and "floral" oils virgin olive oil.

The crushing method has a clear influence on the phenol concentration and volatile composition of EVOO. In fact, the phenolic compounds are most concentrated in the pulp, while little amounts of these substances are content in stone and seed (Servili *et al.*, 1999). The use of a hammer with a differentiated effect on the constitutive parts of the drupes, such as blade crusher, teeth crusher, pre-crusher or stoning crushing, reduces the seed tissues degradation, limiting the release of POD in the pastes, improves the concentration hydrophilic phenols in the EVOO preventing their oxidation during malaxation (Fig. 1) (Servili *et al*., 2007a). Moreover, the crushing system also affect the volatile composition of EVOO. The use of a hammer mill crusher as well as other crushers which determine a more violent grinding of pulp tissues, causes an increase of the olive paste temperature and a reduction of HPL activity (Servili *et al.*, 2002; Angerosa *et al.*, 2004). The olive stoning during EVOO mechanical extraction process increases the phenolic concentration in EVOO (Angerosa *et al.,* 1999; Lavelli and Bondesan, 2005; Mulinacci *et al*., 2005; Amirante *et al.*, 2006; Servili *et al.,* 2007a) and, at the same time, modifies the composition of volatile compounds produced by the LOX pathway, increasing the concentration of those volatile substances correlated to the "green" sensory notes (Angerosa, 2004; Servili *et al.,* 2007a).

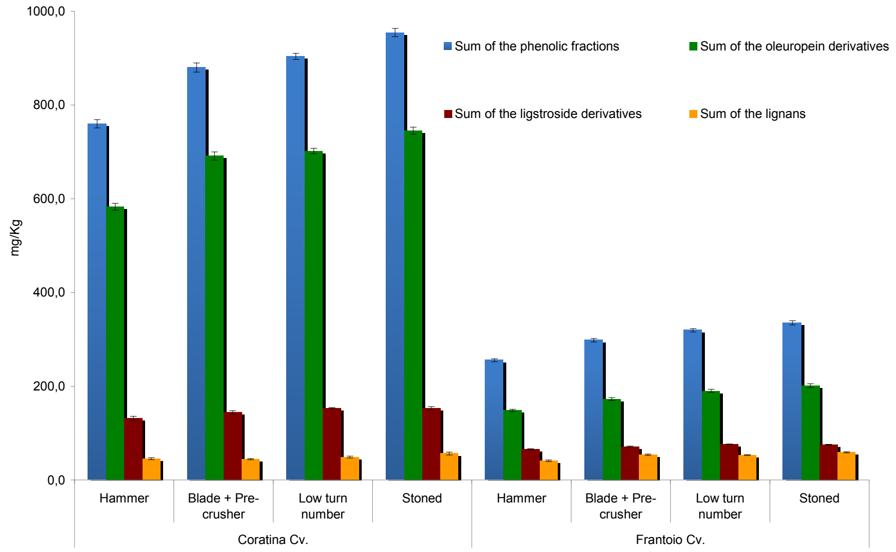

Fig. 1. Phenolic composition (mg/kg) of EVOOs (*Coratina* and *Frantoio* Cvs.) obtained by different crushing methods. Results are mean value of three indipendent determinations ± standard deviation (Servili *et al.*, 2007a).

The aim of the malaxation is to break up of oil/water emulsion and to assure the aggregation of the dispersed oil droplets in the paste to facilitate the subsequent process of the oil separation. In recent years the role of the operative conditions applied during malaxation that largely affect EVOO quality has been deeply investigated. In fact, the concentrations of the phenolic and volatile compounds are strongly related to the management of three main operating variables: temperature, time and availability of oxygen in the malaxer head-space. During the malaxation the LOX activity, representing the basis for the oil flavour production, should be supported; on the contrary the activities degrading phenolic compounds, of which the PPO and POD are responsible, should be inhibited. At this regards the decrease of O_2 inhibits the POD and PPO activities, increasing the amount of hydrophilic phenols in the olive pastes and in the corresponding EVOOs (Fig. 2). Furthermore the natural release of CO_2 due to the olive cell metabolism during malaxation, reduces the O_2 contact with the paste in this phase (Parenti *et al*., 2006 a; 2006b; Servili *et al*., 2008a).

The influence of the malaxation temperature on the concentration of phenolic compounds in EVOO has recently been the object of new investigations (Boselli *et al*., 2009; Gómez-Rico *et al*., 2009). The relationships between temperature and phenolic concentration are also affect by the low amount of O_2 occurring in the covered malaxer. Low O_2 concentration in the malaxed pastes inhibits phenolic oxidative degradation performed by PPO and POD activity and the temperature increase improves the phenolic solubility in the EVOO (Servili *et al*., 2008a; 2008b; Taticchi *et al.*, 2013).

In a recent work the effect of temperature and oxygen level during malaxation on the pastes and the related EVOOs extracted from four Italian cultivars was evaluate. The results showed that the occurrence of phenols in the pastes and the oils is strongly dependent from the temperature of malaxation. All oils from the analyzed *cvs*. are showing direct dependence between temperature and increase of phenolic concentration during malaxation with the highest value at 35°C. The amount of secoiridoids expressed as the sum of the phenolic fractions and oleuropein and ligstroside derivatives is increased increasing the temperature of the process, differently the concentration of lignans does not show any influence by the temperature (Fig. 3).

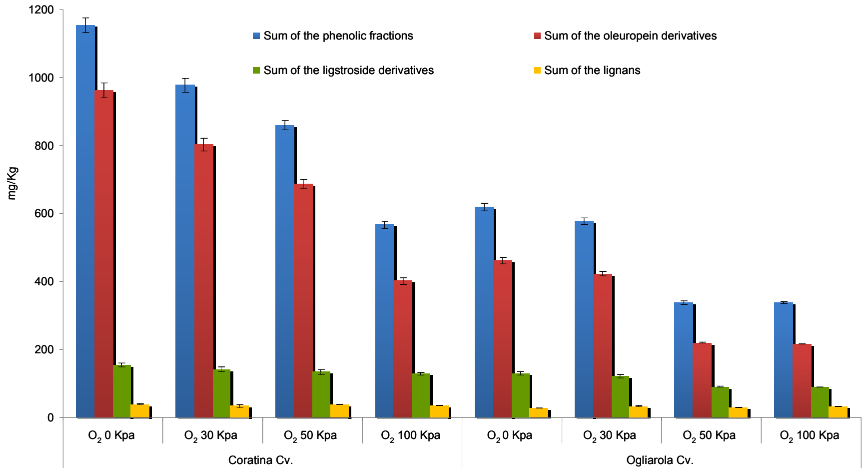

Fig. 2. **Phenolic composition expressed as sum of HPLC phenolic fractions of the EVOOs (*Coratina* and *Ogliarola* Cvs.) malaxed at different O_2 concentrations. The data are the mean values of two independent experiments analysed in duplicate (Servili *et al*., 2008a).**

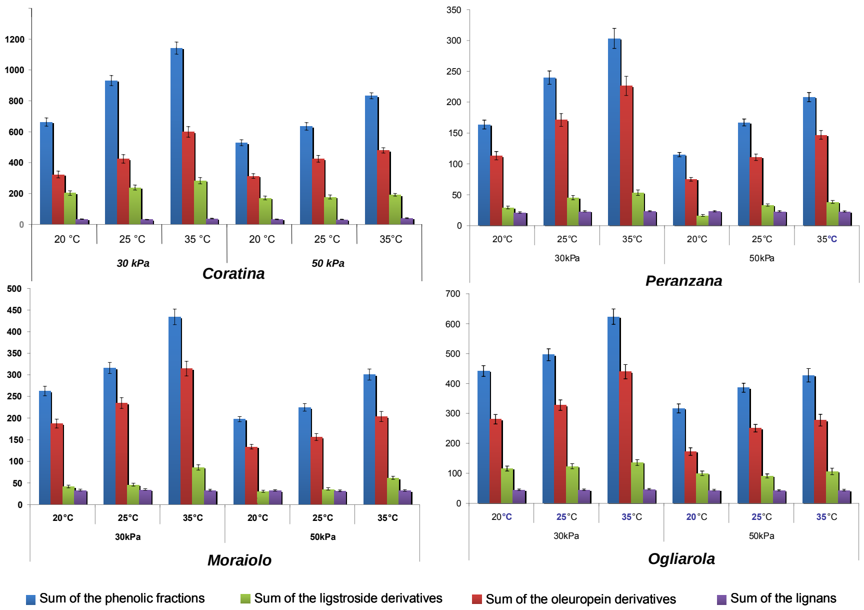

Fig. 3. **Phenolic composition (mg/kg) of EVOOs obtained malaxing at different temperatures and O_2 levels. The data are the mean values of two independent experiments analysed in duplicate (Taticchi *et al*., 2013).**

In addition the increase of the phenolic concentration due to the temperature is significantly related to the cv within a variability range of 85%-41% and the higher values are for the *Peranzana* and *Coratina* cvs at working temperature from 20°C to 35°C. The same Figures 2-3 show that, at constant temperature of the process, the oils of all cultivars malaxed with 50 kPa of O_2 are characterized by a phenolic concentration lower than the sample extract with 30 kPa of O_2 in the headspace of the kneader. This data confirms that the oxygen actively participates in the decrease of the phenolic concentration, above atmospheric values (30 kPa), increasing the processes of oxidative degradation. The data indicate the oxygen is actively involved in the reduction of the phenolic concentration above atmospheric values (30 kPa) increasing oxidative process degradation (Servili *et al*., 2008a).

The temperature of the process seems to have a fundamental role in the regulation of the oxidative activities on phenolic compounds catalyzed by oxidoreductases (POD, PPO) (Fig. 4). In particular the low thermal stability observed for PPO at temperature higher than 35°C seems to be responsible of the increased amount of phenolic compounds due to its partial inactivation during the malaxation process (Fig. 5) (Taticchi *et al*., 2013).

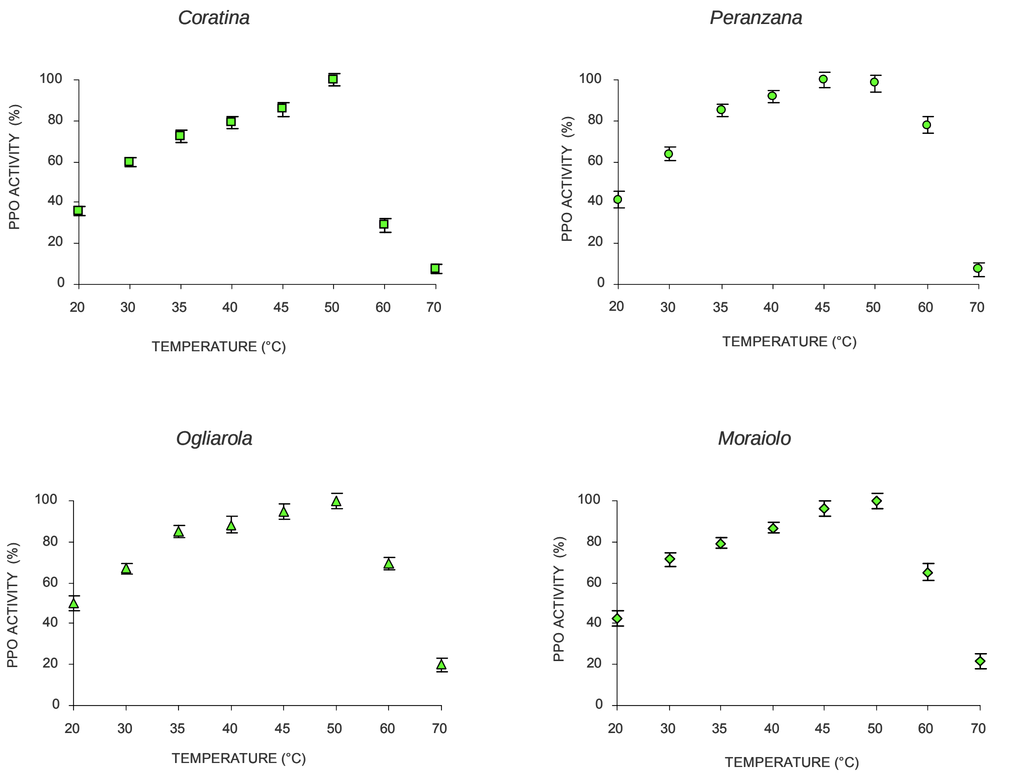

Fig. 4. Activity of the olive Polyphenoloxidase (PPO) at different temperatures. Data are the mean values of two independent experiments analysed in duplicate (Taticchi *et al*., 2013).

Furthermore volatile compounds in oils (Table 1) show significant quantitative differences according to the temperature of the malaxation and also to the *cvs*. Thus as regard to the aldehydes the highest concentration occurs at 25°C, with more significant differences for the *Coratina* and *Ogliarola* compared to the *Peranzana* and *Moraiolo*. As regard to the alcohols of the cvs *Moraiolo* and *Coratina* a trend of increasing concentration as a function of temperature increase was observed, while for *Peranzana* and *Ogliarola* significant variations were showed. The concentration of esters seems to be more influenced by the processing temperature: the minor amounts are observed in all cases at 35°C while the effect of the malaxation temperature of 20°C or 25°C is variable, since not a constant trend for the different cultivars of olives has been observed.

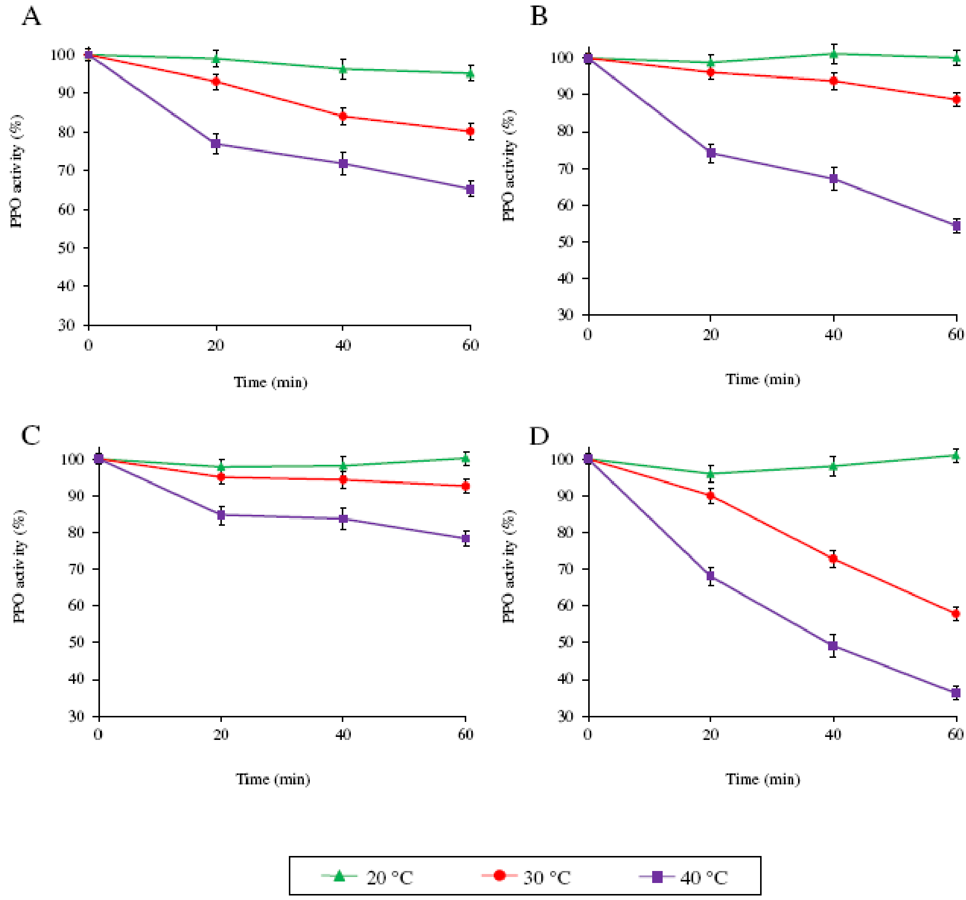

Fig. 5. Thermal stability after different times of incubation of PPO from olives studied at 20°C, 30°C and 40 °C on 4-methyl-catechol in different olive cultivars. A: *Moraiolo* cv.; B: *Coratina* cv.; C: *Peranzana* cv.; D: *Ogliarola* cv. The data are the mean values of two independent experiments analysed in duplicate (Taticchi *et al*., 2013).

Extraction system, pressure and centrifugation play an important role particularly in the phenolic composition of oil. In fact in the traditional centrifugation system, a large amount of water was added, before centrifugation, to reduce viscosity of pastes and improve oil yield. The water addition however, strongly reduce the phenolic concentration of oil and consequently modify its sensory and nutritional characteristics. In the last twenty years an evolution of this extraction system was performed to obtain a reduction of water addition during oil extraction. Due to this aspect the centrifuges can be classified in three groups: (a) the traditional tree phase centrifuges characterized by a water addition between 0.5 and 1 m^3 per ton; (b) the new tree phases centrifuges maximum level of water addition 0.2 and 1 m^3 per ton; and (c) two phases centrifuges that can work without water addition and did not produce vegetation waters as by-product of oil extraction process.

The oils extracted using the new systems showed a high phenolic concentration in comparison to that of the traditional centrifugation process because they reduced the loss of the hydrophilic phenols in the vegetation waters. In conclusion, the reduction of water addition before centrifugation and the temperature control during malaxation are the most important critical points of the oil extraction technology that strongly affect the EVOO quality. In addition the use of two phases centrifuges produced only pomaces, as secondary product, that can be used to produce organic compost. The organic compost may be important to improve fertility of soils particularly in warm area that are very common.

Table 1. Volatile composition (µg/kg) of EVOOs obtained by malaxing at different temperatures (Servili *et al*., 2008a). Aldehydes (Pentanal, Exanal, (E) 2-Pentenal, (E) 2-Exanal); Alcohols (1-Penten-3-ol, 1-Pentanol, (E) 2-Penten-1-ol, (Z) 2-Penten-1-ol, 1-Hexanol, (E) 3-Hexen-1-ol, (Z) 3-Hexen-1-ol, (E) 2-Exen-ol); Ester (Hexyl acetate, 3-Hexenyl acetate)

	20°C	25°C	35°C
		Moraiolo	
Aldehydes	11961.0 ± 694.4	17074.5 ± 995.0	16592.0 ± 972.4
Alcohols	1516.5 ± 43.3	1935.9 ± 61.9	2484.2 ± 88.9
Esters	128.0 ± 7.3	77.5 ± 4.4	24.0 ± 1.2
		Peranzana	
Aldehydes	19084.4 ± 1090.3	23408.0 ± 1330.7	18417.3 ± 1057.7
Alcohols	2398.7 ± 86.6	2462.2 ± 76.9	1911.0 ± 62.1
Esters	1247.7 ± 68.0	1198.0 ± 56.9	1316.2 ± 70.0
		Coratina	
Aldehydes	20139.0 ± 1184.2	34303.6 ± 2020.0	25678.4 ± 1509.5
Alcohols	1853.0 ± 72.5	3078.1 ± 122.0	4199.1 ± 169.3
Esters	75.5 ± 3.3	12.3 ± 0.5	0.0 ± 0.0
		Ogliarola	
Aldehydes	30713.0 ± 1807.1	38362.2 ± 2255.8	31144.7 ± 1825.7
Alcohols	3741.2 ± 154.8	3565.5 ± 130.9	3677.2 ± 145.9
Esters	29.5 ± 1.3	51.4 ± 2.3	9.8 ± 0.6

The volatile content is the mean value of three independent experiments ± standard deviation.

III – New approach to use of the EVOO by-products

The disposal of the by-products such as pomaces and olive vegetation waters (OVW) is considered an additional cost in the EVOO extraction process. The new approach to the EVOO processing should be oriented also towards the valorization of those wastes to improve the process profitability. The potential innovative use of EVOO by-products is related to their richness in hydrophilic phenols. The concentration of those compounds is largely affected by agronomic and technological conditions of VOO production. After the crushing and malaxation only a low portion of phenols, ranging between 1% and 3% of the overall phenolic concentration of olive fruit is released in the EVOO, while a larger amount occurs in the pomaces and OVW (Servili *et al.*, 1999; 2004; 2007a; 2007b; 2011a). The three phases extraction system, the most diffused in Italy, requires a dilution of the malaxed pastes with water (0.2 to 0.5 m^3/t of olives) producing 50-90 L of OVW/100 kg of olive pastes and 50-60 kg of olive pomaces/100 kg of olive pastes. The two phases system is at present largely used in Spain and it is characterized by a strong reduction of water consumption during the extraction process producing 70 kg of olive pomaces/100 kg of olive pastes.

The traditional destination of the pomaces is the extraction by organic solvents of residual oil to obtain crude pomaces oil. Some interesting opportunities for the pomaces valorization include the use as combustible to produce thermal energy from a renewable source, the compost production and the use as supplement in the animal feeding (Pauselli *et al*., 2007; Servili *et al*., 2007a).

The OVW valorization can be dependent from the recovery of the bioactive phenols contained in high amount in this by-product. The OVW consists of an emulsion composed by water, oil, mucillage and pectins and characterized by 3-16% of organic substances containing 1-8% of sugars, 1,2-2.4% of nitrogen compounds and 0.34-1.13% of phenolic compounds (Naionakis and Halvadakis, 2004). The secoiridoids such as 3,4-DHPEA-EDA and verbascoside are the most abundant compounds in OVW (Servili *et al*., 2004). The pollution potential of OVW strictly dependent by the polyphenols' content and expressed as biochemical demand of oxygen (BOD_5) ranges from 35 to 110 g/L, while the chemical demand of oxygen (COD) ranges from 40 to 196 g/L (Niaonakis and Halvadakis, 2004); therefore the recover of the large amount of OVW phenols seems an interesting way to give an added value to a product that represents a disposing cost for the olive oil industries (Roig *et al*., 2006). At this regard several approaches have been already developed (Turano *et al.,* 2002; kujawski *et al*., 2004; Agalias *et al*., 2007; Paraskeva *et* al., 2007; Roig *et al.*, 2006; Russo, 2007; Khoufi *et al*., 2008; Gortzi *et al*., 2008) although there are different constrains to utilize the proposed processes on a plant scale, because of their complexity that requires a OVW pre-treatment as well as their high costs of treatment and plant installation. As shown in Fig. 6 recently a membrane filtration system has been applied in an industrial scale plant to obtain a crude phenolic concentrate (CPC) from an OVW after a pre-treatment with a depolymerising enzymatic pool (Servili *et al*., 2011a). This process permits an OVW volume reduction ranged between 75 and 80% and a wide decrease of the original OVW pollution load (more than 95%). The obtained CPC has a concentration in polyphenols four times greater than that of the initial OVW content, among which the 3,4-DHPEA-EDA and the verbascoside are those present in higher concentrations, although the 3,4-DHPEA-EDA content is strongly conditioned by the OVW prolonged storage time because of its hydrolysis (Servili *et al.*, 2011a).

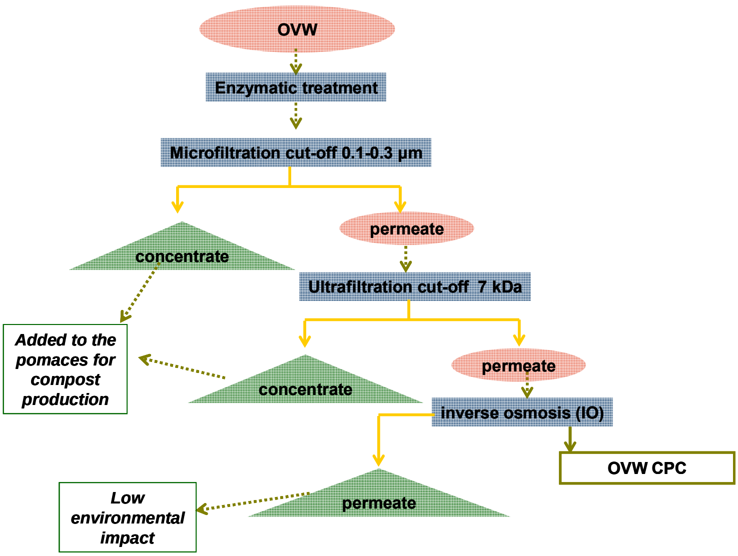

Fig. 6. Flow-chart of CPC production by OVW membrane treatment. Legend: OVW = olive-vegetation water, CPC = crude phenolic concentrate. (Servili *et al*., 2011a).

According to Servili *et al*. (2011a) the phenolic concentrate shows numerous potential uses that include the recycle in the oil mechanical extraction process to obtain EVOO enriched with hydrophilic phenols. Further application of the CPC can for the production of functional foods, enriched with bioactive phenols characterized by the same biological activities observed for the EVOO hydrophilic phenols (Servili *et al.*, 2011b).

To the secoiridoids a high antimicrobial activity is also recognized, especially against pathogenic species (Cicerale *et al*., 2011; Obied *et al*., 2012). These substances, represent an opportunity as alternative or complementary to the conventional additives for food with stabilizing, antioxidant and antimicrobial activities.

Acknowledgements

The authors wish to thank the Consorzio Olivicolo Italiano UNAPROL – Italy (Projects Reg. EC Nos. 2080/2005 and 867/2008) for the financial support.

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Table olive processing technologies

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Abstract. Olive is one of the most important agricultural products of the countries in the Mediterranean basin. Olive and olive oil play a leading role in the Mediterranean diet, being one of the best and healthiest dietary habits. Olives are processed either as table olives or used for olive oil extraction. Though the processing methods of table olives vary according to the variety, ripeness and consumer habits, they can be classified under three main headlines: (1) Treated green olives (Spanish style green olives); (2) Olives darkened by oxidation (ripe olives); and (3) Natural black olives. Turkey, playing an important role in world table olive production, processes 70% of its production for olive oil production while leaving the rest 30% for table olive processing. 85% of the olives are processed as black table olives and the rest, 15%, is processed as green table olives. Turkish consumer preferences are still in favor of natural green and black olives.

Keywords. Table olive – Production technologies – Treated olives – Natural olives – Turkish table olives.

Technologies de transformation des olives de table

Résumé. *Les olives sont l'un des produits agricoles les plus importants des pays du bassin méditerranéen. Les olives et l'huile d'olive jouent un rôle déterminant dans la Diète Méditerranéenne, car étant l'une des habitudes alimentaires les meilleures et les plus favorables à la santé. Les olives sont soit élaborées sous forme d'olives de table ou utilisées pour l'extraction d'huile d'olive. Bien que les méthodes de traitement des olives de table varient en fonction de la variété, de la maturité et des habitudes des consommateurs, on peut les classifier en trois grands groupes : (1) Olives vertes traitées (olives vertes à l'espagnole) ; (2) Olives noircies par oxydation (olives mûres) ; et (3) Olives noires naturelles. La Turquie, qui joue un rôle important en matière de production mondiale d'olives de table, transforme 70% de sa production en huile d'olive tandis que les 30% restants sont préparés comme olives de table. 85% des olives sont sous forme d'olives de table noires et les 15% restants sont préparés comme olives de table vertes. Les préférences des consommateurs turcs sont encore en faveur des olives et noires vertes naturelles.*

Mots-clés. *Olives de table – Technologies de production – Olives traitées – Olives naturelles – Olives de table turques.*

I – Introduction

Olive tree, the symbol of Mediterranean civilization, has set the foundations of all the civilizations existing in the region, for ages. It is assumed that olive growing dates back to early human and therefore it is said that "olive tree is the first of all trees" and thus claimed to be the tree of "life".

Olive is one of the most important agricultural products of the countries in the Mediterranean basin. With an approximate tree population of 900 million, 90% being in the Mediterranean countries, olive is grown in 35 countries, on 10.6 million hectares in the world.

Olive, is an important product with the vitamins, minerals and protein as well as the oil content. Olive and olive oil has a leading role in Mediterranean diet, being one of the best and healthiest dietary habits. Olive is processed as either table olives or used for olive oil extraction.

Table olive production portrays an increase throughout the world. According to the data provided by IOC; world's leading table olive producers are Spain, Egypt, Turkey, Argentina and Syria. Table 1 indicates the table olive production data for the countries in last 5 years (IOC, 2012).

Table 1. Table Olive Production (1.000 t)

Production	07/08	08/09	09/10	10/11	11/12
Spain	553.3	485.7	492.6	597.7	482.1
Egypt	432.0	440.0	409.0	200.0	500.0
Turkey	200.0	300.0	390.0	330.0	450.0
Argentina	100.0	95.0	220.0	250.0	200.0
Syria	100.0	120.0	135.0	142.0	165.0
Algeria	91.0	98.0	136.0	128.0	133.0
Greece	95.0	105.0	107.0	135.0	110.0
Morocco	100.0	100.0	90.0	110.0	100.0
World	2151.5	2082.5	2369.0	2440.0	2565.0

Table olive is predominantly consumed by the producer countries with varying consumption habits on country basis. Countries like Turkey, Morocco and Greece generally consume olive for breakfast or before/after meals, Spain, Italy, USA tend to consume as appetizers (Tunalıoglu, 2003). Important countries in terms of table olive consumption are Egypt, Turkey, Spain, USA and Italy. Table 2 indicates the table olive consumption data for countries in the last 5 years (IOC, 2012). Besides, France, Russia, Brazil are also important countries in table olive consumption.

Table 2. Table Olive Consumption (1.000 t)

Consumption	07/08	08/09	09/10	10/11	11/12
Egypt	350.0	360.0	340.0	200.0	300.0
Turkey	190.0	240.0	260.0	260.0	290.0
U.S.A.	240.5	210.0	203.0	240.0	240.0
Spain	183.6	147.7	107.9	150.0	200.0
Italy	122.0	138.5	122.4	125.0	125.0
Algeria	86.0	97.5	134.0	129.0	137.0
Syria	94.0	94.0	116.0	119.0	125.0
World	2130.5	2110.0	2199.0	2205.0	2387.5

II – Olive varieties

Main varieties of olives in the producer countries are listed as below (COI, 2000):

- Spain: Gordal, Manzanilla, Hojiblanca, Cacerena, Verdial, Picual, Lechin, etc.
- Greece: Conservolea, Kalamon, Chalkidiki, Megaritiki, etc.
- Morocco: Picholine Marocaine
- Algeria: Sigoise, Sevillana
- Argentina: Aracuo

- Syria: Jlot, Kaissy, Sourani, etc.

- Egypt: Aggezi Shami, Hamed, Toffahi

- Turkey: main varieties of table olives (Canozer, 1970):

  Gemlik: Widely in Marmara Region, though cultivated in many more regions recently. Approximately 25 % oil content. Mostly processed as black table olives.

  Edremit: Northern Aegean origin. Approximately 24% oil content. Processed as green-pink-black. Widely used for scratched olive production. One of the most important varieties for olive oil.

  Memecik: Cultivated in Aydın, Muğla area. Oil content is approximately around 22%. Processed as pink-green-black table olives or olive oil.

  Domat: Grown in Akhisar and Aydın region. Most important table olive variety. A fleshy variety, mainly processed as green table olives or stuffed.

  Yamalak: Widely cultivated in Aydın region. Mainly processed as spanish style green olives.

  Uslu: Widespread in Akhisar region. Processed as black table olives.

III – Table olive processing

According to International Olive Council' Standard; the term "table olive" means the product prepared from the sound fruits of varieties of the cultivated olive tree that are chosen for their production of olives whose volume, shape, flesh-to-stone ratio, fine flesh, taste, firmness and ease of detachment from the stone make them particularly suitable for processing; treated or remove its bitterness and preserved by natural fermentation, or by heat treatment with or without the addition of preservatives; packed with or without covering liquid (IOC, 2004).

Table olives are classified according to the degree of ripeness of the fresh fruits (green olives, olives turning colour and black olives), trade preparations (treated olives, natural olives, dehydrated and/or shrivelled olives, olives darkened by oxidation, specialities), and styles (whole, pitted, stuffed, salad and other styles).

Harvested olives cannot be consumed directly, because of the oleuropein substance causing a natural bitterness. The olives are fermentated, through different processing methods considering the ripeness, and thus become ready for consumption.

The processing methods of table olives vary according to the variety, ripeness and consumer habits. We can mention about 3 main trade preparations: (1) Treated green olives (Spanish style green olives); (2) Olives darkened by oxidation (ripe olives); and (3) Natural black olives.

1. Treated green olives

This type of production is called "Spanish style". The basis of this production style is to treat the olive with a lactic acid fermentation in brine after removing the bitterness of the olive through an lye treatment. Production stages are shown in Fig. 1 below.

Green olives are harvested when they reach their maximum size and proper ripeness degree (green to yellow). Harvesting time is vitally important in terms of the product quality. Late harvest may end up in olive's either becoming too soft yet early harvest remaining too hard which will cause problems in fermentation stage. To avoid avoid damaging the fruit, olives are picked by hand. Because of the high costs of harvesting by hand, this process is also done mechanically.

After the harvesting, the olives are immediately transported, in perforated plastic containers, to the plant to be size-graded and sorted. Size-grading is exceptionally important for the olives to be treated with lye. Treating with lye is an important stage in Spanish style olive processing. Olives, after classification and calibration are transferred to processing tanks for lye treatment. The alkali process is to remove the natural bitterness deriving from oleuropein.

Olive

⇩

Harvesting & Transportation

⇩

Clasification (size grading)

⇩

Lye treatment

⇩

Washing

⇩

Brining & Fermentation

⇩

Clasification

⇩

Pittings & Stuffing

⇩

Packing

Fig. 1. Treated green olive production.

Oleuropein hydrolysis is maintained through keeping the olives in 1.5-4.5% (w/v) NaOH solution at 15-25ºC and thus the natural bitterness is eliminated. While the concentration of NaOH shows variation according to the variety and the environmental temperature; lye treatment period changes between 6 to 11 hours depending on various factors like the variety, the temperature and the concentration of NaOH.

Lye treatment parameters in the Gordal de Sevilla, being one of the most important Spanish varieties, is 9-11 hours in 2% (w/v) NaOH solution at 25ºC and it is 6-7 hours for Manzanilla de Sevilla variety at 20ºC, in 2.5% (w/v) NaOH solution. (Rejano and Garrido, 2004).

To complete the alkaline treatment, samples are taken at certain times, from the tanks to see the amount of penetration. Lye should penetrate into the flesh to a depth of 2/3 for Spanish style processing. After this treatment, draining the solution, olives are washed with water, 4 times, to eliminate the alkali.

After this process, the olives are transferred to fermentation tanks to be brined.(appx. 10%). The alkali treatment increases the skin permeability thus resulting in the fermentable compounds' easy flow into the brine. This is important to speed up the fermentation. During the fermentation process, sugars in the olives are converted to lactic acid. The fermentation in olive is a lactic acid fermentation.

While at the first stages of the fermentation, as the gram-negative bacteria are dominant in the brine, the increasing acidity and salt results the elimination of them, leading to the growth of lactic acid bacteria population. For a good fermentation process, controlled microbial population temperature, pH, acidity level, flesh of the olive and salt concentration are vitally important. Fermentation ends in 1-2 months. The final product has an acidity of 0.7-1% (lactic acid) with pH 3.8-4 and 5-6% salt concentration. When the fermentation has finished, olives are sorted/graded and packed as whole, pitted, or stuffed, finally becoming ready for the market.

2. Olives darkened by oxidation

The optimum harvesting time of the olives to be processed with this method is when the colour turns to pink from green. Yet, the olives can be picked when they are green and processed, too. The olives, size-graded and sorted, are transferred to tanks to be kept in brine (4-6% salt concentration) till further processing (Fig. 2).

Salt concentration may be increased to 8-9% depending on the varying the climatic conditions and condition of the olive. To avoid the unwanted microbial activity in brine, 1.5-3.0%. acetic acid concentration is added. To prevent the deterioration of the texture $CaCl_2$ (0.1-0.3%) is added (Brenes *et al*., 1994).

Olive

⇩

Harvesting & Transportation

⇩

Clasification (size grading)

⇩

Preservation in brine

⇩

Clasification (size grading)

⇩

Lye treatment & Air oxidation

⇩

Washing

⇩

Colour fixation

⇩

Pittings & Stuffing

⇩

Caning &Sterilization

Fig. 2. Treated black olive production.

This processing type requires the highest technologies and the production is done in horizontal, cylindrical, steel, polyester or fiber glass tanks. Here, the important thing is the functionality of the tank, rather than the shape, allowing the equal amount of lye exposure and aeration. The tank should be designed to be equally and efficiently aerated (Aktan and Kalkan, 1999). In the production stage, olives in the brine are transferred to oxidation tanks. Oxidation is a process to remove the natural bitterness of the olive and to darken the colour through lye treatment, CO_2 and air.

The number of lye treatments is generally between 2 and 5. Penetration into the skin is obtained at the first stage and at the final stage, the treatment reaches the stone. The number of the treatment depends on depends on the ripeness and the variety of the fruit, as well as the environmental temperature. After lye treatment, the olives are washed. During both lye treatment and washing, air-bubbling is used to attain oxidation.

At the last stage of oxidation process, to preserve the black color obtained, ferrous-gluconate is added to the oxidation tank and thus colour fixation is maintained. After the color fixation, the olives are ready for packing. Olives are packed in brine (ferrous-gluconate and 2-4% salt concentration) and sterilized. The pH of the fruit's flesh is around 7. In case of lowering the pH below 4.6, through adding acid into the brine, pasteurization alone is enough.

3. Natural black olives

It is the traditional Turkish and/or Greek style olive processing method. The olives are placed into brine with a high salt content. The fermentation process takes longer time as the olives have not been treated previously with NaOH and thus, oleuropein is removed slowly. Figure 3 portrays the production stages.

Olive

⇩

Harvesting & Transportation

⇩

Clasification (size grading)

⇩

Brining & Fermentation (aeration)

⇩

Clasification

⇩

Packing

Fig. 3. Natural black olive production.

Olives are harvested when the flesh of the fruit turns purple 2 mm deep to the stone. The harvesting time is vitally important. The desired fruit colour may not be obtained at an early harvest, yet a late harvest may result in the olive's becoming too soft. The olives harvested are immediately transported to the plant in perforated plastic containers, to be size-graded and sorted. They are placed into the brine (8-10% salt concentration) for fermentation. The fermentation period takes around 8-12 months (Sánchez *et al.*, 2006).

Fermentation process may take place under aerobic or anaerobic conditions. As the salt concentration will decrease during the fermentation process, the brine should be controlled and salt should be added. Yeasts are the dominant microorganisms in the fermentation, yet an increase in the population of gram-negative bacteria and lactic acid bacteria can also be observed.

During the fermentation of the olives in anaerobic conditions, microorganisms may increase the CO_2 in the environment, causing "gas-pocket" (fish eye) spoilage. Therefore, it is important to place air columns in the fermenters to obtain air-bubbling and thus get rid of the CO_2 in the environment (Sánchez *et al.,* 2006). Besides, aeration can reduce the fermentation period to 4-5 months. Following the fermentation process, the olives are packed and are ready for consumption.

IV – Table olive production in Turkey

Turkey, playing an important role in world table olive production, processes 70% of its production for olive oil production while leaving the rest 30% for table olive processing. 85% of the olives are processed as black table olives and the rest 15% is processed as green table olives. Table olives are a culturally important part of Turkish style breakfast. Despite the increase in the production of Spanish style green and olives darkened by oxidation. Turkish consumer preferences are still in favor of natural green and black olives.

1. Natural black olive production

Olives, harvested when the flesh of the fruit turns purple 2 mm deep to the stone, are transferred to the processing facility. After size-grading and sorting, the olives are widely put in concrete pools or polyethylene, polyester or fiberglass tanks. Certain amount of pressure -20-25% of the original weight of the olives- is applied on the olives and they are put in brine. The goal of this application is to attain the shape that is called "yanaklı" which is specially preferred by the consumer.

Brine salt concentration is around 10-12% and this ration can be around 14-15% at times. The high salt content may slow down the fermentation process and it may take 6 to 10 months. During the fermentation, circulating the brine, salt and pH controls are done. The bitterness does not disappear completely from final product and residual reducing sugars may also remain at a high level after fermentation period which may cause secondary fermentation during the preservation of the olives. After fermentation, the olives are packed, with or without brine, for the market, according to the preference.

The olives produced by traditional methods are consumed locally or exported to ethnic markets because of high salt concentration. The disadvantages of this production method are the stock cost due to the long fermentation period, the loss of weight around 20% and the lack of exportability except ethnic markets (Fındık, 2011).

The aerated fermentation has been widely used to speed up the fermentation process, shortening the fermentation period. Through this, the fermentation period takes around 5 months.

Lately, natural black olives with low salt content has become popular in Turkish markets, gaining the appreciation of Turkish consumers who especially want to consume diet products.

Besides black olive processing, dehydrated in dry salt, without brine is also popular. Most widely consumed variety is Gemlik, yet Edremit (Ayvalık), Memecik and Uslu varieties are also widespread.

2. Natural green olive production

Scratched and cracked green olives are highly appreciated by the Turkish consumers. Edremit (Ayvalık) variety is widely preferred for scratched green olives. It can be processed whether pink or green. Domat, Memecik and Yamalak varieties are considered to be processed as scratched as well. Soon after the olives are transported to the plant, they are size-graded, sorted and scratched on 2 or 3 sides and put into water. The water is changed every other day to obtain the deserved taste.

The olives transferred to the fermentation tanks. The brine's salt ratio is increased progressively and reaches to 5-6%. After the fermentation, the olives, being ready for consumption, are packed. Although, cracked olives are highly preferred by the Turkish customers, they find limited place in the market due to the short shelf life. The production method for cracked olives is the same as scratched ones, yet the olive is cracked instead of being scratched. Because of the possible storage problems, the product is processed as Spanish style green olives and then cracked to be packed.

V – Conclusions

Table olive and olive oil consumption tend to portray a worldwide increase. Table olive production technologies are determined by the consumption habits and tastes of the consumer and thus varies from country to country. The important thing is to provide high quality products to the market and therefore, the researches carried out should aim to attain decrease in production cost and increase in product quality.

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Case study of an integrated system for olive mill by-products management in Sfax region in central Tunisia

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Abstract. Olive oil extraction generates annually a huge amount of by-products called olive mill wastewater (OMW) and olive husk in the whole of the producing countries all around the Mediterranean basin. In the particular situation of Sfax (a city in the Center of Tunisia) the major part of the 400 olive mills is located in the urban area. This situation makes olive mil by-products disposal and management hard. This work focused on the agronomical valorisation of these by-products. OMW was directly spread in fields while olive husk was primarily composted with cow manure. The technical and agronomic efficacy of these valorization ways was confirmed through three years field studies. Indeed, OMW spread improved soil cation exchange capacity as well as soil fertility with regards to organic and mineral compounds. The obtained olive husk compost was an organic fertilizer of high quality. The agronomic valorisation of olive mill by-products was technically realisable with important beneficial effects on soil and plants and with very limited impacts on environment. The cost of these techniques is moderate and comparable to the cost of actual disposal methods. This makes the integrated way of management interesting and practically feasible at wide scale. This method involve olive mill by-products transport, temporary storage or composting and spread in the fields.

Keywords. OMW – Olive husk compost – Olive mill by-products – Organic fertilisation.

Étude de cas pour une gestion intégrée des sous-produits des huileries

Résumé. *L'extraction de l'huile d'olive génère d'importantes quantités de sous-produits, l'un liquide appelé eau de végétation ou margines et l'autre solide appelé grignon d'olive. Ces sous-produits représentent un problème environnemental de première importance dans tous les pays producteurs. Leur gestion, différente d'un pays à l'autre, engendre des coûts importants et souvent des effets néfastes sur l'environnement. Dans le cas particulier de Sfax qui est une ville du centre de la Tunisie, ce problème est plus épineux dû au fait de la présence de la majorité des 400 huileries dans le périmètre urbain. Cette situation accentue la difficulté de la gestion de ces sous-produits générant un surcoût dû à la nécessité du transport hors de la ville. La valorisation agronomique de ces sous-produits, par épandage direct pour les margines ou après compostage pour le grignon, peut être une solution faisable et rentable. Après la vérification technique de cette possibilité, une méthode de gestion intégrée des sous-produits a été proposée. Le coût de cette méthode reste modéré et est comparable au coût de la gestion actuelle. De ce fait, cette méthode peut être appliquée à large échelle. La méthode englobe le transport des sous-produits dans les zones d'épandage, le stockage temporaire ou le compostage et l'épandage.*

Mots-clés. *Margines – Compost de grignon d'olive – Sous-produits des huileries – Fertilisation organique.*

I – Introduction

Olive oil is among the main arboricultural products of the Mediterranean Basin. Indeed, 99% of the world olive oil is produced within this area (Loumou and Giuourga, 2003; Ulger *et al.*, 2004). The oil extraction process generates, in addition to oil, two sub-products, olive mill wastewater (OMW) and olive husk. OMW is constituted of vegetable water of the fruit and the water used in oil extraction process. It constitutes the aqueous part of the fruit involving soluble components and suspended materials. It represents a serious environmental problem due to its high organic content [biological oxygen demand (BOD_5) up to 90 x 103 mg/l, and chemical oxygen demand (COD) up to 200 x 103 mg/l], with a dominance of phenolic compounds and various flavonoids (Paredes *et al.*, 1987; Ben Rouina *et al.*, 1999; Gargouri *et al.*, 2007). Hence, the Mediterranean basin is particularly affected by OMW pollution. In addition, this concern is increasing in emerging producer countries such as Argentina, Australia and South Africa (Roig *et al.*, 2006). Olive husk from the three-phase system had a second oil extraction with organic solvents after its drying (Roig *et al.*, 2006). Olive husk is formed by olive stones and flesh. It contains, at lesser degree than OMW, some dangerous compounds and important amount of carbohydrates.

In Tunisia, the average olive production (2007-2011) reached 918,800 (FAOSTAT, 2013). The major part of 1,500 olive mills working in Tunisia is using the continuous three phase process with little classic system. It generates more than 700,000 t/year of OMW and 450,000 t/year of olive husk. According to Tunisian legislation OMW is considered as industrial wastewater. Its disposal is regulated according to the Tunisian Norm NT106-02 which gives the limits of concentration in several parameters for the wastewater to be rejected in the environment or to be used in the treatment plants. Yet, the proposed treatment methods were not supported either by policy or by producers due to several reasons. The main cited reasons are: (i) the low efficiency because of the high contamination level of the OMV i.e. an efficiency of 95% is not enough to allow the use of OMW as treated water (Table 1); (ii) the high cost of the treatment; and (iii) the low capacity of the treatment plants with regards to the huge produced quantity in a short time. Actually, the OMW disposal system is based on collecting and drying it in evaporation ponds located near the producing areas. This practice has harmful effects on the environment, such as the volatilization of certain compounds contained in OMWs (phenols and sulphur dioxide) and their emission into the atmosphere (Rana *et al.*, 2003), strong odours and infiltration risks, which can be a serious pollution risk for superficial and underground waters (Mekki *et al.*, 2006a). Husk from the continuous three-phase process is actually utilised as animal feed or is exported for energy production after residual oil extraction.

Many investigators have searched for better potential solutions including physical, chemical and biological treatments and agronomic and energetic valorisation. The sludge produced after OMW evaporation and olive husk can be valorised as fertilizer after composting or for heat production. The OMW sludge was also proposed to be an additive for the development of construction material (Roig *et al.*, 2006). Physico-chemical treatments through coagulation and flocculation were developed producing water for irrigation and sludge that has been successfully composted with other agricultural by-products (Roig *et al.*, 2006). Biological transformations were used for OMW treatment focusing on phenols degradation and agronomic valorisation of treated OMW. In addition production of biogas by anaerobic digestion was reported as efficient disposal method (Roig *et al.*, 2006). The energy recovery through combustion was also described as valorisation way for olive husk. Other methods such as extraction of valuable products mainly bio pesticides and antioxidants were investigated and valuable results were reported (Roig *et al*., 2006). Finally, composting is an efficient and practical way for olive mill by-products disposal.

In central Tunisia at Sfax region, the major part of olive mills is located in the urban area increasing disposal difficulties. 400 olive mills are located in this area producing about 250,000 m^3 of OMW and 150,000 tons of olive husk. Actually the produced OMW is disposed in evaporation pounds located at 35 km from the most important production area located in the urban area. This situation increases disposal cost since the transport along long distances is necessary. Moreover the disposal area occupies a huge surface reaching 60 ha and present some harmful effects leading to social contestations. The sludge obtained after water evaporation is disposed in a particular area without further transformation. Olive husk is collected for secondary extraction of oil and the produced by product is exported to be used for heating.

Face to this situation our objective was to propose a practical solution for olive mill by-products disposal focusing on agronomic valorisation. Our work was divided in three steps: (i) verifying that OMW spreading and olive husk composting are valuable ways for olive mill by products valorisation; (ii) developing a practical procedure for their application with regards to the location of olive mills in the urban area; and (iii) evaluation of technical and economic efficiency of the applied procedure.

II – Materials and methods

In order to study the effects of OMW spreading and olive husk composting and compost use in agriculture a three years survey was realized in the experimental farm of Olive Institute located in Sfax region (34°55' N; 10°34' E) in central Tunisia. The orchard has a sandy soil in lower semi-arid climate with 200 mm of annual rainfall. Four treatments were applied according to full randomized blocks plan. The olive husk was composted with addition of cow manure and use in the same parcel

OMW and olive husk used in this study were obtained from a three phase continuous system oil extraction plant belonging to the farm. Some differences appeared between the OMW according to the year of production (Table 1). However, the OMW composition has mainly the same characteristics with low pH (4.2 to 5.5) high COD, BOD, electrical conductivity (EC) and potassium and phenolic compounds contents. In general the OMW has important amounts of organic and mineral matter allowing it to be considered as liquid fertilizer. The used dose of OMW was 50 m^3/ha. Olive husk was composted with cow manure with a ratio of 2/1 w/w in order to get a starting C/N of 35.

Table 1. Minimum and maximum values of different characteristics of the used OMWs in comparison with the Tunisian norm of reject in the environment or in the treatment plants

Parameter	Unit	OMW		Environment reception limits	Treatment plants reception limits
		Min.	Max.		
Water content	%	87.9	95.4		
pH_w		4.2	5.5	6.5-8.5	6.5-9
EC	dS/m	12.4	18.6		
COD	mg/l	63,790	105,000	90	1000
BOD_5	mg/l	34,900	55,000	30	400
Organic matter	g/l	107.0	32.6		
Sugars	mg/l	14,630	25,300		
Phenols	mg/l	990	5,800	0.002	1
Fat content	mg/l	4,500	3,180	10	30
C	mg/l	1,270	3,740		
Mineral content	g/l	12.1	23.7		
N	mg/l	440	1,400	1	100
PO_4^{2-}	mg/l	186	320	0.05	10
K	mg/l	4,370	7,500	50	50
Mg	mg/l	650	1050	200	300
Na	mg/l	1,150	1,310	500	1000
Ca	mg/l	710	2,300	500	variable
Cl	mg/l	560	1,250	600	700
C/N		2.9	2.7		

Soil samples were collected 3 month after the OMW spreading from different point of each plot.

These samples were collected from one depth horizon: 0-20cm and were air dried, sieved (<2mm) and stored until analysis. Soil analysis interested pH measured on a 1:2.5 soil/water suspension (Pauwels *et al.*, 1996), Organic matter content was measured by Walkley and Black method (Pauwels at al. 1996), total nitrogen was determined by modified Kjelddhal method (Pauwels *et al.*, 1996), available phosphorus content was determined by modified Olsen method (Pauwels *et al.*, 1996) and K an Na amounts were extracted with NH4OAC and measured by emission spectroscopy (Pauwels *et al.*, 1996). Total phenol were extracted by methanol with a ratio soil/methanol 1/5 w/v (Avallone *et al.*, 1997) and the phenol content was by Folin Ciocalteau method and qualitative phenols analysis was realized using HPLC (AOCS, 1990).

The impact of OMW spreading on plant productive behaviors was evaluated throw the measurement of olive yield and oil quality. The olive orchard was rainfed planted at the density of 17 trees/ha. The impact of OMW on olive and olive oil quality was assessed according to standard methods (AOCS,1990).

The main constrain for the application of agronomic valorisation of OMW and olive husk compost was the distance between producing area (urban area) and reception area (rural area) needing transport. The transport has to be as low as possible, for this reason it should be done using big tracks with tanks of 35 m^3 for OMW or dump trailers of 30 tons for olive husk. These devices cannot be used in the field and thus it is mandatory to transfer the product in other equipments adapted for the work. For OMW spreading a tank with high pressure is needed while manure spreader can be used for compost. The raised problem is that these equipments had smaller capacity than transporting equipment. Indeed both of spreading equipments had a capacity of 5 tons. Thus in our work we experimented the use of small buffer pond of a capacity of 400 m^3 and the installation of composting area in the field. The other solution was to build the olive mill in the rural area.

Finally the cost of OMW transport and direct spreading was calculated and compared to actual disposal method cost. In addition the cost of compost fabrication was estimated.

III – Results and discussion

The addition of OMW on soil properties are reported in Table 2. The soil pH was not affected by the OMW spreading This phenomenon may be explained by the buffering capacity of the soil. These results are consistent with those obtained by several other authors (Gargouri *et al.*, 2004; Chartzoulakis *et al.*, 2006). However, contrary results were obtained by Di Giovacchino (2005) and Mechri *et al.*, (2007). The amount of organic matter (OM) in the soil increased after the application of OMW which contain a relatively important amount of organic matter (more than 33 g/l). The amount of OM raised from 0.21% in the control to 0.45%. The more important soil enrichment was observed for the K content. The soil content P showed a small but significant increase caused by the application of OMW. Soil N content was not modified. These results are in accordance with those obtained by several authors (Levi-Minzi *et al.*, 1992; Ben Rouina *et al.*, 1999; Gargouri *et al.*, 2004; Di Giovacchino, 2005; Chartzoulakis *et al.*, 2006; Mechri *et al.*, 2007).

On the other hand, the salinity of the OMW was usually posed as limiting factor. However, the increase in sodium content was not alarming and far under the increase in K content which can counterbalance the negative effect of Na. The phenols content in the soil three months after OMW spreading is the same for the control and for the 50 m^3/ha treatment. These results are in accordance with those obtained by Di Giovacchino (2005) and Chratzoulakis *et al.* (2006). Qualitatively only one phenol compound was detected in treated soil i.e. Tyrosol. This phenomenon indicates the effectiveness of phenol compounds degradation in the soil.

The yield of the olive tree was enhanced by the addition of the OMV. The increase for two consecutive years 2005-2007 was about 83% comparatively to the control while it was 12% for longer period (1995-2007) (Table 3).

Table 2: Soil properties after OMW in field application

	Control	OMW
pH	8.1 + 0.04	8.4 + 0.01
Organic matter (%)	0.21	0.45
Total N (mg/g)	0.42 + 0.01	0.43 + 0.01
P_2O_5 (mg/kg)	59.4	85.4 + 8.8
K_2O (mg/g)	0.2 + 0.003	0.07 + 0
Na (mg/kg)	11 + 1.4	44 + 0.00

Table 3. Impact of OMW spreading on olive yield (kg/ha)

	Yield 2005/2006	Yield 2006/2007	Average (1995-2007)	Effect (1995-2007)
Control	539	75	627.5	-
50 m^3/ha	561	563	705.5	+12%

Di Giovacchino (2005) found that the application of OMW until a dose of 300 m^3/ha increased proportionally the olive production. The contradiction with our results may be due to the aridity of our climate which can slow the organic matter mineralization and reduce the leaching of the eventual excess of some ions. However with a dose of 50 m^3/ha only positive effects were observed.

According to the results obtained during the campaign 2006/2007 (Table 4) the application of OMW has no effect on olive oil major characteristics. This result is in accordance with those obtained by Di Giovacchino (2005), but he found an increase in fruit oil content.

Table 4. Impact of OMW spreading on olive and olive oil quality

Treatment	Control	OMW
Fruit weight (g)	1.17	1.22
Oil / fresh weight (%)	29.02	28.36
Oil / dry weight (%)	55.63	55.21
Free acidity	0.26	0.28
C16:0	20.23	19.61
C16:1	2.45	2.28
C18:0	1.91	2.07
C18:1	57.20	57.82
C18:2	17.14	17.10
C18:3	0.58	0.60
C20:0	0.33	0.33
C20:1	0.13	0.15
K232	1.88	1.87
K270	0.13	0.11
Chlorophylls (ppm)	0.24	0.33
Phenols (ppm)	28.94	23.81
Oxidative stability (hours)	3.03	3.03

The olive husk compost was realised in the experimental farm on a platform avoiding contamination and permitting recycling of lixiviates (Fig. 1). The initial composition of composting material was formed by olive husk from three phase olive mill (66%) and cow manure (34%). This composition was adopted in order to get a starting C/N ratio of 35 and according to the availability and cost of raw material. The humidity of raw materials was maintained at 55% and the aeration was realised by mixing the compost 5 times when the temperature exceeded 55°C. The maturation process took 110 days.

Fig. 1. Composting: a: windrow turning, b: compost platform.

At the end of maturation the obtained compost had a C/N of 12.5, 54% of organic matter and 46% of mineral matter (Table 5). This compost was suitable for agricultural use (Roig *et al.* 2006).

Table 5. Chemical composition of mature compost

Moisture %	pH	EC mS/cm	OM %	MM %	C %	N %	C/N	K g/kg	P g/kg	Na g/kg
16.2	7.8	13.4	54	46	31.2	2.5	12.5	2.6	2	1.4

The obtained compost was spread on the soil of an olive orchard at a rate of 10 tons/ha. The addition of compost improved soil fertility (Table 6). Indeed soil cation exchange capacity (CEC) increased from 0.2 meq/100g dry soil up to 1.2 meq/100g. In addition, organic and mineral content of the soil increased as well as soil electrical conductivity. However soil pH was not affected and was slightly alkaline. These results were consistent with those reported by Roig *et al.* (2006) who claimed that olive mill waste composts are of high purity without recalcitrant toxic substances.

Table 6. Soil physical and chemical characteristics after compost application as compared to control soil

	pH	EC	OM %	CEC meq/100g	N mg/kg	P_2O_5 mg/kg	K_2O mg/kg	Na mg/kg	Cl mg/kg
Control	8.1	0.42	0.34	0.2	290	52.7	136.2	24	92
Treated soil	8.4	0.77	1.57	1.2	560	82.5	325.5	44	116

The positive results obtained after agronomic valorisation of OMW and olive husk compost supports their use at large scale. However, the particularity of olive mills location in the urban area of Sfax makes direct application difficult. For this reason a basin for temporary storage of OMW was build in the field. The basin has a capacity of 400 m^3. It was necessary in order to assure the transport of OMW to use big trucks with tanks of 35 m^3, which is the cheapest way. These trucks are not able to realise the spreading that have to be done by tractors with pressurised tanks of 5 m^3 in the field. The basin plays as a buffer between big and small tanks (Fig. 2). Direct transfer from big to small tanks need much more time than using the buffer basin and thus higher cost. The most important constrain was to avoid environmental bad impact of the temporary storage of OMW. To assure the sealing of the basin, it was coated by a resistant geomembrane. In addition the turnover of the OMW was of 24 hours. Olive husk was transported and compost was made on a platform in the field. The obtained compost was spread using manure spreader of 5 tons.

Fig. 2. a: filling the buffer basin, b: OMW spreading in the field.

The last step of this work was the verification of economical feasibility of the OMW spreading and olive husk composting and use. For this reason the producing cost of compost making and the process of OMW transport and spreading costs were calculated in Tunisia Dinar currency TND (1TND = 0.49 euro).

Two windrow mere installed formed by 80 tons of row materials: 30 tons of cow manure and 50 tons of olive husk. These row materials gave 52 tons of compost with a yield of 65%. The row material cost was: olive husk: 0.012 TND/kg and cow manure: 0.010 TND/kg. Since a 1,000kg of compost needs 1,000kg of olive husk and 600 kg of cow manure the cost of row materials per ton of compost was 18 TND. The fabrication of 1,000 kg of compost needs 0.8 hour of tractor and the cost of one hour of tractor labor is 15 TND. Thus the cost of fabrication of one ton of compost was 12 TND. The platform cost was 31,954 TND and the amortising is calculated on the basis of 30 years. The fabrication of 52 tons of compost needs 110 days for maturation and 10 days for cleaning. Thus during a year, on this platform, it is possible to produce 156 tons (3x52 tons) in three cycles. The cost of amortising per ton of compost was 31.954/30/156=6.8 TND. Finally the global cost of one ton of compost was 18+12+6.8 = 36.8 TND. This cost was high in comparison to other sources of organic fertilisers limiting its valorisation to particular uses needing high quality organic amendments (nursery, gardens...).

The cost of OMW spreading was calculated for olive mills located in the urban area. This means that the costs to be involved are: transport, temporary storage and spreading. The OMW spreading can be made in the area surrounding the storage basin. The quantity to be spread annually is 50000 m^3 in 1000 ha during 120 days. For this reason the quantity to be spread per day is 400 m^3. During 6 hours work a tractor can achieve the operation 6 times corresponding to 30 m^3. Thus 13 tractors are necessary to realise the spreading in a correct way. The cost of the spreading of one cubic meter is 8.100 TND (Table 7).

The actual cost of OMW disposal in evaporation pounds is 8.200 TND financed by olive oil producers. Thus, the application of OMW spreading will not induce additional cost while it will bring valuable beneficial effects.

Table 7. Cost of OMW spreading per m^3

	Cost (TND)
OMW price	0.000
Transport cost	5.000
Temporary storage cost	0.100
Spreading cost	3.000
Total	8.100

IV – Conclusions

The agronomic valorisation of olive mill by-products was technically realisable with important beneficial effects on soil and plants and with very limited impacts on environment. The cost of these techniques is moderate and comparable to the cost of actual disposal methods. This make this integrated way of management interesting and practically feasible at wide scale.

Acknowledgements

The present work was financed by CFC, in the framework of the project "Valorisation of olive by-products in agriculture" CFC/IOOC/04. Thanks are expressed to Soua, N., Jilani, S., Ben Abdelaziz, B. and Jribi, A. for technical assistance.

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Session 2
Marketing strategies

New global and local marketing strategies: Creation of added value through differentiation and high quality products

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Abstract. Market orientation is the greatest challenge confronting olive oil companies who want to open new markets and increase sales in existing markets. To do this, first companies must determine the relevant markets in which they wish to act, based on analysis of consumer behaviour and their own strengths. Once these markets are identified companies must segment the market, select target markets and positioning. In this sense, an olive oil differentiation strategy is the mainstay of positioning management in order to create a product that is perceived as unique in a chosen market segment. Sources of differentiation must be identified prior to determining a market segment. Aspects of differentiation include internal attributes of oil; or other external elements increasingly valued by consumers, such as environmental issues, the search for local products or those linked to a specific territory, or after sales services. In this sense, extra virgin olive oils have a number of attributes that are highly valued by consumers (quality, health, naturalness, territoriality, environmental respect, brand, origin, method of production, etc.) allowing various differentiation strategies.

Keywords. Marketing – Market orientation – Olive oil – Differentiation.

Nouvelles stratégies de marketing globales et locales : Création de valeur ajoutée à travers la différenciation et les produits de haute qualité

Résumé. L'orientation du marché est le plus grand défi posé aux compagnies liées à l'huile d'olive souhaitant ouvrir de nouveaux marchés ainsi qu'augmenter leurs ventes sur les marchés existants. Pour ce faire, ces compagnies doivent d'abord déterminer les marchés d'intérêt où elles désirent intervenir, en se basant sur l'analyse du comportement des consommateurs et sur leurs propres points forts. Une fois que ces marchés ont été identifiés, les compagnies doivent segmenter le marché, sélectionner les marchés cibles et le positionnement. Dans ce sens, une stratégie de différenciation pour l'huile d'olive constitue le pilier de la gestion du positionnement afin de créer un produit qui soit perçu comme unique sur un segment de marché choisi. Les sources de différenciation doivent être identifiées avant de déterminer un segment de marché. Les aspects de différenciation incluent les attributs internes de l'huile, ou d'autres éléments externes de plus en plus appréciés par les consommateurs, tels que les aspects environnementaux, la recherche de produits locaux ou liés à un terroir spécifique, ou les services après-vente. Dans ce sens, les huiles d'olive vierge extra possèdent plusieurs attributs fortement appréciés des consommateurs (qualité, santé, naturalité, territorialité, respect de l'environnement, type, origine, méthode de production, etc.) permettant diverses stratégies de différenciation.

Mots-clés. Marketing – Orientation du marché – Huile d'olive – Différenciation.

I – Introduction

In recent years, a series of events and changes has profoundly altered the operating environment in the oil sector, amplifying the changing and expanding market place in which improved market orientation, especially from the production sector, is necessary.

In our view, the "factors or drivers of change" in the olive oil sector are as follows. First, there has been increased world wide production of olive oil as a result of: (i) an increase in the amount of land used for olive cultivation, principally on intensive or super-intensive plantations; and (ii) the improvement in productivity due to irrigation extension and improved technology, in both the growth and olive-to-oil processing phases. Second, the remarkable worldwide increase in the demand for olive oil has been driven primarily based on scientifically established and increasingly widespread knowledge of the positive health benefits of its consumption, as consumers search for healthy, safe and quality products. Third, there has been increased demand for extra virgin olive oil. Fourth, the reduction, elimination and/or reorientation of public subsidies and further liberalization of markets is causing intense, increased competitiveness. Globalization plays a role in explaining and defining the market situation. Olive oil market protection will be reduced due to pressure from developing countries and the strategic interests of multinational companies. The future will bring more open markets, either through bilateral agreements or under the general system of the World Trade Organization (WTO). Fifth, there are new business opportunities arising from diversification strategies, such as using olive oil as an ingredient in other foods, cosmetics or in pharmaceuticals; the development of "agro-energy olives"; other ways of using by-products and olive waste; and the process of obtaining olive oils. Finally, increased corporate concentration in commercial distribution and the growth of private label market share are related events which have increased the difficulty for manufacturers distributing their own brands, while giving rise to the emergence of specialized industries in manufacturing labels, called "hidden giants".

In the last twenty years, the global demand for olive oil has increased by more than a million tons. However, the oil sector is suffering a decline in profitability due to lower prices in recent years resulting from oversupply and a strong imbalance of power in the sector, information reflected in the European Union Olive Oil Sector Action Plan. Since the olive oil production sector dominates production orientation, producers of virgin olive oils have modernized their farms incorporating the latest technological improvements provided by research. The same thing has happened in the primary processing industries. However, producers are too far away from consumers for the market to reward their efforts. Therefore, it is necessary to adopt a philosophy of market orientation and marketing; that is, producers need to be aware that they "can only produce what they can sell".

Thus, this paper has two objectives: (i) to describe the strategies that the olive oil production sector can use to achieve greater market orientation; and (ii) to identify sources of differentiation of olive oils in order to design and implement a differentiation strategy that makes consumers perceive oils as unique.

Following this introduction, the second section outlines the current challenges confronting the olive sector. Next, a procedure for implementing a philosophy of market orientation for olive oil companies is discussed, as well as new marketing strategies that should be used. Then, sources of olive oil differentiation that add value to the product are described. Finally, the final chapter contains concluding comments.

Our hypothesis is that the behaviour of the olive oil production sector is critical to the development of the global demand for olive oils and their own profitability. It is necessary to transition from the currently dominant production orientation to a market orientation.

II – The challenges confronting the olive sector

In the scenario described above the challenges confronting the olive sector, in our opinion, are:

(i) Constant improvement in the quality and safety of food, an integrated process that includes respect for the environment. It is not enough that olive oils are safe and healthy; the production process must also be safe and healthy.

(ii) Management improvement on farms and in related industries (cost reduction, increased productivity and professional management).

(iii) Making a sectorial approach compatible with a territorial approach. The olive sector is a major driver in the economy of its production areas. It is essential to emphasize the multi-functionality of olive cultivation: it has the ability to unite a territory, create jobs, protect the environment, maintain local populations and production systems, preserve traditional agricultural landscapes, avoid or reduce erosion, fight climate change and maintain biodiversity. In short, it is necessary to assert the fundamental importance of the olive sector in its social, cultural, and environmental dimensions.

(iv) Highlight greater diversification, as mentioned above, by: using olive oil as an ingredient in other foods (sausages, preserves, pastries, etc.), and introducing it in other products (cosmetics, and pharmaceuticals), creating links with the energy market and discovering other forms of using olive waste and its by-products, such as composting, for example.

(v) Create well integrated and adequately sized marketing structures through cooperation agreements, strategic alliances, and mergers within the production sector.

(vi) Improve the functioning of the olive and olive oil production chain, promoting stable and sustainable relationships between different players, based on trust and commitment and the development of vertical collaborative strategies.

(vii) Investing in R & D and training. Increase the transfer of knowledge and consulting within the production sector: stimulate more cooperation between farmers and researchers to accelerate innovation, especially in processed products that bring benefits both in terms of time (convenience products), and in terms of health (functional and nutritional products).

(viii) Use information and communication technology (ICT) in management.

(ix) Conduct efficient marketing based on market orientation. Olive companies, especially, the producers have to be convinced that it is essential to establish an on-going dialogue with consumers to enable them to identify consumer needs and desires. Satisfaction of consumer demands must become one of the main objectives of the organization.

III – Market orientation in the olive sector

Meeting consumer needs should be the primary goal of every business. This is the ideology that underpins marketing management and it is apparent that the term marketing, as Leon and Olabarría point out (1991, p. 9), brings an innate understanding of the consumer, since the goal of marketing is the perpetual dialectic between the product and/or service provider and the consumer-the end user. Therefore, the marketing approach advocated in business management implies the need for every organization to identify their markets, know their customers, understand their needs and know how to satisfy them. This is the only way an organization can design an offer that will satisfy the needs of current and potential customers better than the competition and therefore make a profit. As noted by O `Shaughnessy (1988, p. 102): "All marketing plans are based on a broader set of assumptions about consumers or buyers. Whether it is to keep current customers, attract buyers from the competition, attract new users or just plain raise levels of sales among existing customers, the marketing strategies you design to achieve this will be trying to influence consumers or buyers. The better you know why people want a product, how a specific brand is selected and what causes them to buy or not, the better you are able to design an effective marketing strategy".

In sum, to operate successfully, market-oriented companies, with a marketing orientation must have a full understanding of what makes consumers buy things. They need to know why they buy, what real needs they try to satisfy and what influences affect their product choice, in order to be in a position to design marketing strategies that favourably influence consumer decisions.

A market-oriented company promotes a company culture of organization, based on the fundamental principle that the members of an organization at every level should be aware of the importance of the consumer to their existence, progress and profitability, because while marketing is a business function, above all it is an attitude, and management philosophy.

Market orientation and marketing are two of the great challenges confronting the olive business in order to open new markets and increase sales in existing markets. To achieve these objectives, companies have to first, define their business portfolio, the relevant markets in which to act, and the Three-Dimensional Business Definition (Abell, 1980), which is an intersection of a base function, and technology and a group of consumers. Following this analysis, olive oil companies can identify different relevant markets in which to operate: the bulk market; the packaging market; indoor markets; outdoor markets; homes; hotels, restaurants and catering companies (HORECA), etc. The choice of one or more markets is the result of consumer behaviour analysis and, of course, of the strengths and weaknesses of the company.

Once the products-markets in which a company wishes to act are identified, market oriented companies need to carry out the following tasks in each market: market segmentation, target market selection and positioning. Market segmentation identifies various groups of consumers with similar behaviours within the total market, profiling each of the segments identified. Once the market segmentation is done, the best segment or segments need to be selected. To do this, the potential profit from each of them, a function of their size and growth, and the structural attractiveness, objectives and resources of the organization need to be assessed. Subsequently, the organization must persuade selected target markets that their product will meet a consumer's needs better than competing products. To do this, companies must develop a special image of their product in the consumers' minds relative to competing products. These market segments must feel that the company has a unique way to meet consumer needs.

A market-oriented olive company seeking to operate in any market must analyse consumer behaviour toward oils and fats in that market: including the oils and fats consumed, uses, associations of oils / fats to use, purchase motivations, places of purchase, knowledge about different oils / fats and their differential attributes, consumer perceptions, beliefs and images that consumers have about oils / fats, etc.

For example, Parras and Torres (1996) segmented the Spanish home edible vegetable oil market, using the number and types of oil consumed as criteria. Their results were as follows: exclusive buyers of olive oil (31.8%), exclusive buyers of sunflower oil (4.3%), exclusive buyers of virgin olive oils fit for consumption (4.6%), buyers of both olive oil and sunflower oil (31.8%), buyers of olive oils (virgin and olive oil) (7.5%), buyers of virgin olive oil and sunflower oil (5.3%), buyers of two other types of oils (4.1%) and buyers of more than two types of oils (10.8%). Market-oriented olive companies can use this information to decide whether to focus on one or more of these segments on the basis that the company possesses a competitive advantage over the competition and, in turn, can generate a potential profit.

Outside the Spanish market, the French market has experienced significant growth in recent years and could be representative of emerging foreign markets, in which, as seen in Fig. 1, extra virgin olive oil is considered the healthiest product, yet its use is associated with uncooked dishes or those with a short cooking time (Parras *et al*., 2005). Olive oil use in France is practically limited to salad or raw uses. In this type of market the institutional and business strategy should be to position extra virgin olive oil as a versatile oil, in order to extend its use based on knowledge about the behaviour of olive oils in French gastronomy.

Using the Spanish home market as an example of a large olive oil consumer market, it is clear that the consumption of extra virgin olive oils is still small compared with the overall consumption of olive oil, as in other production markets. A business and institutional development strategy in these markets would be to increase consumption of extra virgin oil in households that are exclusive consumers of olive oil and in those that consume small amounts of extra virgin oil. To do this, oil usages, purchase motives and the image that consumers have of various products needs to be taken into account.

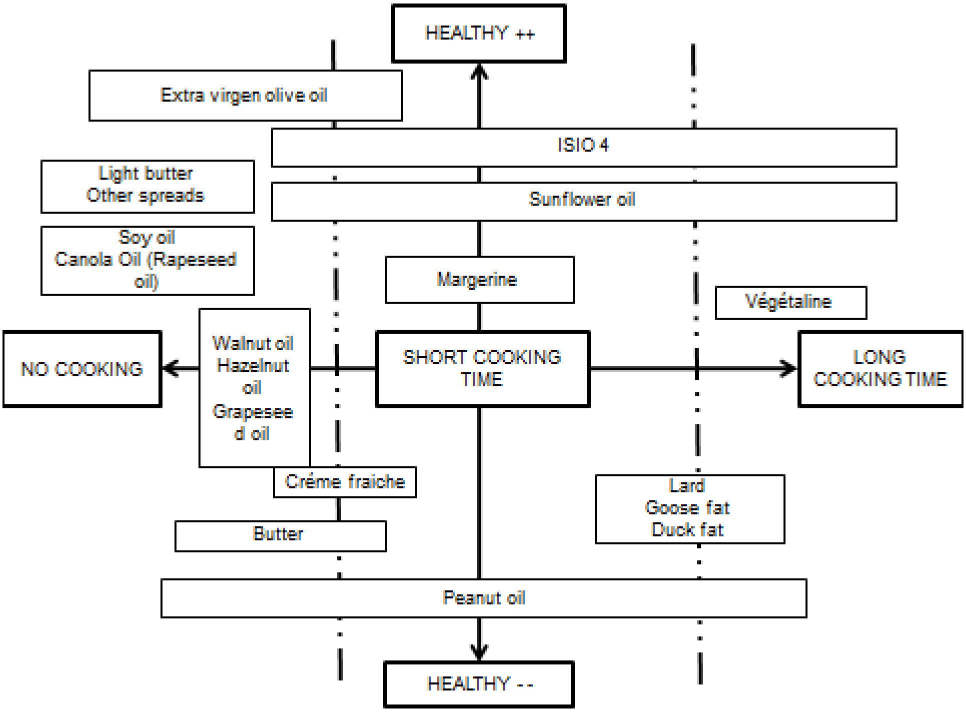

Fig. 1. Positioning of extra virgin olive oil in the French oils and fats market (Source: Parras *et al.*, 2005).

Market orientation also involves designing and implementing new marketing strategies, such as consumer sensory education and the dissemination of an olive oil consumption culture, in order to close the gap between a sector that puts forth great effort to obtain quality olive oils and a consumer who generally does not appreciate this quality (Sanz *et al.*, 2012). These measures are necessary in order for the effort in producing extra virgin oils to be rewarded in the market, especially in those markets where consumers have little knowledge about the different types of olive oils and its distinctive features are poorly understood. In the same vein, it is necessary to change the generic names of olive oils that are unclear and which prevent consumers from differentiating between oil qualities, and are not useful to facilitate the buyer's purchase decision (Parras, 2000). The confusion in some markets does little to sell virgin olive oil from the producers because when there is confusion the consumer takes refuge in known brands, even if those oils are not the best available. A strategic marketing principle is necessary to provide consumers with accurate, sufficient and understandable information on the characteristics of olive oils.

It is also interesting to incorporate varietal information, historical and cultural features related to products, and tasting descriptors on olive oil labels intended for minority, but emerging consumer segments. Moreover, there is a need for an urgent ban on re-usable olive oil containers that allow immediate and virtually unlimited reuse in markets where it is not prohibited, for example in Spain. This widespread practice in foodservice establishments presents a host of risks for end consumers and generates distrust in among quality oil producers who run the risk that one of their bottles can be filled with another inferior oil

(Martinez and Parras, 2011). It is necessary for olive oil to be packaged in non-refillable containers in order to ensure product authenticity. Finally, the use of ICTs is key in new marketing strategies, not only for technological support, marketing designs and implementation strategies, but also for e-commerce use in business settings related to olive oil.

IV – The strategy of differentiation and added value. Factors or attributes of differentiation in olive oils

As Lambin noted (1994, p. 336-337), the first step in preparing a development strategy is to specify the nature of a defensible competitive advantage, which will support strategic and tactical actions later.

Different basic strategies can be adopted depending upon whether or not they are based on productivity gains, and therefore cost is affected, or based on a differentiation element and, consequently, price is affected. Porter (1980, p. 56-57) identifies three broad generic strategies, which are internally consistent (able to be used individually or in a combination) to create a long-term defensible position and beat competitors in the industrial sector. These three strategies are general leadership, differentiation and a high segmentation approach (Fig. 2).

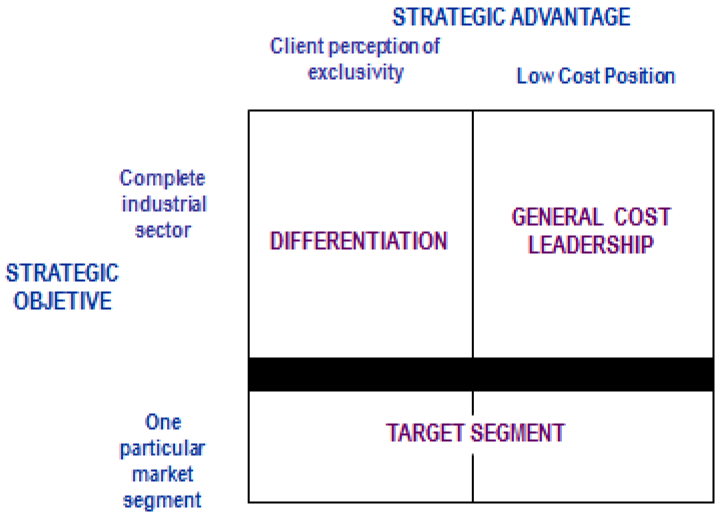

Fig. 2. Porter's generic strategies (Porter, 1980).

The strategy of product or service differentiation is to create something that a market segment perceives as unique. This idea is the mainstay of position management in market segments. All segmentation is based on the concept of differentiation. The distinction, if achieved, is a viable strategy to earn higher than average returns in an industry, as it creates a defensible position against the competition. Differentiation provides security against competitive rivalry due to brand or product loyalty and lower sensitivity to resulting prices. It also increases profits, which avoids the need for a low cost position. Differentiation strengthens the position of a firm relative to its competitors and substitutes and increases the dependence of consumers or buyers. On the other hand, some risks associated with differentiation include emulation of the distinguishing feature by other companies and, secondly, a price advantage by a competitor which could induce a significant sector of the market to prefer it, reducing interest in the business differentiator. How can differentiation from the competition be achieved? It is useful to draw on the Lancaster's Theory of Demand Characteristics (1966) which is based on the assumption that consumers maximize the utility of features of objects rather than the objects themselves. From this perspective, a product as seen from the buyer's point of view, can be defined as a specific set of attributes that benefit the buyer. These include more than just the basic service typical of the type of product, extending to necessary or ancillary services, which are distinctive product elements, and which might influence the preferences of buyers. Consequently, an attribute is the advantage sought by the buyer, or the attribute that generates service, and satisfaction and, as such, is used as a selection criterion (Lambin, 1995, p. 114-117).

The literature distinguishes between intrinsic and extrinsic attributes. Intrinsic attributes are those that cannot be changed or experimentally manipulated without modifying the physical characteristics of the product itself (Olson and Jacoby, 1972). Extrinsic attributes are by definition external to the product, and are related to it, but are not part of the physical product. For food generally and olive oils, in particular, intrinsic attributes include taste, colour, odour, range, nutrient capacity, health effects, and freshness, etc. Some extrinsic attributes are price, packaging (material and design), the brand, the logo, the perception of quality, labelling, the form of production or crop, and origin, etc.

On the other hand, food in general and olive oils in particular, are increasingly differentiated through social, emotional and epistemological aspects, including: attention to biodiversity in the production process, the fight against climate change, contributions to the improvement of rural landscapes, environmental care, innovation, the desire for knowledge, and other social and cultural aspects, etc., Additionally, both food and olive oil are differentiated through services valued in market segments, for example, after sales service, fast delivery, and advice on the use and gastronomy of olive oil.

Figure 3 shows a diagram in which, using olive oil as a base for food, features have been added showing "necessary services" which are useful to differentiate olive oils in the market. Along with these, "added services" are shown. These services are increasingly appropriate to add value to companies' products through differentiation.

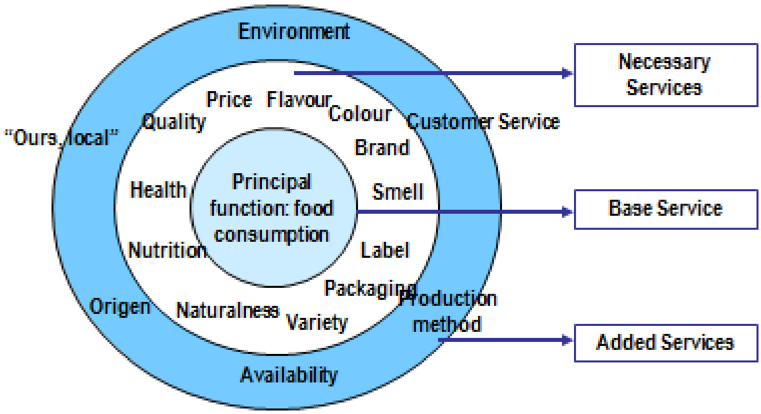

Fig. 3. Extra virgin olive oil, shown as a package of benefits.

Virgin olive oils have attributes that make them different from other oils and fats and which are valued by consumers, such as their positive effects on health, their characteristics in fried food, and their quality and naturalness. Health has emerged as the sales pitch which has provoked increased consumption of olive oil in general, and of virgin oils in particular, especially in markets located far from the Mediterranean. The position that consuming extra virgin olive oil is an investment in health seems to have been achieved for virgin olive oil. This position has been reinforced by the inclusion of olive oil polyphenols on the European Food Safety Authority list of authorized health claims. Along with these attributes, the quality of extra virgin oil is a valued attribute that consumers need to be more informed about, as mentioned above. According to the Special Eurobarometer report on food and agriculture in the European Union, published in July 2012, food quality is the most important determinant of purchase for 96% of Europeans, over price (91%). However, the low prices of extra virgin oil at major retailers have not helped generate an impression of a high quality product for consumers, therefore quality oil producers are trying to establish another category of oil. Meanwhile, use of the term "Premium" to differentiate their oils or the words "extra payment virgin olive oil", "home-grown extra virgin olive oil", "first day harvest extra virgin olive oil", etc. These initiatives are interesting since they associate olive oil with wines, a product that is better known among consumers. One risk of this strategy is that consumers may not be able to distinguish between products. Another differentiation strategy for quality virgin olive oil is obviously to invest heavily in positioning a brand in the minds of consumers.

On the other hand, extra virgin olive oils with Designation of Origin (PDO) are beginning to be recognized, although a significant portion of consumers do not associate them with a specific territory, an issue worthy of discussion since food origin is important for 71% of respondents in the Eurobarometer. The return to consumption of local products should be a catalyst for development of these oils. Finally extra virgin olive oils from integrated and organic production methods are positioned based on their environmental attributes and are increasingly valued (particularly organic oils) by the market segment with a strong environmental commitment, which chooses these foods to reward agriculture that does not pollute. However, in some countries, like Spain, consumption of organic oils is severely restricted by the distribution channels used to reach the end consumers and the high regard for conventional extra virgin oils, limiting the willingness to pay a lot more for organic oil.

V – Conclusions

The remarkable increase in the demand for olive oil in the last twenty years is the most characteristic feature of the evolution of the world olive oil market. However, this development has not translated into increased profitability for producers, who in recent years have seen prices drop to levels below the cost of cultivation and processing, as a result of an oversupply and a strong imbalance of power relations within the olive sector. This problem stems from the production-oriented culture prevalent among producers. In this context, in order for the efforts of the producers to be rewarded by the market, they need to adopt the philosophy of market orientation, a strategy that could generate great returns, considering the enormous possibilities that different types of virgin olive oils have in different markets.

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Turning food into a gastronomic experience: Olive oil tourism

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Abstract. Nowadays, gastronomy has taken on a new role associated with social, cultural, pleasure and entertainment needs and has become one of the main motivations for travel. Therefore, agriculture and food have become extremely important new drivers of tourism in production areas. The positive relationship between gastronomy and tourist activity is an economic catalyst for growth in specific territories, promoting local products and providing added value to the tourist. In this context, gastronomic tourism is an excellent business opportunity for Spain if the country is able to capitalize on the development of high-quality agriculture and food, especially related to olive oil. This paper analyses the state of olive oil tourism in Spain. Based on qualitative interviews with gastronomic tourism experts, and specifically olive oil tourism experts, this paper proposes a series of recommendations to guide the design and improvement of olive oil based tourism products and aid the creation of related experiences.

Keywords. Olive oil tourism – Value co-creation – Experiential marketing – Gastronomic tourism.

Transformer l'aliment en une expérience gastronomique : Oléotourisme

Résumé. De nos jours, la gastronomie a assumé un nouveau rôle lié aux besoins sociaux, culturels, au plaisir et au divertissement, et est devenue l'une des principales motivations au voyage. Ainsi, l'agriculture et l'alimentation sont devenues des moteurs extrêmement importants pour le tourisme dans les zones de production. La relation positive entre gastronomie et activité touristique est un catalyseur économique pour la croissance dans des terroirs spécifiques, avec la promotion de produits locaux et l'apport de valeur ajoutée pour le touriste. Dans ce contexte, le tourisme gastronomique est une excellente opportunité commerciale pour l'Espagne si ce pays est capable de capitaliser sur le développement d'une agriculture et de produits alimentaires de qualité, surtout dans le domaine de l'huile d'olive. Cet article analyse la situation du tourisme oléicole en Espagne. En se basant sur des entretiens qualitatifs avec des experts en tourisme gastronomique, et en particulier des experts en oléotourisme, cet article propose une série de recommandations pour guider la conception et l'amélioration des produits touristiques basés sur l'huile d'olive et aider à la création d'expériences dans ce domaine.

Mots-clés. Tourisme oléicole – Co-création de valeur – Marketing expérientiel – Tourisme gastronomique.

I – Introduction

Tourism as an act of consumption refers to all of the activities a person does from the moment they experience the need to travel until making a purchase and using tourist services. This process is influenced by different internal and external stimuli such as marketing. Among these stimuli, the motivation to travel is one of the most important internal conditions since it is the element that activates the purchasing process.

In recent times, there has been a significant change in consumer tourist behaviour since leisure time is an essential part of consumers' personal and social self-realization. Consumers are more demanding, have more choices and require more information and knowledge to make decisions. Therefore, the tourism model characterized by seasonal, mass tourism, with little diversity in supply, in which consumers adopt a passive role, has given way to a more fragmented model, which relies on the pursuit of quality as the key and gives consumers a more active role in the purchase and consumption process.

This new approach views tourism as a complex activity in which consumers seek deep experiences, and intense emotions, which are the main motivation for travel. From this perspective, companies are challenged to design products that consumers consider experiences. This requires greater attention to service, to so-called "moments of truth" and to consumer interactions with the organization, rather than a focus on the functional benefits of the product or service.

Experienced based marketing is particularly important in emerging tourist areas, which need innovative management approaches to compete in a well established marketplace. Products and services that provide comprehensive experiences, generating added value, are the basis for attracting and retaining customers.

However, value is created not only by an enterprise but is the result of a process involving multiple actors including consumers. This approach, called value co-creation, means that the consumer is an endogenous variable in the value creation process so that value creation and consumption processes are seen as inseparable (Ordanini and Parasuraman, 2011). A basic premise postulates that companies do not deliver value because it is created by the customers themselves when using or consuming products or services (Lusch and Vargo, 2011). Thus, the role of the company, prior to customer interaction, is to facilitate value, providing customers with goods and services that generate value through use or consumption. Nevertheless, a company can act as a co-creator of value through interactions with customers.

The adoption the co-creation of value approach in designing consumer experiences is considered a suitable framework for tourism management and thus can be directly applied to the development of olive oil tourism. As Vargo and Lusch (2004), point out, the co-creation of value provides opportunities to innovate and make a product or destination more attractive, offering the tourist what he or she really wants. This is the main challenge facing olive oil tourism in order to gain a foothold in an increasingly crowded marketplace with many, poorly differentiated packages, where a low price is still the common denominator.

Based on the previously established positive relationship between gastronomy and tourism, this paper analyses the current olive oil tourist situation in Spain. Interviews with experts in olive oil and related agents resulted a set of recommendations and considerations that respond to some of the challenges facing olive oil tourism and that should guide the design and development of tourist products based on olive oil.

II – The gastronomy and food binomial

Throughout history, food has played an essential role in nutrition being the way in which individuals satisfied their most primitive need. Recently, there has been a proliferation of increasingly differentiated ways of eating. According to Espeitx (2004), this diversity can be explained because food has become a commodity through which an individual expresses him or herself through consumption patterns, and this has led to its introduction in the field of leisure and fun. A broad range of eateries have developed not only to meet a basic need for food, but also to be a source of fun and entertain. Moreover, food has a social dimension that is the result of social ties and relationships that occur when food is shared, a situation that is amplified in the field of entertainment.

Thus, the cuisine has acquired new functions associated with social, cultural, health-related and pleasure needs. Food has become one of the main attractions in a tourist destination and one of the most important travel motivations. In Spain, about five and a half million people a year visit a destination for this reason and the vast majority of the fifty million foreign tourists mention the appeal of Spanish cuisine as one of the most highly valued aspects of their visit (Anson, 2010).

Moreover, some research has indicated that tourists spend nearly 40% of their budget on gastronomy (Boyne *et al.*, 2002) leading to the question of whether it is possible to integrate food intake with tourist activity in order to attract higher income consumers. The answer is yes, and has given rise to so-called food tourism (Hall *et al.,* 2003), culinary tourism (Wolf, 2002), gastronomic tourism (Hjalanger and Richards, 2002) or tasting tourism (Boniface, 2003) motivated, among other factors, by growing consumer interest in the product development process in the place of origin.

In general, this type of tourism is seen as an activity in which tourists or visitors plan their trips wholly or partly to taste local gastronomy or participate in activities related to gastronomy (Fandos and Flavián, 2011). Gastronomic tourism, though still a minority tourist modality, has high growth prospects. It can be considered as the main motive or principle experience of tourist activity, or as a secondary travel motivation, which is a more developed typology. According to Millán and Agudo (2010), gastronomic tourism involves visits to primary and secondary producers of food, food festivals, restaurants and specific locations where food tasting and experimentation in the process of food production is the main reason for the completion of the journey.

Several different types of food tourism have been identified. These include variables such as a tourist's level of involvement with food (Royo, 2011) or the type of need to be satisfied (Tikkanen, 2007). Focusing on this criterion, the following types of tourism have been identified: (i) tourism based on biological needs where food is perceived as an attraction in itself; (ii) tourism based on social needs where food becomes the central element of festivals, fairs or other events; (iii) tourism where the need for learning or prior knowledge are the main motivation; and (iv) tourism based on self-realization needs consisting of attendance or participation in fairs, conferences or seminars.

Gastronomic tourism is also often associated with the heritage and cultural resources of an area and, in this sense, can be defined as tourist activity linked to indigenous food tasting as means to get closer to the culture, tradition, history and customs of a particular area. Thus, food products, which identify a village or territory, become a vehicle for cultural approach (Feo, 2005). Similarly, Montoya (2003) points out that the recovery of local traditional cuisines and their inclusion in tourist itineraries will not only enrich interior cities but will help keep centuries-old cultural heritage alive. This approach makes food products tourist resources that contribute to the development of further tourism as well as establishing effective tools for the promotion and marketing of quality food products (Armesto and Gómez, 2004; Kivela and Crotts, 2006). Therefore, this type of tourism can consolidate regional productive culture, enhance regional products and boost regional economies through the promotion of products and food culture. In short, three objectives can be achieved through gastronomic tourism: first, it provides added value to tourists, second, it contributes to the promotion of a region’s typical products, and third, it boost competitiveness of a territory.

Thus, culinary tourism can become an effective instrument for the development of a tourist destination. Some studies indicate the existence of a strong relationship between food and culture (Reynolds, 1993), considering food an easy way to experiment and make contact with the culture and lifestyle of a destination. In this line, Hall and Mitchell (2000) contextualize gastronomic tourism identifying four, key dimensions of it: (i) as part of the local culture; (ii) as a tourism promotion instrument; (iii) as an element of local economic development; and (iv) as an indicator of patterns or habits of the local population. Thus, food has been used as a recurring attribute to promote tourist destinations associated with healthy and quality food.

This growing trend of culinary tourism provides a business opportunity for Spain considering its vantage point in the development of quality food products, including olive oil, ham and wine, among others. The consumption of local products with a designation of origin (D.O.) is usually motivated by the desire for authenticity and unique experiences, making the choice a crucial factor for the consumer. In this context, a food product becomes important as a tourist product and as variable that influences the tourist's decision process (Table 1).

Table 1. The agricultural food product from the perspective of the supply and the demand

Supply: As a tourist product	Demand: Variables on which it has influence
• Establishments of restoration and sale • Food fairs and events • Local and regional agricultural markets • Schools and cooking workshops • Farms and factories: visit installations • Interpretation centers • Feeding circuits and tours: tourism routes	• Decision-making of the tourist (Hjalanger and Corigliano, 2000) • Satisfaction with the experience or tourism destination (Neild *et al*., 2000) • Tourism destination image (Neild *et al*., 2000) • Involvement and / or attachment to the tourism destination (Gross and Brown, 2006) • Design of tourism products (Henderson, 2009) • Promotion of products and destinations (Henderson, 2009) • Image and positioning communicated (Frochot, 2003)

Source: Adapted from Royo (2011).

In the case of olive oil, it is necessary to design tourist products based on experiences to enrich the act of product consumption. To do this, it is necessary to know what has been done so far in the field of olive oil tourism and what could be done.

III – Olive oil tourism in Spain

As a complement to its traditional role of food, olive oil is considered a tourist resource with enormous potential in the field of culinary tourism. Indeed, the combination of food product and tourism raises promising new business opportunities for the olive, boosting the economy of certain territories. The cultivation of the olive tree, the olive harvest and oil production is a distinctive culture with it’s own slang, customs, lifestyles and identity that form the "culture of the olive and olive oil."

In this context, "oleo tourism" or olive oil based tourism emerges. On a scientific level, very few studies have focused on this tourist activity since it is still in the early stages of development. However, in recent years, business events and several institutional projects whose main objective was the exchange of experiences related to the enhancement of the resources associated with olive oil have been held.

Oleo tourism is understood as a set of activities that revolve around oil. These include visits to olive groves and mills (sometimes coinciding with the olive harvest), conducting oil tastings and tasting typical local dishes in which olive oil is the star ingredient. Additionally, olive oil tourism can include other cultural activities related to nature and which immerse the visitor in local culture of the environment and territory.

To understand the potential of this tourism activity in Spain it is important to analyse some indicators related to supply and demand of olive oil tourism.

From the supply perspective, Spain is the largest producer of olive oil in the world with a production level of 1,389,600 tonnes in 2010/11 (IOC, 2011) and a per capita consumption rate of 9.66 litres (MAGRAMA, 2011). This data gives Spain a privileged position in the marketplace that can be exploited in the field of olive oil tourism. However, this phenomenon is also being developed in other countries linked to the olive sector, such as Italy, Greece, Portugal, France, Morocco and Tunisia, among others, with similar levels of achievement.

There are significant tourist resources related to olive oil and olive oil mills including oil factories, specialized museums, olive groves and views of landscapes, and oil fairs and festivals that can be visited throughout olive producing territory. These resources have been integrated into various tourist routes offered by small businesses and professionals dedicated exclusively to the development of this activity. Currently, these routes are in an embryonic state not only because of the small number of activities on offer, but also in terms of marketing and management. In this regard, it is noteworthy that these routes are not operated by a single entity and that there are no explicit cooperation agreements between the companies offering this type of tourism, leading to questions about the quality of this tourist product.

However, when taking into account the objectives established by the Ministry of Tourism (Secretaría de Estado de Turismo, 2000) for this type of tourist product, it is clear there are very few existing routes that contribute to these goals. These objectives include increasing and removing the seasonal stigma of this tourist activity in a particular geographic area, generating wealth through activities which complement traditional ones, and improving the infrastructure of the geographical area thus increasing the quality of life of people who live there. Currently these objectives are not being met principally because they do not generate continuous tourism and management does not lies within one entity that boosts, energizes, coordinates and markets this tourist product as a whole. For these companies, the business can be summarized basically in providing information services and some olive oil related resources for a traveller to visit in a given geographical area. However, there are no partnerships, cooperative agreements, or philosophy of working together between the actors involved in olive oil routes so each tourism provider operates independently.

These routes have been developed in the main olive oil producing areas: Jaen, Cordoba, Seville, Cadiz, Granada, Aragon, Extremadura and Catalonia. Information about tourism in these areas and in this field can be found on different specialized websites such as: www.cerespain.com, www.oleoturismo.es and www.olearum.es[1], among others, or in specific guidebooks such as the Mercacei Guide to Extra Virgin Olive Oil from Spain (Peñamil, 2004) or the Guide for Oil Museums in Spain (Lorenzo, 2008). Table 2 summarizes the main oleo tourism experiences now available in Spain.

From the demand perspective, the research does not reveal conclusive results about the oleo tourist consumer profile mainly because there have only been studies about specific geographical areas which analysed only the profile of visitors to the mills.

Given this limited information the olive oil tourist can be defined as a married male, aged 45 and up, with a monthly income between 1,001 and 1,500 euros, from an urban habitat and who rarely sleeps in olive territory mainly due to poor tourist infrastructure. Satisfaction with visits is high, again, emphasizing the consumption experience. However, as the number of days in a stay increases, satisfaction with tourist visits decreases due mainly to the short supply of open mills and lack of existing complementary offers (Millán *et al.*, 2011).

A deeper analyses of demand is required in order to define and segment the target olive oil tourism market and to identify the main motivations and expectations of visitors, in order to design commercial offers adapted to each segments' needs.

The previous analysis indicates that there is great potential for the development of oleo tourism in Spain. However, the current offer is inadequate and suffers from serious problems. Thus, tourism products have focused only on activities such as mill visits and oil tastings, leaving aside complementary leisure activities that could increase the length of stays and the attractiveness of this kind of tourism. Furthermore, these activities are offered by individual companies, which prevent the existence of joint management of olive routes, a situation that calls into question whether these initiatives are true tourist products as they don't integrate resources and provide a unified image. Finally, the housing supply in olive growing areas is scarce, limiting the development of olive oil tourism and the possibility of combining tourist

[1]Olearum is an association of producers, millers, technicians and friends of olives and olive oil who have joined forces to defend, promote and disseminate the olive culture and heritage linked to this product.

resources. There must be an increase in the promotion of hotel development to increase the attractiveness of olive oil based tourism.

In summary, this analysis highlights the need to promote tourist attractions designed to offer integral experiences surrounding olives, olive oil and its related culture.

Table 2. Main Oleotourism experiences in Spain

Routes of the Olive Oil	More important tourism resources
Tours in Jaen, province with the highest concentration of olive trees. Globally, it ranks first in production of olive oil. Paths that meander through the Cazorla, Segura and Las Villas natural park, the Sierra Magina region, the comarca of Southern Highlands and the Sierra de Andujar natural park.	• Visitable oil mills: La Almedina (Cazorla), Potosí 10 S.A.(Orcera), Olivar de Segura (Puente de Genave), Aceites Campoliva, S.L. (Pegalajar), Aceites Viana (Garcíez), Ildefonso Espinosa (Pegalajar), Aceites La Laguna (Baeza), Almazara García Morón (Arjonilla), Galgón 99, S.L. (Villanueva de la Reina), Hermejor de la Reina, S.L.(Villanueva de la Reina), Cortijo del Madroño (Martos), Pydasa (Martos). • Specialty shops: La casa del aceite (Ubeda y Baeza), Oleoteca Cueva del Ponto (Beas de Segura), Oleocata (Jaén), Artesanía del Olivo (Sabiote). • Museums: Museo de la Cultura del Olivo, the largest in Spain on this genre, nestled in the resort Hacienda La Laguna (Baeza), Museo de Artes y Costumbres Populares (Jaen), which presents a representative sample of the popular culture of the province (kitchen utensils, farm tools, old mills, etc.), Museo del Alto Guadalquivir de Cazorla and Museo de Jodar (which displays interesting objects and equipment related to the culture of the olive). • Olives unique: Olivo de Fuentebuena (Arroyo del Ojanco), olivo de la Era de la Zarza (Castillo de Locubin) and la Estaca Grande (Martos). • Festivities: Fiesta de la aceituna (Martos) on 8 December. • Fairs: Feria Internacional del Aceite de Oliva e Industrias Afines EXPOLIVA (the most important event in the world which is held every two years in March); Feria Internacional del Olivar Ecológico ECOLIVA, biannual. • Tourism products: the route of olive tree and the olive oil greenway route.
Tours in Cordoba Routes that pass by Montoro-Adamuz, Pedroches, Baena, Priego de Cordoba, Countryside South, Alto Guadalquivir and Cordoba city.	• Alameños countryside or "four legs" olive trees (Cordoba city). • Núñez de Prado Oil mill and museum of olive and olive oil (Baena). • Thematic exhibition of olive trees of the company oleo cultura (Castro del Rio). • Historical and archaeological museum (Almedinilla). • House-museum Castil de Campos (Priego de Cordoba). • Festivity of arremate (Iznajar). • The old Mill (Cabra). • The Mill of the Duke (Aguilar de la Frontera). • The oil train (Montilla, trazado ferroviario del aceite). Tourism products: Club of tourism product "Olive Tree Lands".
Tours in Extremadura Most important routes: Monterrubio and Gata-Hurdes	• Oil mill and packaging Aceites Bonet situated under the cloister of an ancient monastery in Olivenza. • Coto de la Serena host the DoO Aceite Monterrubio. • Production area of Sierra de Gata. • San Martín de Trevejo olive oil museum. • Ethnographic Museum of Cilleros where rural life is reconstructed from a wealthy farming family. • Mill museum of Medio de Robledillo de Gata. • Festivity of the Baile del Capazo held in Torre de Don Miguel. • Olivac de Don Benito fair.

Table 2 (cont.). Main Oleotourism experiences in Spain

Routes of the Olive Oil	More important tourism resources
Routes in Catalonia Routes are concentrated in the provinces of Tarragona, Girona and Lleida where the route of "Les Garrigues" is one of the most visited	• Oil tematic park, considered one of the best oil thematic museums in Spain. • Tourist Interpretation Centre of Les Garrigues, that allocates an exhibition to promote the culture of olive oil. • Field cooperative "Sant Isidre". • Festivity of olive oil: Fira de l'Oli Extra Verge de Les Garrigues held in January. • Olive oil and rural world in Castelldans museum. • The oil ecomuseum of La Pobla de Cérvoles. • Old oil mill of Belianes. • Agricultural Cooperative of Soleràs offers the opportunity to learn the process of oil production and it has a farm shop where their products can be bought.
Routes of Bajo Aragon Provinces of Zaragoza and Teruel.	• Visitable oil mills: The centennial mill oiler of Jaganta in the Parras de Castellote, The oil mill Alfonso Muniesa (Belchite) and the disseminator center of the Aceite del Bajo Aragon D.O., multiservice space specializing in olive oil (tasting rooms, shops oil). • Museums: La Muela (Zaragoza), specialized in teaching and disseminating of the techniques and traditions related to olive growing and oil production and the Ráfales museum (Teruel). • Centenary olive trees of the Belchite and Alcañiz comarcas. • The oil meson in Bulbuente. • Agricultural Fair of olive trees and olive oil held in Calaceite. • Festivity of the mill, organized by the Regulator Council of the Designation of Origin Aceite del Bajo Aragon held at the end of the harvesting the olives.

Source: Own elaboration.

IV – Olive oil routes designed to create experiences

The creation of tourist routes is one of the strategic options in the design and development of tourist products based on food. In general, routes can be defined as the creation of a cluster of activities and attractions to encourage cooperation between different areas and serve as a vehicle to stimulate economic development through tourism (Briedehhann and Wickens, 2003).

The design of a tourist route should: facilitate contact between the client and the tourist product provider (Herbert, 2001), be built on the basis of an activity that distinguishes and differentiates itself from others in the market, be developed with the support of a road/travel network, and begin where the service provider can offer a traveller all the necessary elements to follow the route properly (Fernández and Guzman Ramos, 2003).

Routes based on food products are usually organized around a product or set of products that represent the culture and identity of an area and are composed of producers, regional restaurants and companies engaged in regional agribusiness.

Certificates of food quality are the backbone of attraction for many tourist routes since they differentiate routes from competitors' tourist products. In Spain, the system that certifies the quality of a food is based on the granting of Protected Designations of Origin (PDO) and Protected Geographical Indications (PGI). According to Regulation (EC) 510/2006 (20 March 2006), the PDO, defined as the name of a region, place or country used to describe an agricultural product or food, requires that the product originates from that place, that the quality or characteristics are due essentially to the geographical area in which it is located and that the production, processing and preparation take place in the defined geographical area. For PGI certification, the first two requirements are the same as for PDO certification, but the third requirement is that the geographical area may be related to any stage of the product development but not all stages. In sum, these certifications differentiate a food product based on its characteristics stemming from the geographical area in which it is produced and where the product is processed.

There are 27 PDO and PGI (Table 3) recognized by the Ministry of Agriculture, Food and Environment (MAGRAMA, 2012) for olive oil in Spain.

Table 3. Designation of Origin and Protected Geographical Indications for the Olive Oil in Spain

Autonomous Region	Number	PDO & PGI
Andalusia	12	Antequera Baena Estepa Lucena Montes de Granada Montoro-Adamuz Poniente de Granada Priego de Cordoba Sierra de Cadiz Sierra de Cazorla Sierra de Segura Sierra Magina
Catalonia	4	Aceite de Baix Ebre-Montsià Aceite de Terra Alta Les Garrigues Siurana
Castilla-La Mancha	4	Aceite Campo de Montiel Aceite de La Alcarria Campo de Calatrava Montes de Toledo
Valencian Community	1	Aceite de la Comunitat Valenciana
La Rioja	1	Aceite de La Rioja
Aragon	1	Aceite del Bajo Aragon
Extremadura	2	Aceite de Monterrubio Gata-Hurdes
Community of Navarra	1	Aceite de Navarra
Balearic Islands	1	Aceite de Mallorca
Total	27	

Source: MAGRAMA (2012).

Based on an experiential approach, olive oil routes comprise a set of experiences related to this product that are offered to consumers in a particular territory and reinforce the culture of the olive and valorisation of olive oil (Murgado *et al.*, 2011).

From this perspective, an olive oil tourist route is based on a model of concentric circles representing different experiential components (Fig. 1) including: visiting a mill, oil tasting, buying olive oil, visiting "oleotecas" (olive oil bodegas) and specialty shops, visiting museums, attending fairs and festivals related to olives and olive oil, tasting the local gastronomy, visiting landscapes and olive farms, and staying in places associated with the product.

The inner circles are smaller and represent experiences that have the greatest impact on tourists (especially the visit to the oil mill) and the activities represented in the external, larger sized circles cause less impact. Similarly, the situations separated by a horizontal line represent activities that are controllable by tourist companies and those that are not.

Interactions between the service provider and customer, or "service encounters or moments of truth" take place throughout the buying and consumption process. A tourist builds his or her perception and satisfaction of the tourist product based on these moments of truth. In each of these service encounters the customer evaluates the quality of the service, and although the first encounters may be especially important due to a risk of dissatisfaction reflecting on subsequent services, any meeting can be potentially critical when it comes to determining satisfaction and customer loyalty.

This tourist product model is designed to generate multiple "service encounters" as a result of the participation of different businesses (hotels, restaurants, museums, mills, tourist service companies, etc.) and their interactions with a client. The interdependence of these companies creates the need to strengthen partnerships between them since the degree of customer satisfaction does not depend on a single agent or operator, but on all service providers as a whole. Thus, positive experiences with each service provider will result in a perception of overall quality of the tourist product and vice versa. However, a combination of positive and negative experiences will increase the level of insecurity in the client and therefore the product will be more vulnerable in the market.

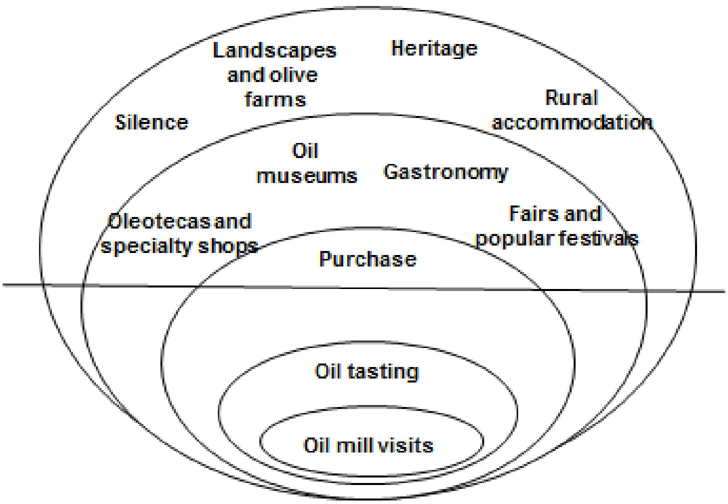

Fig. 1. Components of an olive oil tourist experience. **Source: Murgado *et al.,* 2011, p. 202.**

For this model to work, some obstacles and problems currently present in olive oil related tourism need to be overcome. Some of these problems are endemic to agricultural and gastronomic tourism, and experts in the sector cite their resolution as the key to successfully develop this tourist activity.

V – Overcoming problems in olive oil related tourism

Based on a qualitative study in which experts related to general culinary tourism management and specifically, to olive oil related tourism were interviewed, nine factors important to the successful development of olive oil tourism were identified. These factors are explained in detail below:

1. Lack of cooperation between those involved in the supply of tourist products. This is considered one of the most challenging problems in gastronomic tourism in Spain and is due to the lack of cooperative culture among companies. Overcoming this resistance to cooperation is crucial when taking into account that the interdependence between the companies providing services influences the level of overall customer satisfaction.

Some of the proposals put forward to promote an integrated approach to the management of tourist products include the creation and use of instruments such as a Tourism Product Club or a support from incoming travel agencies to promote cooperation networks between area businesses and entrench existing strategic alliances. In short, solving this problem requires a high level of involvement on the part of both public and private players related to olive oil tourism.

2. Inexperience and lack of personnel training among olive oil tourism service providers. This is especially evident in key activities such as visits to mills or oil tastings, which require a high level of training in order to explain the production process and technical issues and respond to questions. This problem stems from the low involvement of the mills in the tourist product and scepticism about the project, as evidenced the small number of mills open to the public, reduced tourist visiting hours, and the small investment dedicated to this business activity.

3. Poor business infrastructure that requires investment to meet high quality standards for this tourist product. It is necessary to promote and foster a corporate marketing culture.

4. Lack of attractive tourist products in the market to spark demand for olive oil related tourism. Therefore, we propose the creation of an official olive oil route in Spain that brings together high quality tourist resources and better standards of equipment. Additionally, the established of a such a route would improve services related to the olive culture among all participants: mills open to the public, old oil mills, "oleotecas" and specialty shops, olive and olive oil museums, rental cottages and rural houses, unique olive landscapes, organic olive groves, centenarian olive trees, oil festivals, traditions, regional gastronomy, designations of origin, monuments dedicated to olives and/or olive oil, oil trade shows, restaurants featuring olive oil menus and related archaeological sites.

Likewise, it is important to create a unique brand that is actively managed by an integrated marketing plan. To do this, specific brand positioning must be defined and clearly identified with consumer perceptions about the destination and product category linked to the site and its values.

5. Insufficient hotel infrastructures limit the potential for development of olive oil related tourism. Since most visitors do not stay overnight in "olive territory." This restricts tourism to very specific services such as visits to the olive groves, mills or oil tastings, but prevents the development of a broader range of services that could provide a tourist with more knowledge and allow them to experience the culture of the territory. Also, there is no specialized hotel package related to olive oil tourism. Such a package would better serve the middle-upper level income tourist segment resulting in more visits, longer average stays and increased average spending per visitor.

6. Meagre range of extra-activities to strengthen olive oil tourism. It is important to emphasize the need to develop additional services that link the client with the olive oil producing area as this could improve the level of tourist satisfaction and perceived value of the product. Therefore, we propose the creation of distribution networks specializing in traditional products and restaurants to increase tourist attraction.

7. Lack of a comprehensive and continuous communication plan to adequately disseminate information and strengthen the identity of the tourist product. Thus, the following actions are proposed: (i) promote the culture of olive oil by promoting a better understanding of the nutritional and culinary properties of this product; (ii) the use of this culinary product as a tourist attraction and added value for tourists; (iii) the use of simple icons, representing the historical and cultural values of olive oil and the cultivation areas; and (iv) increased use of the Internet and social networking to publicize olive oil tourism packages, participating organizations and tourist attractions that can be visited.

8. Poor interactive marketing, a crucially important aspect of tourist services. Proper interaction between companies and customers helps achieve higher levels of satisfaction, involvement and customer loyalty. Thus, if the interaction is positive and the customer is satisfied, he or she will become the best form of product publicity.

9. A misdirected marketing approach focused on the product, not the customer. Experiential marketing is an especially important way to convert a tourist product into an authentic and singular proposition that stirs emotions, and feelings, and that adds value for the customer. Thus, the important thing is not the tourist resort itself, but the experience that can be generated in and around it. It also requires proper management of perceived service quality not only technically, but also functionally.

VI – Conclusions

The present study analyses the potential of olive oil tourism in Spain as an emergent model of tourism based on the search for quality. This model gives the consumer a more active role in the process of purchase and consumption.

This kind of tourism is called gastronomic tourism and gastronomy and its related activities are the main motivations for tourist visits to a particular region or country. Therefore, agriculture and foods are important not only for their tourist value, but also as a variable influencing a tourist's decision-making process.

In Spain, olive oil tourism is in its initial stages. Currently, there are some tourist routes in the principle olive oil production areas, which include important related resources that can be exploited in the field of tourism. Additionally, Spain is known for being the main olive oil producing country in the world and its advantageous position in the cultivation of high quality agricultural foodstuffs emphasizes the notable economic potential of this activity.

However, the success of the olive oil tourism depends on the design and improvement of tourist products in order to create culinary tourist experiences that will attract high-income tourists. Therefore, the best strategic option to create integral tourist experiences around olive oil is the organization of one or more related stops on a route in which the tourist will have to pass through various experiential stages including: mill visits, oil tastings, olive oil purchases in "oleoteca" or olive oil bodega and specialty shops visits, museum visits, attendance at fairs and festivals related to olives and olive oil, tasting local gastronomy, landscape and olive farm visits, and accommodation in places associated with olives and olive culture.

In this context, the current lack of cooperation between the potential players in an olive oil tourism route, combined with the inexperience and lack of personnel training among olive oil tourism service providers, the poor business infrastructure, the lack of attractive tourist products, hotel infrastructures and the scarcity of related extra-activities highlight important challenges to developing successful tourism in this field. In addition, the development of a successful olive oil tourist route demands changes in marketing management, such as strengthening interactive marketing and implementing an integral communication plan.

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The case of Hojiblanca

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Abstract. The Group Hojiblanca is a group of Spanish agricultural cooperatives, manly involved in olive oil production. It is currently the largest producer in the world, with an average production of 200,000 t of virgin olive oil and 67,000 t of table olives. It brings together the efforts of more than 50,000 families of olive producers through 96 oil mills and 22 olive processing plants. This paper aims at presenting the Group's history and future projects, that involve strengthening its role as reference olive oil operator in as many links as possible so that member farmers can increase profitability.

Keywords. Market share – Marketing – Production costs – Second-tier cooperative – Table olives – Virgin olive oil.

Le cas de "Hojiblanca"

Résumé. *Hojiblanca est un groupe de coopératives agricoles espagnoles, principalement engagées dans la production d'huile d'olive. Actuellement il s'agit du plus grand producteur mondial, avec une production moyenne de 200 000 t d'huile d'olive vierge et 67 000 t d'olives de table. Il rassemble les efforts de plus de 50 000 familles d'oléiculteurs à travers 96 huileries et 22 unités de transformation d'olives. Le propos de cet article est de présenter l'histoire du groupe et ses projets futurs, pour lesquels il lui faudra renforcer son rôle comme opérateur de référence pour l'huile d'olive pour autant d'aspects que possible afin d'augmenter ainsi la rentabilité pour ses agriculteurs adhérents.*

Mots-clés. *Part de marché – Commercialisation – Coûts de production – Coopérative de second degré – Olives de table – Huile d'olive vierge.*

I – Introduction

Before discussing the case of Hojiblanca, we should like to make some comments on the current situation of the olive sector. The agricultural sector is experiencing financial and price crises; there is uncertainty regarding the EU subsidies; there is greater liberalization, and the most recent evidence is the entry into force of the agreement between the EU and Morocco that affects oil; new plantations are being implemented … To this we have to add the specific context which has led the olive sector into a price situation which makes many olive farms unviable, the main problem being the lack of organization of the production sector. The poorly organized production sector is highly atomized and has to face the great concentration of demand, by means of an oligopoly of operators resulting from the concentration of distribution. The food crises and the devaluation of our produce, worsened by the economic situation, complement this situation in a changing environment where the olive sector structure is also changing.

Against this background, olive producers, cooperatives, have to respond by adapting to the new times. From the very beginning, the Hojiblanca Group has believed in bringing together supply so that production could be better protected, something we think is essential in the current context.

There are five big olive operators who can buy half of the olive oil sold in the world (Deoleo with 300,000 tons; Sovena with 160,000 tons; Migasa and Salov with 150,000 tons; and Acesur with 70,000 tons), and only a small number of groups of producers, led by Hojiblanca with a production of 247,000 tons this year[1].

It is true that these big operators have emerged as a response to the world's large groups of distributors who have a huge market share. The gross value of the Spanish olive oil may be around 3000 million euro, and the world's ten leading retail companies have a turnover of more than 50,000 million[2].

The truth is that the Spanish producers grouped in cooperatives have a weight on the market they are unaware of. According to average production data from the International Olive Council (IOC) of the past five years, production of Spain's cooperatives amounts to 1,331,000 tons on average, which represents 31.6% of the world total; that is, if all Spanish cooperatives marketed jointly all their production they would sell one of every three kilograms of oil.

It is true that we still have a long way to go, if we take into account that the agro-food cooperative movement in Spain still has much to do if compared with other European countries (Table 1). In fact, the first Spanish cooperative (the livestock coop "Coren" from Galicia) is number 54 in the best ranking 100. It is also true that within the agro-food sector, Spain's olive sector and related cooperatives are world leaders. Therefore, we are working on this line of activity, because Hojiblanca S.Coop.And. is open to incorporating more oil mills or oil marketing groups.

Table 1. Ranking of agro-food cooperatives in Europe according to turnover (2010-2011)

Cooperative	Country	Sector	Turnover (million euro)
1. FrieslandCampina	The Netherlands	Dairy	9,626
2. Vion Food	The Netherlands	Meat	8,870
3. BayWa	Germany	Supplies/Commercial	7,903
4. Arla Foods	Denmark	Dairy	7,384
5. Danish Crown	Denmark	Meat	6,954
6. Agravis	Germany	Supplies/Commercial	6,468
7. Südzucker	Germany	Agriculture	6,161
8. In Vivo	France	Supplies/Commercial	6,083
9. DLG	Denmark	Supplies/Commercial	5,494
10. Metsälliltto	Finland	Forestry	5,346
54. Coren	Spain	Meat	1,005
62. Capsa	Spain	Dairy	738
84 Grupo AN	Spain	Multiple sectors	528
87. Anecoop	Spain	Fruits and vegetables	506
95. Hojiblanca	Spain	Olive oil	453

Source: CO-OP Champions.

In fact, during the 2011/12 season, 24.02% of the oil from Andalusian cooperatives and 21.81% of the Spanish cooperatives oil were marketed by the Hojiblanca Group; in total terms, 17.31% and 15,32%. The degree of concentration by province exceeds 88% in the province of Malaga, exceeds 10% in Cadiz (48.61%), Jaén (13.51%), Cordoba (35.34%), Castilla-La Mancha

[1] Data from web pages and press reports.
[2] Means calculated from reports by the Administration (Junta de Andalucía and Ministerio de Agricultura) and from the yearly report on distribution by the consultancy group Deloitte.

(14.86%) and Seville (15.84%)[3].

Hojiblanca, as an instrument for farmers, does not focus only on olive oil, but –upon the request of its farmers– it embraces other sectors such as the table olive, inputs and livestock. In the future there may be more sections.

As will be seen further on, Hojiblanca has lead the process of integration and organization of the olive production sector, drawing cooperatives to come together and better defend their members by means of an unstoppable process driven by the need and undoubtedly improving all members' profitability.

II – The case of Hojiblanca

The Group Hojiblanca is a second-tier cooperative, that is, a union of cooperatives grouping more than 55,000 families of farmers and breeders from Andalucia, Castilla-La Mancha and Extremadura.

At present, it is the world's largest producer of virgin olive oil (7.8% in the 2011/13 season) and table olives (2.6% in the same season), and Hojiblanca is a national leading brand regarding the sales of extra virgin olive oil[4]. It packs some 35,000,000 litres and exports to more than 100 countries, in many of which it is leader: China, United States, Italy, Mexico, Brasil, etc.

The annual turnover is more than 400 million euro, making it the largest agro-food cooperative in Andalusia. In 2010, 451 million; in 2011, 389; the forecast for 2012 being 500 million: fluctuations are related to harvest volume and product value.

1. History

The current "Hojiblanca S.Coop. And." is the result of the combination and merger of several cooperatives that wanted to grow and believed that they could achieve more things if they worked together. Here are the most important milestones:

(i) 21 February 1979. "Aceitunas de Mesa de Córdoba SA" was established, and was the origin of the future cooperative "Acorsa".

(ii) 28 March 1980. "Cordoliva" was established, a cooperative grouping some twenty oil mills from Cordoba, and core of one of the two founding firms of "Hojiblanca S.Coop.And".

(iii) 24 November 1987. Articles of association of "S.Coop.And. Oleícola Hojiblanca de Málaga", a second-tier firm initially made up of 13 cooperative oil mills from the north of the province; among them "SCA Olivarera Nuestra Señora de los Dolores de Villanueva del Trabuco", and years later "SCA Olivarera del Guadalhorce", both merged into "SCA Olivarera del Trabuco".

(iv) 3 April 1997. Public presentation in Malaga of the Hojiblanca extra virgin olive oil brand, which is currently the sales leader for this sector in Spain.

(v) 22 June 1998. The King and Queen of Spain visit the new packing plant “Reina Sofía” in Antequera.

(vi) 1st November 2003. Effective merger between "SCA Oleícola Hojiblanca de Málaga" and "Cordoliva SCA" giving birth to "Hojiblanca S.Coop.And". with 42 oil cooperatives in Cordoba and Malaga, becoming the world's biggest producer of virgin olive oil.

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[3] Comparison between production data from Hojiblanca S.Coop.And. and the Agencia para el Aceite de Oliva.

[4] Regarding data from the International Olive Council.

(vii) 1st October 2005. Merger between "Hojiblanca S.Coop.And." and "Aceitunas de Mesa de Córdoba S.Coop.And. (Acorsa)" resulting in a new table olive section with 6 associated cooperatives from "Acorsa". "Hojiblanca" diversifies and the same structure will market the farmers' olive products.

(viii) 1st January 2006. Effective merger with the second-tier cooperative "Suministros Agromálaga S.Coop.And." (founded on 11 August 1982 as "Agrupación Malagueña de Cooperativas del Campo SCL"), which counted on a number of olive cooperatives from the province of Malaga, joined by others from other sectors and provinces, such as Cadiz and Cordoba.

(ix) 1st January 2007. Merger with the second-tier cooperative "Suministros Agrocórdoba S.Coop.And" (established on 21 September 2000) which was mainly made up of cooperatives from "Hojiblanca" oil and olive sections.

(x) 16 October 2007. Signing of a 50% joint-venture between the USA multinational "Cargill" and "Hojiblanca"

(xi) 1st April 2008. Merger with second-tier cooperative "Suministros Cooperativos del Sur S.Coop.And. (Sumicoop)" established on 28 December 1993, and based in El Saucejo, grouping cooperatives from Seville, Cadiz and Malaga.

(xii) 30 September 2009. Opening of the new packing plant of "Mercaóleo SL" for retail olive oils.

(xiii) 1st November 2010. Merger with "SCA Sierra Norte" second-tier cooperative from Seville (set up on 2 July 1973), resulting in 7 cooperatives from Seville and Badajoz joining the Group.

(xiv) 1st October 2011. the merger with "SCA Agropecuaria del Sur" (second-tier cooperative) became effective and as a result the livestock farming section was set up, comprising 3 cooperatives (Olvera, Teba-NS Cabeza and Almargen)

(xv) March 2012: trade agreement with Moreno SA for setting up "Agroalimentaria Musa SL", extending the commercial portfolio of sauces and wines and promoting that of oils from the Cordovan firm.

(xvi) October 2012: agreement with "Deoleo", pending ratification by the assembly.

2. Activities

At present the Hojiblanca Group has four independent sections:

A. Oil

It is the most important section volume-wise. This year production has amounted to 246,000 tons. It has three industrial centres: Antequera (2 packing plants: Reina Sofía and Mercaóleo, the latter shared with Cargill at 50%), Guarromán (Jaen) and Villarrubia-Córdoba.

There are 96 oil companies currently operating in this section: 21 in Jaen, 27 in Cordoba, 25 in Malaga, 2 in Cadiz, 4 in Ciudad Real, 1 in Badajoz, 12 in Seville and 4 in Granada.

It has the following extra virgin olive oil brands: Hojiblanca, Cordoliva, Acorsa, Torcaoliva, Olivabella, Dcoop and others for the domestic and international markets.

In October 2012 an agreement was reached with the world's most important olive oil operator, Deoleo (it has 20% of the world's packing market with brands such as Carbonell, Bertolli and Carapelli) by which Hojiblanca becomes shareholder with 10% of the capital in return for the Hojiblanca brand and the packing plant in Antequera; this agreement has to be ratified by the shareholders' meetings. Hojiblanca S.Coop.And. will develop through Deoleo (300,000 tons of packing capacity) its branding project; to this Mercaoleo is added (50% shared with the USA multinational Cargill) with 25,000 tons of packing capacity for retailer brands; as well as brands for its own cooperatives, national and export markets with the brands Dcoop, Cordoliva, Torcaoliva, Acorsa…

B. Olive

It has a production quota of 67,000 tons and 22 associate cooperatives from Cordoba (9), Malaga (9) and Seville (4). It has two industrial plants: Monturque (Cordoba) and Dos Hermanas (company Acyco). It packs and exports most of its production. It operates mainly with the brands Acorsa and Hojiblanca. It is leader in exports to the European Union and reference operator in United States, Arab countries and former soviet republics.

C. Inputs and services

It operates with more than 120 cooperatives and its goal is to lower farmers' and breeders' costs with activities such as: joint purchase and sale of fertilizers and plant health products; Agricultural Technical Department that provides free information and advice to members; mobile telephone service, insurance; shops at the cooperatives; oil making machinery repair service, and other services.

D. Livestock farming

It is made up of 3 livestock cooperatives (1 in Cadiz and 2 in Malaga), involved in jointly buying raw materials for feedstuff, buying and selling animal health products and marketing white pork, although activities will be extended in order to move forward in the value chain.

3. Performance

Hojiblanca sells all members' products, that is, everybody's oil belongs to everybody and has to be marketed through the group, hence its strong position on the market making it a reference operator.

For that the participation of all cooperatives is essential. They are represented by appointees and up to 100 people can attend the meetings.

Hojiblanca pays its members depending on the average market value throughout the year of their oil type and quality.

The role of Hojiblanca has been successful in the sector precisely because of the implementation of clear, agreed, common and applied rules; the involvement of everyone; the realization of decent results; the consolidation of the cooperative as a sound and viable business; as well as the search for horizontal and vertical synergies.

The current Hojiblanca S.Coop.And. is the result of the merger of eight second-tier cooperatives since 2003: the oil coops Cordoliva, Oleícola Hojiblanca de Málaga and Sierra Norte de Sevilla; the input coops Agromálaga, Agrocórdoba and Sumicoop; the livestock coop Agropecuaria del Sur; and the olive coop Acorsa.

The original Oleícola Hojiblanca de Málaga was founded in November 1987 with 13 oil mills associate cooperatives. Today, there are 96 members, highlighting the success in marketing oils. If in 2002, the average oil production was around 35,000 tons, today it has increased six-fold; in the case of olives we have gone from 6 cooperatives with 20,000 tons to 22 cooperatives with 67,000 tons of olive treatment capacity.

4. Future

The objective of Hojiblanca is to ensure maximum profitability for its members by the best possible marketing of its products and reducing costs. To that end it is necessary to have a solid, viable, participatory, plural and transparent company, with clear ideas. We understand that the future work will involve:

(i) consolidating a large agro-food cooperative which is able to better defend its members in a globalized world.

(ii) adding more cooperatives to ensure better opportunities on the market.

(iii) work towards reducing farmers' costs.

(iv) fighting for objectives shared by the sector: product promotion, market management systems, fraud control, etc.

Conclusions

Since it was founded, Hojiblanca Group members are clear as to how to proceed to achieve the highest profitability, which involves reducing costs and improving the marketing of their products. In this sense, it is essential to structure the sector around the weakest link by concentrating supply. Hojiblanca S.Coop.And. has taken important steps in this direction to become production leaders, but further progress is needed as well as participation in the value chain, and therefore is planning to own Deoleo. Because of its size and volume, the Group can cover other activities and have better opportunities on the market. The idea is to become a world reference oil operator, a unifying model in this sector, that can be extrapolated to other agricultural sectors.

In our opinion, the structure of the olive oil sector would be inconceivable today without the influence of Hojiblanca S.Coop.And as the backbone of the production sector and an axis articulating initiatives to support the value chain.

Development of electronic commerce in the Spanish olive oil sector: Regulations and guarantees

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Abstract. In a context of profound crisis, online markets in Spain have experienced an important and almost steady growth of the volume of e-commerce, both in the field of B2B as well as in B2C. However, available statistics show that this growth of the online business is not taking place with the same intensity in all sectors. On the contrary, the agro-food sector in Spain, and the olive sector in particular, is lagging behind regarding the use of the Internet as a marketing channel. This situation is not related to technical constraints but to the fact that companies underutilize the technologies set up for commercial purposes, do not see the internet as a channel to sell perishable products or consumers' perception of lack of security. The Internet offers solutions to some of the problems related to the features that shape the cooperative sector in Spain, such as poor marketing of packed products for the end consumer, little bargaining power with big retailers and confusion and lack of information among consumers when making buying decisions. The evolution of the online market highlights the growing awareness within the olive oil sector of the advantages offered by the commercial use of the Internet. This adds to the efforts made to increase the users' perception of safety in the transactions processed and settled through the Internet. In view of the protective EC regulation concerning consumers and users of distance contracts, we believe that progress will be made within the EU regarding the exponential growth of electronic commerce as a consequence of the correct defence of their economic interests which, undoubtedly, entails greater confidence of users and consumers in this commercial system.

Keywords. Confidence – Consumers' information – Consumers' protection – Contact with consumers – Marketing – Web 2.0.

Développement du commerce électronique dans le secteur oléicole espagnol : réglementations et garanties

Résumé. Dans un contexte de profonde crise, les marchés en ligne en Espagne ont connu une croissance importante et presque régulière du volume de commerce électronique, à la fois entre entreprises et d'entreprise à particulier. Toutefois, les statistiques disponibles montrent que cette croissance des entreprises en ligne n'est pas également forte dans tous les secteurs. Au contraire, le secteur agroalimentaire en Espagne, et en particulier le secteur oléicole, est à la traîne pour ce qui est de l'utilisation de l'internet comme canal de commercialisation. Cette situation n'est pas liée à des contraintes techniques mais au fait que les compagnies utilisent peu les technologies disponibles à des fins commerciales et n'envisagent pas l'internet comme canal de vente de produits périssables, ou à la perception sécuritaire défaillante qu'en ont les consommateurs. L'internet offre des solutions à certains des problèmes liés aux caractéristiques du secteur coopératif en Espagne, tels qu'une faible commercialisation de produits emballés destinés au consommateur final, peu de pouvoir de négociation avec la grande distribution et une confusion et un manque d'information chez les consommateurs lors de la prise de décision d'achat. L'évolution du marché en ligne montre une prise de conscience grandissante du secteur oléicole concernant les avantages découlant de l'utilisation commerciale de l'internet. Ceci s'ajoute aux efforts faits pour augmenter la perception croissante des usagers concernant la sécurité des transactions effectuées et réglées à travers l'internet. Au vu de la réglementation protective de la Communauté européenne concernant les consommateurs et les usagers de contrats à distance, nous pensons que des progrès seront réalisés au sein de l'UE favorisant une croissance exponentielle du commerce électronique comme conséquence d'une bonne défense de leurs intérêts économiques ce qui, indubitablement, entraînera une plus grande confiance des usagers et consommateurs vis-à-vis de ce système commercial.

Mots-clés. *Confiance – Information chez les consommateurs – Protection des consommateurs – Rapport avec les clients – Commercialisation – Web 2.0.*

I – Introduction

It was in 2008 when the worsening of Spain's main macroeconomic indicators became noticeable. For the first time, after a period of 15 years of economic growth, at the end of 2008 the onset of technical recession in Spain was confirmed and today, four years later, far from seeing the end, their consequences compounded and spread, not only in the economic but in the political and social sphere as well. Focusing on the economic front, from the point of view of demand, in 2011 the domestic components increased their negative contribution to the GDP, consumer expenditure having the greatest negative contribution of the domestic demand, with a decrease of 0.7% in comparison with the previous year (Junta de Andalucía, 2011).

This general context contrasts with that of the online market, where an important and almost steady growth of the volume of electronic commerce has been reported in our country, both in the case of B2B as well as in B2C. Thus, in accordance with Instituto Nacional de Estadística (INE, 2012), in 2011 the turnover generated by this format amounted to 187,596 million euro, with an increase of 11.7% year-on-year. Sales through electronic commerce accounted for 13.7% of total sales made by Spanish companies. According to the information provided by the Telecommunications Market Commission (2011), which collects information about electronic commerce transactions settled using credit cards in Spain and which is, thus, closer to the online consumption reality, during the fourth quarter of 2011, electronic commerce in Spain reached a turnover of 2,401.4 million euro, an increase of 25.7% in comparison with the same quarter in 2010; the total number of operations amounting to 36.9 millions. The turnover accumulated in 2011 of electronic commerce in Spain reached a record figure of 9,200.7 million euro, an increase of 25.7% compared to 2010.

However, the available statistics show that this growth of the on-line business is not taken place with the same intensity in all sectors. According to the ePyme 2011 report by Fundetec (2012), Spain's agro-food sector is lagging behind in comparison with the rest regarding the use of the Internet as a sale channel. Although in 2011 around 90.7% of the agro-food companies had a website, 23 points higher than in 2010, only 7.3% of them sold their products on the Internet. Compared with the rest of the sectors analysed, the agro-food sector uses the internet to sell to a much lesser extent.

However, the previous data hide the outstanding effort made by the sector entrepreneurs in 2011 to modernize their businesses, incorporating more ICT products and services in order to encourage competitiveness at this time of economic crisis. Thus, according to Fundetec (2012), 99.5% of the sector companies have internet access, being the second sector with higher level of penetration of this communication channel. It is also the sector that has made the greatest effort to increase its presence on the Internet via website in the 2010-2011 period, with a spectacular increase of 23.5 percentage points in only one year. Other indicators regarding the use of services channelled through this communication network (email, relations with suppliers and clients, bank operations, dealings with the administration, etc.) also reflect a marked growth in the past year.

The previous information indicates that the gap between the agro-food sector and the rest in matter of e-commerce figures cannot be attributed to technical deficiencies, but to a poor utilization of the technology set up for commercial purposes. The main reason pointed out to explain this situation is the "existence of products that are not suited to be sold on the internet" (Fundetec, 2012). However, a growing number of companies are overcoming this obstacle of having perishable products and offer multiple solutions to firms and consumers, ranging from purchasing on an online supermarket, to buying directly from producers with no intermediaries or daily discounts on gourmet products. In many cases, they have been able to gain advantages from a sales channel that uses no intermediaries and thus offers fresher products or products that are difficult to access in other channels and on many occasions with lower price margins, which is an interesting option for consumers. Regarding demand, the opportunities afforded by having this type of consumer in this channel should be taken into account. These consumers have a very specific profile, they are young, have a higher education level and better purchasing power. The new applications that shape the so-called web 2.0, mainly social media, provide much more information about these consumers' needs and their opinions of the products aiming at complying with such needs.

Research conducted in Spain on the olive oil sector shows that it fully shares the characteristics of the agro-food sector: high ICT infrastructure provision, presence on the internet, but reduced usage of it as an online marketing channel[1].

It should be pointed out that the use of the internet offers important potential advantages to the activity of any company, which become more evident in the oil sector, mainly composed of networked cooperatives, which in the case of Spain share the features of the Mediterranean Cooperative Model, that is, highly scattered companies with low turnover (CCAE, 2006).

The above-mentioned characteristics bring out problems that have been traditionally present in the development of the oil sector, among which we can highlight poor marketing of packed consumer products, low bargaining power with big retailers and the confusion and disinformation faced by consumers when making buying decisions. At present, Internet is presented as one of the possible solutions to overcome such deficiencies and a growing number of oil companies are capitalizing on these advantages. Focusing on the developments within the commercial sphere, the objective of this paper is twofold: on the one hand, to analyse to what extent the olive oil sector is making use of the Internet in order to address the deficiencies that have traditionally accompanied its development: the confusion among consumers regarding the product attributes and the difficulty to reach the final client, both on the domestic market as well as abroad; on the other, to identify the latest regulatory developments aimed at providing legal certainty for the parties involved in online transactions and which respond to one of the main obstacles faced by this type of trade: the user's lack of confidence. In order to attain these objectives, this paper is structured in the following manner: following this introduction, the next section will analyse the main areas where the olive oil sector can use the Internet to solve some of the main problems that are currently hampering its development; the third section will review the current situation and latest developments within the legal framework which is aimed at introducing legal certainty and security in online trade transactions; the paper finishes by summarizing the main conclusions.

II – Advantages of the internet in the olive oil sector

1. Communication with stakeholders

The environment where the oil companies work involves facing an increasingly open market, with more sophisticated clients who demand a greater diversity of choices and who are more sensitive to the information directly related to the quality of the end product and the externalities derived from the production process. The increasing awareness of consumers towards environmental degradation and the social impact of the companies' actions (European Commission, 1999) are reflected on their buying decisions and consumption habits over the last two decades[2]. Aspects such as compliance with Social Corporate Responsibility[3], organic

[1]See, among others, Mozas *et al.* (2007) and Moral *et al.* (2012).

[2]Several studies such as that of Foretica (2006) show that there is a lack of communication concerning a well-structured and conditioned SCR according to different socio-cultural strata of consumers, which prevents the general public from having access to this information and limits the dissemination of the concept of responsible consumption. And this, despite its growing impact on the consumers' buying decisions. Thus, the report by Foretica (2008) illustrates that 82.4% of citizens show a clear preference for products and companies having a good image concerning SCR, provided that price conditions are at least identical. Likewise, a study carried out by the Confederation of Consumers and Users (2008) shows how

products or the features of the socio-economic environment where products are produced (designations of origin) are increasingly taken into account, not only by consumers but by the rest of the s*takeholders* as well (share-holders or members, workers, suppliers and the society in general) who will judge business actions and, whether they accept them or not, will influence in the permanence and sustainability of the companies (Berbel *et al.*, 2007).

The consumers' higher demand for information can hardly be satisfied with labels that are already crowded with advertising and a sea of information required by the changing European, domestic and regional legislation, which in some cases has to be included in the different co-official languages, thus resulting in inconvenient formats which consumers find difficult to understand. Besides, olive oil consumers have traditionally faced disinformation regarding varieties, quality and properties of this product.

The disinformation and confusion faced by consumers when buying virgin olive oil can be overcome with services provided through the internet, among which the social media and websites can be highlighted, since they can become a fundamental element in the communication strategy of the companies of this sector. As Baourakis *et al*. (2002) pointed out, Internet is the best information channel for products such as organics, due to the huge amount of information related to the product features that is needed by consumers in order to make a purchase decision. The possibility of having a bidirectional flow of information between the company and consumers through the social media or websites makes the internet a space that can be used as a PR tool, as an advertising instrument to promote sales and is essential in developing relationship marketing initiatives aimed at keeping customers loyal (Rodríguez, 2006). As noted by Evans and Wurster (1997), this greater wealth of information is more useful when the products to be marketed have a strong connotative context, as is the case with some organic or DO agro-food products. Besides, it is important to stress that one of the biggest benefits of the Internet as a promotion channel is its low cost, offering small companies, which are dominating the production of agro-food products, the same possibilities to be on national and international markets as the larger ones (Baourakis *et al*., 2002). In fact, authors such as Stockdale and Standing (2004) pointed out that these companies are the ones who can really take full advantage of the speed and flexibility of virtual environments because of their smaller size.

The potential of the Internet as a communication channel has not gone unnoticed by the sector and many websites have mushroomed where a lot of emphasis is placed on informing about the organic nature of the product, its socially responsible production and the singularities of the economic and social environment where they are produced. Thus, there are many companies in this sector providing stakeholders with information about their compliance with the social corporate responsibilities and even the compliance of other firms they have business dealings with (e.g. Mandicplace)[4]. In the case of *organic products*, in order to face some of the main obstacles related to the decreased demand in Spain[5], companies in the sector (e.g. Oro del

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having information on a company's social and environmental performance could be used by many consumers (75% of the respondents) in the buying process.

[3]In the oil sector, the prevailing business model, the cooperative, is inherently socially responsible, and decisions are made democratically taking into account business, social and cultural arguments.

[4]See as an example, the online gourmet shop Mandicplace (http:// www.mandicplace.com), where a selection of the best olive oils from Spain is offered. According to the website, the company selects its suppliers based on similar corporate values such as social actions, environmental awareness and corporate social responsibility (the use of renewable energies, organic farming, nature preservation, recovery of traditional methods and cultures, and social and labour insertion). Besides, MandicPlace donates 0.5% of their annual sales to any health- (cancer) or education-related causes or social actions in developing countries.

[5]That is, the existing price differential between organic and conventional food products, the poor distribution –scarcity of points of sale and supply assortment– and, lastly, the consumer lack of knowledge and confusion regarding this type of food products which, on occasions, is a source of distrust (Schmid *et al*.,

Desierto) use the web as a sales channel to avoid the costs associated to intermediaries, offer an accessible and close channel to clients and provide sufficient information on the qualities of the product. On the other hand, in view of the growing interest of consumers in the place of origin (cultural, socio-economic, traditions, environment, etc.)[6], the Internet also offers the possibility to detail and inform in a friendly manner about the reputation of a product marketed under a designation of origin. There is a growing number of companies (e.g. Cerespain) who, aware of this fact, offer information about their DO products, including olive oil.

2. Marketing on the domestic market

Over the past decades, a substantial change has taken place in the agricultural sector, that has resulted in a change from a production-oriented to a market-driven agriculture. Thus, one of the characteristics that traditionally defines the olive sector is the poor participation of producers in the marketing of their products, which has prevented them from retaining an important part of the revenues generated in the marketing process. At present, agrofood marketing has become the fundamental pillar upon which the necessary and inevitable modernization of agriculture is based.

Within the above-mentioned context, the use of the Internet as a giant virtual centre with no specific physical location or timetable, as a means to market production, opens up great opportunities for SMEs too, offering certain advantages in comparison with traditional means. According to Rosello (2003) the web, as a tool for promoting and communicating with clients, allows for reduced promotion costs, avoids physical movement, offers the possibility to constantly update the catalogue of products, encourages the interaction with final clients, provides immediate information on the demand requirements, can reach the whole world, or is used to assess the repercussion of the promotions by controlling the number of visitors and their origin. There is a growing number of companies who avoid intermediary costs and benefit from the previous advantages by selling on the Internet (e.g. OlivaOliva.com)[7].

3. Exports

One of the challenges faced by the Spanish olive sector, which accounts for near 46% of the world's olive oil production[8] (International Olive Council, 2011), is the marketing of its products on foreign markets. Indeed, although the statistics indicate that Spain is the main exporting country of olive oils (United Nations, 2011), it should be noted that around 80% of this oil is sold in bulk (Torres, 2008), other countries, mainly Italy, benefitting from the added value generated in the packing process and selling to international markets under an Italian brand[9]. In this paradoxical context, Internet, as a channel of information, promotion and sales that facilitates

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2007; Tsakiridou et al., 2008; Roitner-Schobesberger *et al.,* 2008, Hamzaoui and Zahaf, 2008; Padel and Foster, 2005; Radman, 2005; Vega, 2011).

[6]Some studies (Espejel *et al.*, 2007) have shown the importance attached by consumers to the place of origin, the land, the climate, and know-how of a given geographical area, since together with the strict controls applied to these products by the Supervisory Councils, they are seen as a sign of quality and safety.

[7]An example of these online sale initiatives is found in OlivaOliva.com (http://www.olivaoliva.com) which supplies the product directly from oil mills located in 16 provinces in Spain to the consumer's home, with no intermediaries, and in many cases pack-to-order to guarantee freshness.

[8]According to the IOC (2011) world olive oil production amounted to 3,024,000 tons in the past season for which there are total (provisional) data available (2009/2010). Of this, 2,245,500 tons, 74.25%, corresponds to the production of the European Union. Spain is a leading producer in the EU contributing 1,396,300 tons in the above-mentioned season, 62% of the Community production.

[9]In 2010, Spain exported 420,233 tons of olive oil to Italy, 50% of total olive oil exports (Ministerio de Industria, Comercio y Turismo, 2011). According to the IOC, the production of olive oil in Italy in the 2009/10 season was 460,000 tons. The Italian olive oil sector satisfied a domestic demand in that season that amounted to 675,000 tons and a demand of 165,000 tons (IOC) from outside Europe.

contact with trading partners from all over the world, is an opportunity harnessed by Spanish companies to increase their portfolio of clients and sell abroad. This presence is realized either individually (e.g. Asoliva)[10] or taking advantage of platforms that support electronic markets where hundreds of companies from different countries interrelate in order to secure trade transactions (e.g. Ecospain)[11]. The evolution of the Internet towards the web 2.0 offers a new generation of electronic markets in the form of B2B social media (e.g. Grera.net), which include commercial functions of the traditional format of 2.0 tools to facilitate even more interrelations and contact with companies that are part of this network. It adds to traditional electronic markets, automated processes which on a periodical basis offer potential clients, suppliers, offers and quotations of their interest, at the same time as they offer more functionalities, such as in-house mail, working groups, business events, besides others such as assessment of other users.

III – Internet contracts from a legal perspective

1. Background

As mentioned above, electronic commerce has experienced a favourable evolution in the past years. Even at times of severe economic and financial crisis, and in areas where, at the beginning, the implementation of this commercial technique was more than questionable. Take for example the market for perishable products and especially agro-food products.

There are many reasons to justify the exponential evolution of electronic commerce, of which I should like to stress the consumers increasing confidence in purchasing on the Internet. Thus, a situation in which users are very reluctant to buy products or services on the internet has turned into exactly the opposite scenario. Indeed, the Internet appears as an additional (virtual) space, where you can find, 24 hours a day, an updated offer of products and services which are often sold at more competitive prices than on conventional markets.

The consumers' increased confidence in the internet is the result of a series of circumstances, and the adoption of a protective legal framework is specially significant, since it introduces legal certainty and security in commercial transactions, among others the information obligations planned for the pre- and post-contracting phases as established in Directive 2000/31/EC on the Information Society and electronic commerce.

Now, several years after the entry into force of this Directive and upon approval of Directive 2011/83/EU of the European Parliament and of the Council, of 25 October 2011, on consumer rights, we should like to examine the new legal framework in the EU regarding consumer protection in the area of contracts and, in particular, in the field of conclusion of distance contracts, whose application to electronic contracts is clear, the latter being a special type of the former. Indeed, it is an interesting analysis which will help to determine whether in the EU electronic commerce will be able to keep up this exponential growth in the coming years, or will eventually experience a recession due to the expected new level of consumer protection.

[10]Examples of the use of the Internet to reach foreign markets are found in Asoliva.com, ASOLIVA (Spanish Association of Olive Oil Industries and Export Trade), private and non-profit entity which is currently made up of 59 olive oil exporting companies from several provinces in Spain, mainly Andalucia and Catalonia, whose sales outside Spain account for more than *95% of domestic olive oil exports* and between *50 and 75% of exports of olive oil in bulk*, depending on the season (See http://www.asoliva.es).

[11]An initiative in the field of electronic markets that should be highlighted is that of Ecospain (http://www.ecospainb2b.com), a wholesale market for companies to buy and sell certified organic products with no intermediaries. This portal can only be used by those Producers, Processors or Traders (hereafter organic suppliers) who have the corresponding organic certification issued by Spain's Regional Governments.

That said, bearing in mind this objective, it should be stressed that it is not our intention to examine the above-mentioned innovative regulatory instrument in depth. Indeed, in view of the short time and space available for this presentation, our study is more modest and aims to analyse only some provisions in this Directive devoted to consumer protection in the above-mentioned contracting context. It is an interesting study for two reasons; namely, because this set of rules enjoys preferential applicability even in areas where there are already specific rules (as is the case in telematic contracting). In this sense, the second section of Article 6(8), when establishing information obligations for distance contracting, mandates that "*without prejudice to the first subparagraph, if a provision of Directive 2006/123/EC or Directive 2000/31/EC on the content and the manner in which the information is to be provided conflicts with a provision of this Directive, the provision of this Directive shall prevail*"([12]).

Besides, the importance of this study relates to the fact that the contents of the Directive will pervade the legislative framework of EU countries, who will be obliged to implement it before 13 December 2013 ([13]), and as a consequence both will be aligned and thus the level of consumer protection will be standardized across the Community territory in the field of distance contracts.

2. Levels of information to consumers

A. Information as a means of protection

One of the means traditionally used by Community legislators to protect consumers in the market has been to increase the level of information about specific commercial offers. In fact it is a question of compensating for the information asymmetry that exists on the competing market by establishing the obligation for companies to provide consumers and users with the relevant information on the products and services offered, in such a way that they can make rational, responsible and economical choices, without wasting time and money.

Thus, Community legislators play a fundamental role in the area of distance contracting, especially in contracts using information technologies, since in this case contractual obligations arise without the simultaneous physical presence of the contracting parties, and without the opportunity to experience the subject matter of the contract first-hand. For this reason, through Directive 2000/31/EC, Community legislators have shown –as previously noted– a concern to provide a high level of relevant information for consumers in the area of electronic contracting.

Therefore, let us look at what information requirements are envisaged in the new regulatory instrument concerning telematic contracting.

B. Information requirements envisaged in the new Directive

After a careful reading of Directive 2011/83/EU, we can infer that Community legislators have imposed a rigid information obligation to good and service providers, when mandating in Article 6(1) that *"before the consumer is bound by a distance or off-premises contract, or any corresponding offer, the trader shall provide the consumer with the following information in a clear and comprehensible manner".*

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[12]Even when in the definition of scope in Article 3 mandates that *"if any provision of this Directive conflicts with a provision of another Union act governing specific sectors, the provision of that other Union act shall prevail and shall apply to those specific sectors".* (see Miranda Serrano L., "La Directiva 2011/83/UE sobre los derechos de los consumidores: una nueva regulación para Europa de los contratos celebrados a distancia extramuros de los establecimientos mercantiles", Cuadernos de Derecho y Comercio, 2012, in press).

[13]Although Article 28 of the Directive establishes, under the title *"transposition"*, that *"Member States shall adopt and publish, by 13 December 2013, the laws, regulations and administrative provisions necessary to comply with this Directive"*, it is true that Community legislators have established a new term for the entry into force and application of these internal provisions, when mandating later in the Article that Member States *"shall apply those measures from 13 June 2014"*.

Then it is clear that the obligation to inform about the commercial offer is defined by legislators from a three-fold perspective; namely, by the its timing, format and content. First of all, information shall be provided before the contractual relationship is established, because in this way, consumers will be able to make a rational decision about the contracting of goods or services.

Secondly, information shall be provided in a clear and evident way, so that target consumers (for whom such products and services are intended) can assimilate it easily. In this sense, two comments can be made. On the one hand, and in view of the linguistic diversity within the EU territory, Community legislators have allowed member States to introduce in their respective national legislations *"…language requirement regarding the contractual information, so as to ensure that such information is easily understood by the consumer …"* [Art. 6(7), Directive]. On the other, the Directive mandates that the contractual information if provided on a durable medium shall be legible [Art. 8(1), Directive] and, in any case, with the confirmation of the contract concluded within a reasonable time, and at the latest at the time of the delivery of the goods or before the performance of the service begins [Art. 8(7), Directive].

Thirdly, this information shall necessarily refer to a series of points which allow consumers comprehensive awareness of several defining elements of the contract to be concluded, as well as the effects derived from its conclusion. For instance, the identifying data of the other contracting party, the subject matter of the contract, the payment and delivery method (indicating the date), the system for processing claims and its functioning or the definition of the withdrawal right itself. It is thus a wealth of data which, as legislation points out in Article 6(5) of the Directive, *"…shall form an integral part of the distance or off-premises contract and shall not be altered unless the contracting parties expressly agree otherwise"*.

3. The right of withdrawal as a protective tool for consumers

Another means of protection envisaged by Directive 2011/83/EU in the field of contracts is represented by the recognition of the withdrawal right in favour of consumers and users, that is, the right to withdraw from a distance contract without having to refer to proper reason and only on condition that certain format, content and timing requirements are met as provided for in the legislation. As generally established in Article 9(1) when it mandates that *"…the consumer shall have a period of 14 days to withdraw from a distance or off-premises contract, without giving any reason …".* In any case, this wide recognition of the right of withdrawal contained in Article 9 should be systematically interpreted with Article 16 of the Directive, since, on the basis of several reasons, different assumptions are taken into consideration where this right has been directly eliminated. Consider, for example, *"the supply of goods or services for which the price is dependent on fluctuations in the financial market which cannot be controlled by the trader and which may occur within the withdrawal period*"; *"the supply of goods which are liable to deteriorate or expire rapidly"*; or *"the supply of sealed audio or sealed video recordings or sealed computer software which were unsealed after delivery"* [vid letters b), d) and i) of Article 16 of the Directive.

Thus, we will now present an outline of the new legal arrangements concerning the right of withdrawal established for distance contracts, and we will pay attention to the main elements defined in the Directive.

(i) Withdrawal period: As stated above the Directive establishes that consumers shall have a period of 14 days to exercise their right of withdrawal. It should be noted that this basic period may be extended if the trader omits in the information for consumers the existence of this right. Thus, in this case, *"…the withdrawal period shall expire 12 months from the end of the initial withdrawal period …"* [Article 10(1) of the Directive]. But, when does it begin? According to Article 9(2) of the Directive, the 14-day period starts the day on which the consumer acquires physical possession of the ordered goods, but in the case of multiple or compounded goods with deferred delivery, the day from which we start counting shall be the day the consumer acquires physical possession of the last lot or piece. Conversely, in the case of contracts for regular delivery of goods during a defined period of time, the withdrawal period shall expire after 14 days from the day on which the consumer acquires physical possession of the first good [Article 9(2), (iii) of the Directive].

(ii) Formalities in the exercise of the right. This is a relevant point, and its regulation allows the protection of consumers to be increased or decreased. In this sense, the need for any kind of formality would be detrimental to the protection of this contracting party. For this reason, in order to increase the consumers' and users' protection level, Article 11(1) of the Directive has provided for this right to be exercised through an unequivocal statement targeted to the trader setting out the decision to terminate the contract. For that, the model withdrawal form attached to the Directive shall be used, or any other type of statement.

Besides, and in order to speed up the effects of the withdrawal, the theory of issuance is followed, according to which the consumer shall have exercised his right of withdrawal when the communication concerning the exercise of the right of withdrawal is sent by the consumer before the period has expired [Art. 11(2)], whether or not the trader has received it. For this reason the burden of proof shall be on the consumer [Art. 11(4)].

(iii) Legal consequences of the exercise of the withdrawal right. As previously mentioned, the exercise of this right allows consumers to dissociate from the contract concluded, terminating the obligations of the parties. So says the legislative authority in Article 12 of the Directive when it mandates that *"The exercise of the right of withdrawal shall terminate the obligations of the parties to .... perform the distance contract...."*.

Consequently, once this right is exercised, the contracting parties shall enter into a process of settlement of possessions, in which benefits are restored. Thus, and regarding the trader, he shall reimburse all payments received, including the costs of delivery, not later than 14 days – and using the same means of payment– from the day on which he is informed of the consumer's decision to withdraw from the contract.

In order to guarantee that consumers return the goods, the trader has the right to withhold the reimbursement *"…until he has received the goods back, or until the consumer has supplied evidence of having sent back the goods …"* [Art. 13(3) of the Directive].

As far as the consumer is concerned, he shall send back the goods subject of the contract not later than 14 days from the day on which he has communicated his decision of withdrawal. In this sense, it will be sufficient if within this period he sends back the goods to the trader or to a person authorised by the trader [Art. 14(1) of the Directive]. In any case, the consumer shall bear the cost of returning the goods, *"…unless the trader has agreed to bear them or the trader failed to inform the consumer that the consumer has to bear them"* [Art. 14(1) of the Directive]

In every case, and regardless of the cost of returning the goods, the consumer shall not be liable for any diminished value of the goods traded through the terminated contract, provided that this diminishment results from the handling of the goods other than what is necessary *"…to establish the nature, characteristics and functioning of the goods …"*. Obviously, any manipulation of the products that exceeds the above-mentioned cliché shall imply the accrual of the right of compensation by the consumer, except when the trader has failed to provide notice of the right of withdrawal, in which case *"the consumer shall in any event not be liable for diminished value of the goods …"* [Art. 14(2) of the Directive].

IV – Conclusions

Internet allows for the promotion of products offered on a global market at a low cost and contact with worldwide clients/importers or distributors as well. If the company is able to perceive the opportunities derived from the strategic use of its web, it will try to offer quality resources which facilitate contact with clients on domestic and international markets. However, available statistics suggest that, despite the important efforts made by the sector companies to increase the use of ICTs, they generally underuse the potential of the internet as a channel to sell goods and services.

In order to solve this situation, efforts are needed in different areas, particularly those aimed at increasing users' perception of safety regarding transactions processed and settled on the Internet. In view of the protective nature of the Community's regulatory activity regarding consumers and users in the field of distance contracts, we believe that in the EU further progress will be ensured to develop exponentially electronic commerce as a result of the correct defence of their economic interests that, of course, supports the consumers and users' greater confidence in this type of commercial system.

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Marketing organic olive oil: From fork to field

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Abstract. In this paper we illustrate the use of concept of business model as a tool for a successful fork to field approach in marketing organic extra virgin olive oil (EVOO). Two case studies help understanding the potential of business model generation to successfully creating and delivering value to the company and its customers. Lack of information and market transparency makes it very difficult for farmers and distributors to make efficient strategic marketing plans on organic EVOO. The proposed tools to design business models may help to reduce the risks and further develop the organic EVOO market.

Keywords. Organic olive oil – Marketing – Business model.

Commercialisation de l'huile d'olive biologique. De la table à la ferme

Résumé. *Dans cet article, nous illustrons l'utilisation du concept de modèle d'entreprise comme un outil pour aborder avec succès la commercialisation de l'huile d'olive extra vierge bio «de la table à la ferme». Nous présentons deux études de cas pour aider à comprendre le potentiel de génération de modèle d'entreprise pour créer et offrir de la valeur à l'entreprise et à ses clients. Le manque d'information et de transparence du marché rend très difficile pour les agriculteurs et les distributeurs de faire des plans de marketing stratégique efficaces pour la commercialisation de l'huile d'olive extra vierge bio. Les outils proposés pour concevoir des modèles d'entreprise peuvent aider à réduire les risques et à développer davantage le marché de l'huile d'olive biologique.*

Mots-clés. *Huile d'olive biologique – Marketing – Modèle d'entreprise.*

I – Introduction

The market for organic olive oil combines the premium characteristics of extra-virgin olive oil (EVOO) with those of organic certification. By legal definition, organic olive oil may solely be extra-virgin, so when we speak of organic olive oil we actually speak of organic EVOO.

No reliable figures currently exist on the global market of organic EVOO.

With respect to land area, in 2010 organic and in-conversion olive plantations covered 491,400 hectares, about 5.3% of total olive-planted area (Research Institute of Organic Agriculture FIBL, 2012). In 2000, the area was only just a little less than 206,000 hectares (IOBOOO, 2012). Apart from these basic figures, few data exist on the market.

In Germany, the GfK household panel reports –in 2011– 5,096 litres of organic EVOO purchased, for a total household purchases of 23,134 euros. The value market share is 15.2% while the volume share is 16.6% –quite an impressing market– and the growth rate is 3.1%. Surprisingly, in Germany organic EVOO appears to be cheaper –on average– than conventional EVOO (Schaack, 2012).

In Italy, while organic food supermarket sales grew 8.9% in 2011, sales of organic vegetable oils (including EVOO) decreased of 18% with respect to 2010, representing a market share of only 1.7% (ISMEA, 2012). At the same time, ISMEA (2011) reported that organic EVOO sales grew up of 10.4% in 2010.

Sparse information exists on other countries.

If little market data exist, even less is known about more modern marketing channels and business models. Performing a Google search on "organic olive oil" combined with "e-commerce" yields 14,300 results, while the same search without the word "organic" yields 466,000 results. With large approximation, we can conclude that *organic* olive oil e-commerce operations are about 3% of total olive oil e-commerce, but we ignore the overall sales volume and value of organic EVOO e-commerce.

Lack of information and market transparency makes it very difficult for farmers and distributors to make efficient strategic marketing plans on organic EVOO. In this paper we will present a method and some tools to design business models for the future of the organic EVOO market, and will show the risks embedded in making plans without fully acknowledging the risk of operating in a niche market with high uncertainty and low transparency and without taking in consideration consumer needs. For successful marketing of organic EVOO, a company should have clear for whom is creating value and how this value can be created in a profitable way. We will show how the concept of business model may help a company to be customer focused, in order to generate a value proposition that targets the needs of the final consumers. In other words, business model is a tool for a successful fork to field approach, and we will illustrate its usefulness in two case studies applied to organic EVOO.

II – Background

No generally accepted definition of a business model exists. Apparently the first authors to use the term were Bellman *et al*. (1957), but its popularity is much more recent (Osterwalder *et al*., 2005). Table 1 report the occurrences of the term "Business Model" found in SCOPUS, one the largest abstract and citation database of peer-reviewed literature. The first occurrence in the Source Title was in 1985, while in the Abstract was in 1975 (not reported in the table). Globally we counted 1524 occurrences (of which 1492 after 1999) in the Title and 8049 in the Abstract (7102 after 1999). The recent exponential growth of academic interest on the topic is quite evident.

In the last decade, three studies attempted to review the existing definitions and propose integrative frameworks for characterizing the business model concept.

Shafer *et al.* (2005) reviewed 12 different definitions of a business model, and found 42 different components across these definitions, that were classified in four basic clusters: Strategic Choices, Value Network, Create Value, Capture Value. Out of this analysis, Shafer *et al*. (2005) proposed the following (unifying) definition of a business model: *a representation of a firm's underlying core logic and strategic choices for creating and capturing value within a value network.*

According to Morris *et al*. (2005), the business model is distinguished but related to other managerial concepts e.g. business plan (which is more operational) and strategy (strategic elements are part of the model). By reviewing 30 definitions in 19 studies (seven of which supported by empirical evidence in the form of surveys or case studies) they proposed a framework composed of six basic components, each addressing a key question: (i) How will the firm create value?; (ii) For whom will the firm create value?; (iii) What is the firm's internal source of advantage (core competencies)?; (iv) How will the firm position itself in the marketplace?; (v) How will the firm make money?; and (vi) What are the entrepreneur's time, scope and size ambitions?

Osterwalder *et al.* (2005), in their ontological paper on the business model concept, review the literature on business models and perform a survey on 62 practitioners, to conclude that a lot of the confusion about business models "stems from the fact that when different authors write about business models they do not necessarily mean the same thing". They therefore produce a classification of the literature in three different categories of business model conceptualization that they consider hierarchically linked to one another. These three levels of the business model concept define a business model as: (i) an abstract overarching concept that can describe all real world businesses; (ii) an abstract taxonomy of different types of business, each model describing a set of businesses with common characteristics; and (iii) a conceptualization of a particular real world business model.

Table 1. Occurrences of the term "Business Model" in peer-reviewed literature

Year	In Title	In Abstract
2011	278	1,076
2010	259	1,027
2009	213	887
2008	138	802
2007	144	717
2006	114	639
2005	97	566
2004	76	440
2003	76	400
2002	37	205
2001	32	199
2000	28	144
1999	9	65
1998	8	42
1997	7	26
1996	3	29
1995	1	12
1994	1	8
1993	1	2
1992	1	2
1991	0	3
1990	0	4
1989	0	3
1988	0	1
1987	0	2
1986	0	1
1985	1	1

Source : SCOPUS database (1985-2011)

These different concepts, although distinct, compose a business model concept hierarchy as depicted in Fig. 1.

On the basis of this hierarchical approach, Osterwalder *et al*. (2005) propose the following definition of a business model:

A business model is a conceptual tool that contains a set of elements and their relationships and allows expressing the business logic of a specific firm. It is a description of the value a company offers to one or several segments of customers and of the architecture of the firm and its network of partners for creating, marketing, and delivering this value and relationship capital, to generate profitable and sustainable revenue streams.

In a way similar to Shafer *et al*. (2005), they review the 15 most quoted studies and consider the business model components mentioned by at least two authors. They purposely exclude all elements related to competition and to business model implementation, which they consider related but external to the business model. They end up with 9 building blocks or components. These nine components were subsequently further refined and form the basis of the "canvas" approach presented in Osterwalder and Pigneu (2010), which is a toolbox for analysing and generating business model widely used by practitioners.

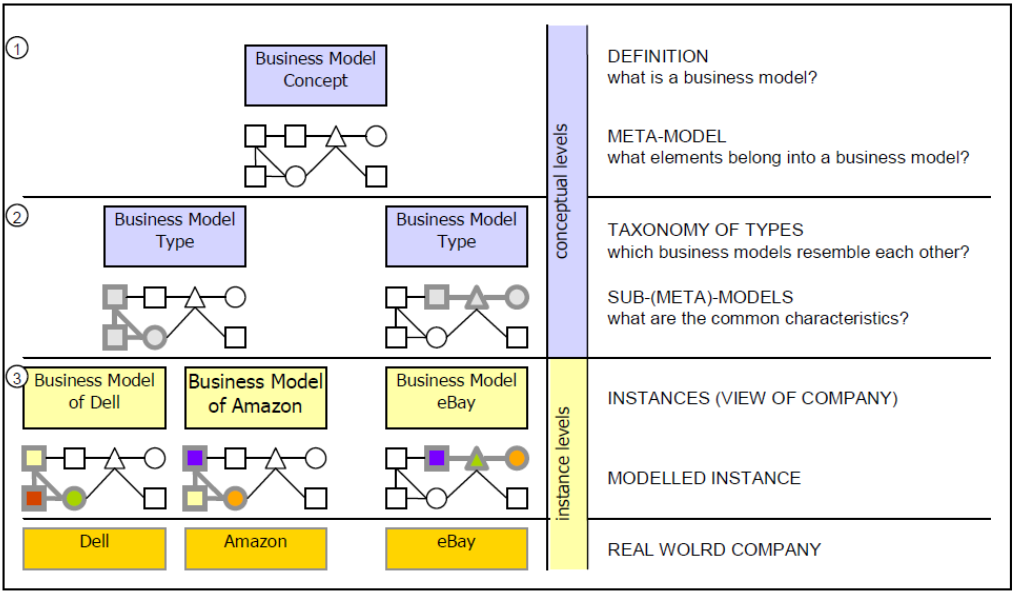

Fig. 1. Business Model Canvas (from Osterwalder *et al*., 2005).

III – Methods

In order to investigate alternative value creation approaches in the organic EVOO market, we have combined two different approaches to business model generation.

The first approach is the so called "business model canvas", composed of nine building blocks, proposed by Osterwalder and Pigneu (2010), which we mentioned in the previous section. The canvas is shown in Fig. 2, and is sourced by the authors as a Creative Commons licence.

The canvas is used in an interactive way to help to capture, visualize, understand, communicate and share the business logic.

The second approach is the business model experimentation template proposed by Sinfield *et al*. (2012). Its components are six, and they follow a logical order each addressing a key question: (i) Who is the target customer?; (ii) What need is met for the customer?; (iii) What offering the business will provide to address that need?; (iv) How does the customer gain access to that offering?; (v) What role will the business play in providing the offering?; and (vi) How will the business earn a profit?

The business model development template is shown in Fig. 3. The answer to each question will represent a decision with different possible outcomes, in the templates represented by numbers. Choosing a different outcome for just one component can often result in a substantially different business model. According to Sinfiled *et al*. (2012), business model experimentation consists in a series of "thought experiments" that provide a means to methodically and routinely explore multiple business model alternatives, in order to enable business model innovation.

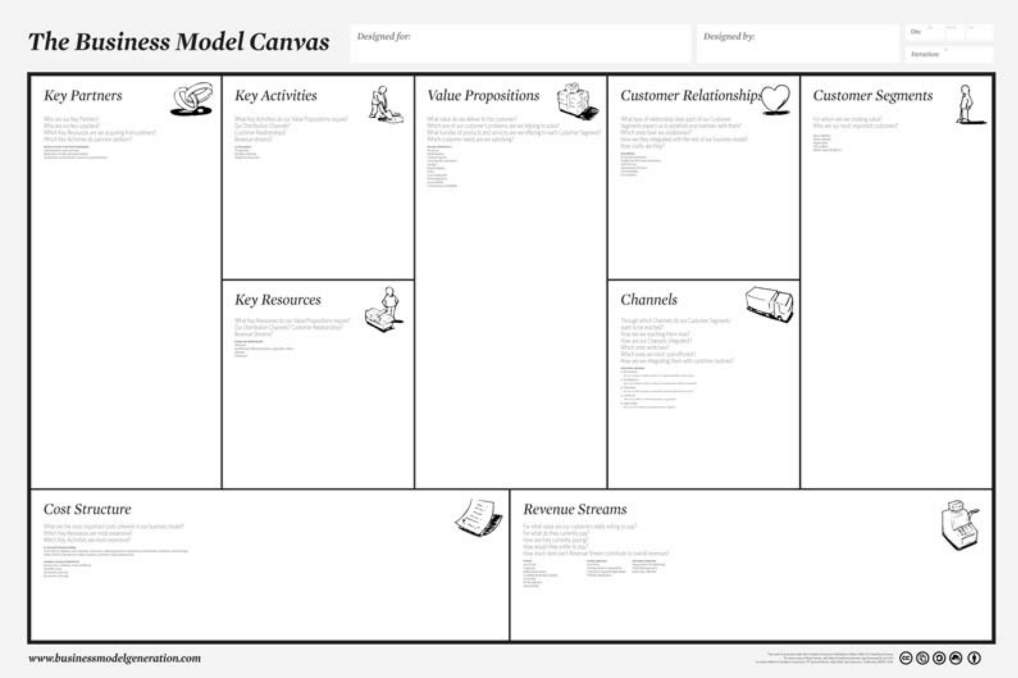

Fig. 2. Business Model Canvas.

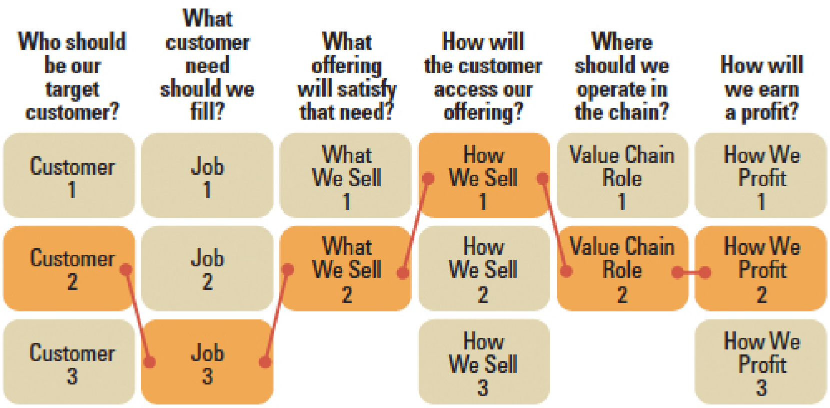

Fig. 3. Business model development template (from Sinfield *et al*., 2012).

Both approaches consider business model as a process to examine alternative approaches to value creation in a business, and complement each other for conducting what-if scenario analysis of interrelated strategic choices. By using both the "canvas" and the "template", the business model provides entrepreneurs with a framework to take decisions, while encouraging them to seek complementary relationships among building blocks and components through unique combinations, and ensuring consistency with the goal of sustaining competitive advantage and profitability, as advocated by Morris *et al*. (2005).

IV – Results and discussion

Two case studies will be presented by using the canvas approach to illustrate how different business models can be studied and evaluated.

The Business model development template (Sinfield *et al*., 2012) will complement the canvas model in the second case study, to show how business model alternatives can be generated in practice.

1. Case study: Kailis organic olive grove (AUS)

Kailis Organic Olive Groves began producing Premium Organic EVOO in 2000, with olives groves and processing facilities located in Western Australia. Kailis Organic sells their premium range of Greek monovarietals (Kalamata and Koroneiki), their "Chef's Premium Blends" of Frantoio (50%), Leccino (25%) and Coratina (25%) varieties, as well as organic extra virgin olive oils infused with blood orange, lime and lemon. In-conversion EVOO is sold by a separate brand – Splish – originally bottled in an "innovative" Tetrapak Crystal carton targeted to the mass-supermarket channel, and also towards increasing the company's exports.

In 2009 the company sold 160,000 litres of extra virgin olive oil of which 57% was organic (Johnson, 2010). About two-thirds of those sales were for Kailis Organic branded products, with the remainder sold into the bulk commodities market. 80% of its products were sold to domestic markets, while exports – to seven countries, including Germany and USA – accounted for the remaining part. In 2010 the company, in an attempt to overcome lowering oil prices, made an 1800 hectares acquisition of the failed Australian agribusiness Great Southern in a bid to become one of the largest organic olive oil market player on a global scale. The company raised more than 20 million euros from investors to fund the 16 million euros acquisition and further company expansion. One year later, at the end of 2011, Kailis Organic collapsed and was placed in administration. Last October, six Chinese investors have purchased the company for 12 million euros.

The business model canvas of Kailis organic is shown in Fig. 4. Kailis Organic is a good example of how business development and growth can be detrimental if not backed up by proper understanding of the business model tailored for the specific organic market.

Kailis Organic has attempted to overcome the problems stemming from lowering global olive oil prices (Fig. 5) by a traditional cost-leadership strategy, trying to gain efficiency by expanding its output and achieving economies of scale, in an attempt to achieve the lowest production and distribution costs. The launch of the mass-market Splish brand follows the same business logic. Unfortunately, this business model was totally inappropriate to tackle the challenges offered by the organic EVOO market, for various reasons. First of all, organic consumers – both regular and occasional – perceive organic EVOO quality as a means to other ends, namely Health, Wellbeing and Sustainability (Bech-Larsen *et al*., 1996; Marchini and Checcarelli, 2006). Current claims associated to (or even in competition with) organic are "all-natural" and "local", while companies are trying to sustain new emerging claims such as "ethical" and "eco-friendly" (e.g. by ISO 14001 and SA 8000 certification). Importing olive oil from Australia can be economical – even in a world of growing transportation costs – but surely not so well accepted by many organic consumers, at least in Europe (Padel and Goessinger, 2008, Padel and Zander, 2009).

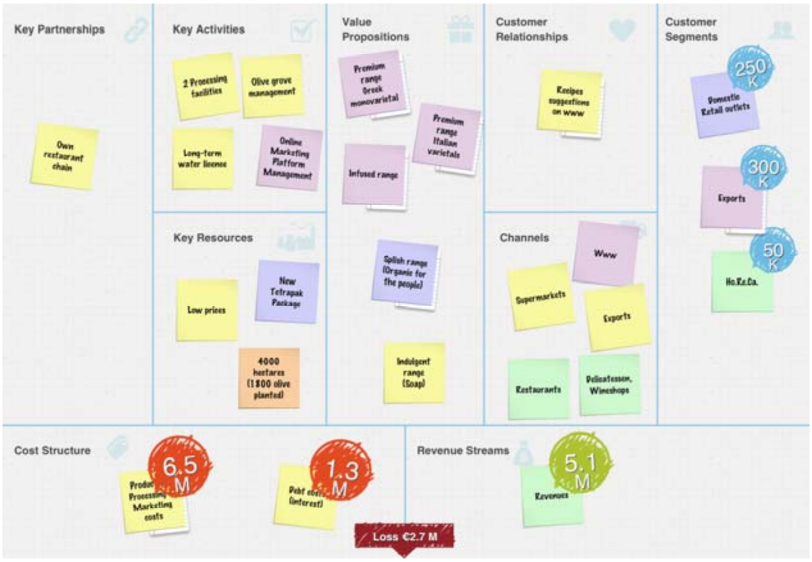

Fig. 4. Business model canvas for Kailis Organic olive grove.

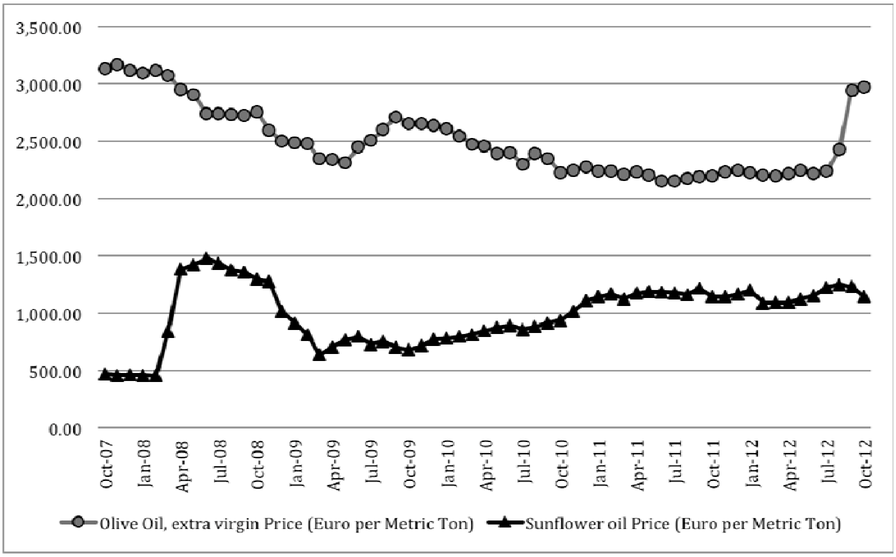

Fig. 5. Trends on EVOO and sunflower oil prices (source: IndexMundi).

Secondly, many studies have shown that the low price of organic EVOO is not a primary goal for consumers, since higher price is often perceived as indicator of higher quality (Cicia *et al*. 2002; Soler *et al*., 2002; Scarpa and Del Giudice, 2004).

Therefore, the main elements of Kailis Organic strategy – as depicted in the Value Proposition area of the canvas – presume a standard approach to market segmentation: some consumer segments need cheaper organic EVOO, other will go for premium brands. This approach contradict the evidence that consumers – especially in the emerging EVOO markets with high growth rates – looks for premium brands and high prices since organic EVOO consumption per capita is still quite low in those markets (Gavruchenko *et al*., 2003). On the other hands, in the countries with high consumption of EVOO, consumer choose different channels for reducing the prices of their organic purchases, namely bulk purchases at the producer – via direct marketing or short supply chain channels (farmers markets, box schemes, purchase groups, farm shops, direct sale e-commerce). Besides, a non-glass packaging – even if made by "innovative" Tetra pak Prisma system – is, in the eyes of the consumer, a further low quality indicator. Recent studies have shown how glass packaging is always preferred in the case of organic food (Vairo and Zanoli, 2009; Naspetti and Zanoli, 2011) and olive oil is not an exception (Krystallys and Ness, 2005).

Kailis Organic failed since its business model was not responding to the customer needs, and its attempt to overcome lowering oil prices proceeded in the wrong direction. Attempting to expand the sales in the mass market by "conventionalising" organic EVOO instead of pursuing new consumer needs such as the need of local, eco-friendly (e.g. carbon neutral) and ethical organic production was punished by the market, ending up in big losses and failure in less than a year.

Instead, business model innovation, even when aimed at cost reduction, should attempt to answer to the following key questions (Osterwalder and Pigneur, 2010): (i) what are the most important costs inherent in the existing business model?; (ii) which key resources are most expensive?; and (iii) which key activities and partnerships are most expensive?

Reducing costs is always important in any business, but low-cost structures are not equally important in all business models. Organic farming is not perceived as a low-cost industry by the prospect consumers. Organic farming is a value-driven business model, and premium value propositions are more important than low-cost production and economies of scale. However, an important category of costs – nowadays – is related to debt. Kailis has failed also by trying to double its production by producing an overall debt five times as large as its revenues. Among it key resources, both the packaging and low price image of the emerging Splish brand ended up – paradoxically – to contribute more to the costs (in terms of revenue losses), since they failed to boost up the demand for the company’s products.

2. Case study: Developing a business model for a small organic olive farm in Italy

Before presenting the case study canvas, we will show how Sinfield *et al.*’s business model innovation template can help in exploring alternatives and prototyping a business model.

The choices for each variable are not infinite (Sinfield *et al*., 2012). In particular, in this case we brainstormed with the farmer how to innovate the variable "How to sell", specifically for regular organic consumers. The farmer has already a dedicated channel for regular consumers via consumer purchase groups (GAS). Unfortunately, this channel is usually very local and allows to serve a limited number of households. How can the business model attribute "local and short supply chain" maintained and at the same time expanded to a larger network?

The template exercise yielded two different solutions, illustrated in Figs 6 and 7.

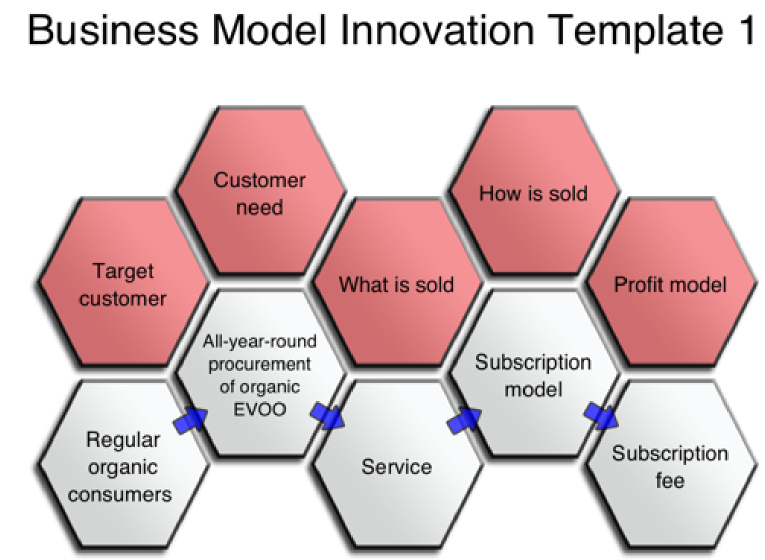

Fig. 6. Generating a new business model by changing the variable "How is sold": Subscription model.

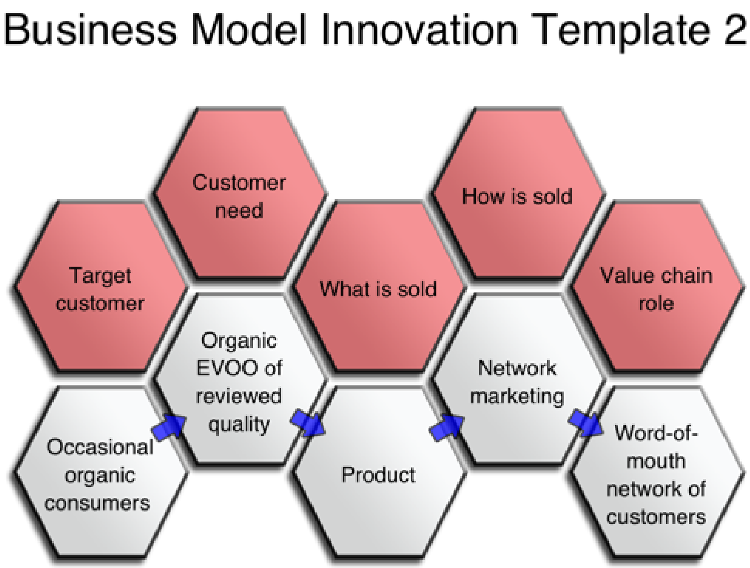

Fig. 7. Generating a new business model by changing the variable "How is sold": Network Marketing.

The first template refer to regular organic consumers that need to find an affordable way of procuring organic EVOO for the all-year-round family needs. A subscription model – similar to what has been traditionally used in the Italian olive oil market by F.lli Carli – was proposed as a solution that may work in the organic "premium" range market. It is somewhat a futures market, since by subscribing a customer buys rights to acquire a share of future organic production of the farm.

The second template illustrate how a company can satisfy occasional consumer needs of having good quality organic EVOO. It is well known that referral or word-of-mouth plays an important role in influencing consumer purchases (Buttle, 1998). Consumers often trust other consumers' referrals more than any other information source, and this explain the popularity of eno-gastronomic guides and of reviews online services like Tripadvisor. Multi-level or network marketing – also known as referral marketing – may allow offering direct sales to even distant consumers, by exploiting word-of-mouth networks and by limited distribution costs (commissions).

Both templates share the same profit model, based on direct product sales.

The two business model innovations are then introduced in the canvas (Fig. 8), representing the proposed business model for the small organic olive oil farm (12 hectares of olive trees).

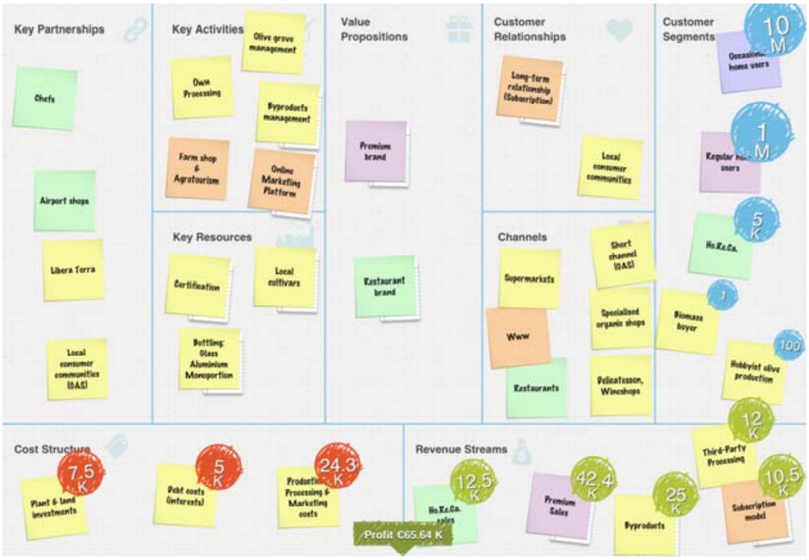

Fig. 8. Business model canvas for small organic EVOO farm in Sicily.

The company sell all its products on the local and domestic market – representing just a very small share of the Italian organic EVOO market (around 0.01%).

Part of its revenues comes from third-party processing – since the oil cold-pressing plant has a capacity that goes beyond the farm's needs. Another source of income is the sale of processing by-products (dried pomace) for energy purposes. These – in the future – could also be re-utilised on-farm, should a biomass generator be installed at the processing plant.

Both the value propositions are "premium" grade, but the restaurant brand often carries the name of the restaurant and is sold in large containers (25 l) or very small monoportions.

The company is already maximising its value chain by selling most of its products directly – either on-farm, online or through local consumer communities (purchase groups or GAS).

The subscription model and the network marketing are both potentially relevant for the farm. At the end, the subscription model was implemented in the canvas since it is more coherent with its customer relationships logic, aimed at building long-term relationships with regular consumers. It will allow expanding the farm's consumer community beyond the local scale, allowing to reach households who are not embedded in local networks.

V – Conclusion.

"A mediocre technology pursued within a great business model may be more valuable than a great technology exploited via a mediocre business model" (Chesbrough, 2010).

In this paper –with the aid of two case studies– we have attempted to illustrate how business model generation can help organic EVOO companies to develop, no matter how large is their original market share, and how limited are the financial and technological resources.

Business model generation canvas is a powerful tool to help business to prototype and generate multiple development scenarios, in order to reinvent the business and to replace out-dated models while creating value for the company, its customers and –ultimately– the society.

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Session 3
Olive oil and olives, human health and nutrition

Nutrigenomics, cardiovascular diseases and the Mediterranean diet

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I – Introduction

The effect of dietary changes on phenotypes (i.e., plasma lipids, body weight and blood pressure) differs significantly between individuals (Jacobs *et al.*, 1983; Katan *et al.*, 1997; Katan *et al.,* 1986). Some individuals are relatively insensitive (hyporesponders) to dietary intervention, whereas others have enhanced sensitivity (hyperresponders) (Katan *et al.,* 1986). This singularity has been specially investigated in relation to dietary fat, plasma lipid concentrations and prevention of cardiovascular disease (CVD) as compared with other pathological conditions.

Although low fat diets have been associated with reductions in total and plasma low-density lipoprotein cholesterol (LDL-C), the clinical evidence shows dramatic inter-individual differences in response which may be one of the underlying causes of the limited success of dietary recommendations in disease prevention reported by randomized clinical trials (Prentice *et al*., 2006). The current knowledge supports the hypothesis that the inter-individual variability in response to dietary modification is driven by genetic factors (Loktionov, 2003). The main translational challenges are (i) how to uncover and elucidate the many potential gene-diet interactions, and (ii) how potential epistatic (gene–gene) interactions caused by differing ancestral background effect these gene-diet interactions.

Several genes have been associated with the variability in response of LDL-C levels in response to changes in dietary fat but the findings have been highly inconsistent. These conflicting outcomes reflect both the complexity of the mechanisms involved in dietary responses and the limitations of the traditional experimental designs used to address this problem. In addition to their effects on plasma LDL-C levels, low fat diets can result in reduced plasma HDL and/or increased triacylglyceride (TAG) concentrations (Katan *et al.*, 1997) that may be particularly harmful for some persons. For example, it has been shown that individuals with a predominance of small, dense LDL particles (subclass pattern B), a phenotype that is associated with an increased risk of coronary heart disease, benefit more from a low-fat diet (Krauss, 2001) than do those with the subclass pattern A (larger LDL). A significant proportion of the latter group unexpectedly exhibited a more atherogenic pattern B subclass after consuming a low-fat diet. Therefore, intervention studies are increasingly focusing on the inter-individual differences in response to diet rather than on the mean effect analyzed for a population. Moreover, new evidence indicates that the variability in response is an intrinsic characteristic of the individual, rather than being the result of different dietary compliance with the experimental protocols. Jacobs *et al.* (2004) found that individual TAG responses to a high-fat or to a low-fat diet were vastly different, suggesting that many patients with hypertriglyceridemia are not treated optimally if general advice for either a low-fat or a high-fat diet is given. Studying the basis for this variation will allow us to better identify individuals who can benefit from a particular dietary intervention. Something that some authors already attempted using more traditional approaches (Parks *et al*., 2001).

II – Nutrient-gene communication

Before presenting some of the current nutrigenetic evidence in the area of lipid metabolism and CVD, it is helpful to gain an understanding of how nutrients and other chemicals in the diet may influence gene expression and drive gene-diet interactions. The study of these interactions is the subject of nutrigenomics, which seeks to understand gene-diet interactions in the context of the total genetic makeup of each individual. Technological limitations in the past restricted the investigator to a piecemeal approach: one gene, one gene product and one nutrient at a time.

Conceptual and technological advances are changing the playing field. Nowadays, researchers can cast a wide net in the form of microarrays to capture the information about each one of the genes expressed in a specific cell or tissue of interest. Despite these advances, the challenges are not trivial given the chemical complexity of food, and our incomplete knowledge about the various bioactive components present in food grown in different climates at different times of the year. This is clearly the case with regard to the composition of olive oil, a key element of the Mediterranean diet (Angerosa *et al*., 1999; Bianco *et al*., 2006). Moreover, our ability to carry out mechanistic studies in humans gets impaired by our inability to assay gene expression in the most appropriate target tissues in humans and by the challenge of controlling for or determining many lifestyle factors that also influence expression of genetic information.

Regulation of expression of genes involved in fatty acid metabolism occurs when a dietary fat or metabolite binds to and activates specific fatty acid transcription factors. These dietary chemical-regulated transcription factors are members of the nuclear receptor super family. This gene family consists of 48 mammalian transcription factors that regulate nearly all aspects of development, inflammation, and metabolism. Two subclasses, the peroxisome proliferator-activated receptors (PPARs) and liver X receptors (LXRs), are lipid-sensing receptors that have critical roles in lipid and glucose metabolism (Li *et al*., 2004; Pegorier *et al*., 2004; Jump, 2004). PPARs are among the best-studied fatty acid-regulated nuclear receptors (Clarke, 2004; Lapillonne *et al*., 2004). After uptake into target cells, subsets of fatty acids or their metabolites are transported to the nucleus in association with fatty acid-binding proteins (FABPs), which facilitates their interaction with PPARs. Several PPAR subtypes have been described (Kota *et al*., 2005). PPAR-alpha (PPARA) plays a key role in lipid oxidation and inflammation, whereas PPAR-gamma (PPARG) is involved in cell (adipocyte) differentiation, glucose lipid storage and inflammation.

PPAR-delta (PPARD, also known as PPAR-beta) may play an important role in development, lipid metabolism and inflammation. In addition to the potential effects of the fatty acids present in olive oil on gene expression (Menendez *et al*., 2006), it should be noted that PUFA n-3, present in fish and nuts, and also part of the traditional Mediterranean diet, could play a relevant role in providing the health promoting effects of such dietary culture. Moreover, other minor components present in extra virgin olive oil could regulate gene expression (Bellido *et al*., 2006) and this regulation could be affected in subjects with different alleles at key genes (Soriguer *et al*., 2006). In addition to fatty acids, pharmacological agonists have been developed for each receptor: PPARA binds fibrates, PPARD binds lipophilic carboxylic acids, and PPARG binds glitazones. The fibrates are used to treat hyperlipidemia. The glitazones are used to manage plasma glucose levels in patients with insulin resistance (Berger *et al*., 2005). Pathway analyses using the MetaDrug workflow software (www.genego.com), showed that rosiglitazone and 15-deoxy-prostaglandin J2 (15-deoxy-PGJ2, a metabolite of dietary fatty acids) had three identical targets but also and 43 common cellular elements (Kaput *et al*., 2007). Although many of these elements were components of the insulin response or control pathways, a substantial number of "common targets" were in pathways regulating other cellular processes, such as genes involved in apoptosis and regulation of detoxifying enzymes. Pathway analyses demonstrated that drugs and dietary components affect more than one target, that diet would likely alter responsiveness to drugs through multiple pathways, and the practical importance of assessing dietary intakes for clinical medicine.

Many of the previously published nutrigenetic [i.e., single gene/single nucleotide polymorphism (SNP)] studies focused on genes that are the subject of regulation by PPARs and other nuclear receptors (Mandard *et al*., 2004). Polymorphisms in promoter regions of these genes may disrupt or at least alter the communication with these transcription factors, which would have significant consequences in a person's response to dietary factors that are ligands (i.e., PUFAs) of the transcription factors. It is also obvious that polymorphisms within the transcription factors themselves will have a significant impact in the way that each one of us responds to dietary factors. The evidence for gene-diet interactions between common SNPs at candidate genes and dietary factors related to lipid metabolism is increasing and so is the understanding of the interactions resulting from the consumption of a Mediterranean diet from recent studies such as the large PREDIMED Study (Estruch *et al*., 2006; Razquin *et al*., 2009, 2010a, 2010b, 2010c; Ortega-Azorín *et al*., 2012; Sotos-Prieto *et al*., 2012) and other smaller intervention studies (Buttriss and Nugent, 2005; Vincent-Baudry *et al*., 2005; Garaulet *et al*., 2011; Sánchez-Moreno *et al*., 2011). However, caution is needed before applying these results to clinical practice for three primary reasons: (i) the meaning of "statistically significant results" is subject to differing interpretations and often depends upon the study design, (ii) many initial gene-nutrient-phenotypes associations are not replicated in subsequent studies, and (iii) gene variations may influence phenotypes differently in individuals from different ancestral backgrounds due to gene-gene (epistatic) interactions.

III – Results from interventional studies

Interventional studies in which subjects receive a controlled dietary intake provide the best approach for conducting gene-nutrient-phenotype association studies. However, these well-controlled feeding studies have several important logistical limitations, most importantly the small number of participants and the brief duration of the interventions. Scores of interventional studies examining gene-diet interactions on different parameters of lipid metabolism have been published. However, the level of replication among studies analyzing the same genetic variation tends to be low. The lack of replication is most likely due to the different characteristics (ethnicity, physical condition, age, lifestyle differences) of study subjects, length of intervention, sample size, and heterogeneity in the design. In a systematic review (from 1966 to 2002), Masson *et al.* (2003) identified 74 relevant articles including dietary intervention studies that had measured the lipid and lipoprotein response to diet in different genotype groups and 17 reviews on gene-diet interactions.

After a comparative analysis of the individual findings, they concluded that there is evidence to suggest that: (i) variations in the APOA1, APOA4, APOB, and APOE genes contribute to the heterogeneity in the lipid response to dietary intervention; and (ii) all of these genes are regulated directly or indirectly by PPARA or other nuclear receptors. However, the evidence suggested by Masson *et al.* (2003) in relation to the above genes comes from meta-analyses of the published data and described the average effect. It should be noted that there is not total consistency of results among individual studies.

More recently, one of our groups (Corella and Ordovás, 2005; Ordovás and Corella, 2004a,b) reviewed this topic extensively and included additional studies reported after 2002. The median for the sample sizes in these more recent studies was in the range of 60 subjects. These small sample sizes highlight one of the traditional problems for lack of reproducibility, specifically, the statistical power is low. In addition, the composition of the dietary intervention in these studies varied considerably. We propose that the design of future intervention studies should be standardized for key dietary intake variables and phenotype measurements using the tools developed by Hamilton *et al.* (2011). A minimum set of variables would include patients' physical and genetic characteristics (including genetic ancestry analyses), medications, composition and length of the dietary treatment, and sample size. Such standardization would allow better comparison among studies and the possibility of conducting meta-analyses, which is the current trend in observational genetic association and gene-diet interaction studies (Hamilton *et al*., 2011).

IV – Results from observational studies

Observational studies have the advantage of large numbers of subjects and the ability to estimate long-term dietary habits. However, the level of evidence of the results obtained from these studies has traditionally been considered to be lower than that of experimental studies. Nevertheless, the level of confidence in such studies can be increased by taking into consideration the principle of Mendelian randomization (Campbell *et al*., 2005). This concept reflects the random assortment of alleles at the time of gamete formation. Such randomization results in population distributions of genetic variants that are generally independent of behavioral and environmental factors that confound epidemiological associations between potential risk factors and disease. This topic has been extensively reviewed (Ordovás and Corella, 2004a). The median population size for recent observational genetic association studies has increased dramatically in the last few years driven by the formation of large consortia and the implementation of meta-analysis. Current sample sizes amounting to hundreds of thousands of individuals for some common traits are allowing the discovery of an increasing number of loci associated with complex traits, including CVD-risk factors. However, event these very large numbers may just have barely enough statistical power to address genome-wide gene-environment interactions. This is due to multiple reasons including the higher measurement error of dietary intake in comparison with experimental studies. As pointed out for intervention studies, replication of results is still very low. In addition, these findings need the synergy of those studies examining the effects of nutrients on gene expression (nutrigenomics) to provide the mechanistic knowledge that will support the reported statistical associations. In addition, genotype-nutrient-phenotype analyses may be improved by determining ancestral backgrounds of each study participant. These additional data are necessary since SNPs may be expressed differently among individuals of differing ethnicities because of varying gene-gene and gene-nutrient interactions. Determining the genetic architecture (that is, geographical origin of chromosomal regions) in each study participant may reduce statistical noise caused by mismatching case control (Campbell *et al*., 2005).

Some knowledge is starting to emerge about the additional benefits of the Mediterranean diets in subjects with specific alleles (Soriguer *et al*., 2006; Razquin *et al*., 2009; Razquin *et al*., 2010a,b,c; Ortega-Azorín *et al*., 2012; Sotos-Prieto *et al*., 2012; Garaulet *et al*., 2011; Sánchez-Moreno *et al*., 2011). This is the case with the reported interaction between the Pro12Ala SNP at the PPARG locus, type 2 diabetes mellitus (T2DM), and peripheral insulin sensitivity in a population characterized by a high intake of oleic acid (Soriguer *et al*., 2006). These investigators examined these associations and interactions in a population-based study in Pizarra (Spain). A total of 538 subjects, aged 18-65 years, were randomly selected. Consistent with some previous reports, those subjects with the Ala12 allele had lower risk of diabetes. Moreover, a significant and complex interaction was observed between the homeostasis model assessment insulin resistance index (HOMA-IR), obesity, the PPARG Ala12 allele and the intake of MUFA. This interaction suggests that obese subjects with the Ala12 allele have higher HOMA-IR values in the background of a low intake of MUFA. Along those lines, we have reported how MUFA are not associated with increases in BMI and risk of obesity, especially in subjects with certain allele at the APOA5 locus (Sánchez-Moreno *et al*., 2011; Corella *et al*., 2007). In the Framingham Study (Corella *et al*., 2007), our objective was to study whether dietary intake modulates the association between APOA5 gene variation and body weight in a large population-based study. Specifically, we have examined the interaction between the APOA5-1131T > C and 56C > G (S19W) polymorphisms and the macronutrient intake (total fat, carbohydrate, and protein) in their relation to the BMI and obesity risk in men and women. We found a consistent and statistically significant interaction between the –1131T > C SNP (but not the 56C > G SNP) and total fat intake for BMI. This interaction was dose dependent, and no statistically significant heterogeneity by gender was detected. In subjects homozygous for the –1131T major allele, BMI increased as total fat intake increased. Conversely, this increase was not present in carriers of the -1131C minor allele. When specific fatty acid groups were analyzed, MUFA showed the highest statistical significance for these interactions. Therefore, our study showed that the APOA5-1131T > C SNP, which is present in approximately 13% of this population, modulated the effect of fat intake on BMI and obesity risk in both men and women and this effect might be primarily driven by the intake of MUFA characteristic of the Mediterranean diet. Another interesting observational study has focused on the interaction between oxidative modification of LDL, the methylenetetrahydrofolate reductase (MTHFR) C677T mutation and the Mediterranean diet (Pitsavos *et al*., 2006). The investigators studied demographics, lifestyle, clinical, biochemical and genetic data from 322 men and 252 women free of clinical CVD from the Attica region in Greece. The distribution of MTHFR genotypes was: 41% for homozygous normal (CC) genotype, 48% for heterozygous (CT) and 11% for homozygous mutant (TT) genotype. Ox-LDL levels were higher in TT as compared to CT and CC (71, 64 and 51 respectively). Greater adherence to the Mediterranean diet was inversely associated with ox-LDL levels. However, stratified analysis revealed that adherence to the Mediterranean diet was associated with lower ox-LDL levels in TT and CT individuals, but not in CC. Therefore, the reported gene-to-diet interaction on ox-LDL concentrations may provide a pathophysiological explanation by which a Mediterranean type of diet could influence coronary risk in people with increased oxidative stress.

V – Gene-diet interactions in the postprandial state

Human beings living in industrialized societies spend most of the waking hours in a non-fasting state. Postprandial lipemia, characterized by a rise in TAG after eating, is a dynamic, nonsteady-state condition (Ordovás, 2001). Over three decades ago, Zilversmit (Zilversmit, 1979) proposed that atherogenesis was a postprandial phenomenon since high concentrations of lipoproteins remnants following food ingestion could deposit onto the arterial wall and accumulate in atheromatous plaques. Several studies have investigated the potential interaction between some polymorphisms in candidate genes and diet on postprandial lipids [for review see (Ordovás and Corella, 2004b)]. In postprandial studies, subjects usually receive a fat-loading test meal that has differing compositions depending on the nutrient(s) to be tested. After the test meal, blood samples are taken to measure postprandial lipids to compare with preprandial levels (Ordovás, 2001). Consistency among studies is still very low and replication of findings is a major necessity, but complicated by the paucity of replication sets available for direct testing or for meta-analysis and the lack of standardization of procedures among the few existing studies. Those studies that have investigated the interaction between a Mediterranean-like diet or olive oil and the postprandial response have been even fewer and subjected to the sample size limitations indicated above (Pérez-Martínez *et al*., 2003; Pérez-Martínez *et al*., 2005; Dworatzek *et al*., 2004). The results suggest that MUFA may provide benefit in terms of the postprandial response to subjects carrying alleles associated with an increased atherogenic profile, but with the limitations described above.

VI – The roadmap to solidifying the nutrigenomics field

Despite the excitement arising from an increasing number of findings related to nutritional genomics, the progress of the field is hampered by the inadequacy of the current experimental approaches to efficiently deal with the biological complexity of the phenotype(s), the complexity of dietary intakes, differing genetic background among participants, and the limitations of statistical power of the individual studies. We and others have proposed that only a comprehensive, international nutritional genomics approach (van Ommen and Stierum, 2002; Kaput *et al*., 2005) will yield short- and long-term benefits to human health by: (i) revealing novel nutrient-gene interactions, (ii) developing new diagnostic tests for adverse responses to diets,

(iii) identifying specific populations with special nutrient needs, (iv) improving the consistency of current definitions and methodology related to dietary assessment, and (v) providing the information for developing more nutritious plant and animal foods and food formulations that promote health and prevent, mitigate, or cure disease. Achieving these goals will require extensive dialogue between scientists, the private sector and the public about the nutritional needs of the individual vs groups, local food availability and customs, analysis and understanding of genetic differences between individuals and populations, and serious commitment of funds from the public and private sectors. Nutritional genomics' researchers are seeking collaborations of scientists, scholars, industry representatives and policy makers, to maximize the collective impact on global poverty and health by advancing our knowledge of how genetics and nutrition can promote health or cause disease.

VII – Conclusions

Although the current evidence from both experimental and observational nutrigenetics studies may not be enough to embark in widespread personalized nutritional recommendations based on genetic information, there are a large number of examples of common SNPs modulating the individual response to diet as proof of concept of how gene-diet interactions can influence lipid metabolism among other traits (i.e., obesity). It is critical that all studies go through further replication and that subsequent studies be properly designed with sufficient statistical power and careful attention to phenotype and genotype. The many challenges that lay ahead are evident. This review has examined the vast world of nutrigenetics and nutrigenomics only through the small keyhole of dietary fat and CVD risk factors. Analogous to the use of the X-ray diffraction patterns 50 years ago to determine the structure of DNA, which led to today's progress in sequencing the entire human genome, these initial steps in understanding nutrigenomics will likely lead to fundamental breakthroughs that will both fill today's gaps and pave the way for clinical applications. Hopefully, bringing nutrigenetics to the state of becoming a practical and useful tool will not take 50 years. However, to arrive at the point where it is possible to assess the modulation by specific SNPs of the effects of dietary interventions on lipid metabolism and other common risk factors, well designed, adequately powered, and adequately interpreted randomized controlled studies (or their equivalent) of greater duration than current studies are needed, with careful consideration given to which patients to include in such studies. Moreover, research must also investigate the potential mechanisms involved in the gene-diet interactions reported by nutrigenetic studies (van Ommen and Stierum, 2002). These imperative needs can be achieved only through the collaboration of experts in the different fields involved, which must include nutrition professionals (Kaput *et al*., 2005; Ordovás, 2006).

One of the first situations where personalized nutrition is likely to be beneficial is with dyslipidemic patients that require special intervention with dietary treatment. It is known that these individuals will display dramatic heterogeneity in response to the currently recommended therapeutic diets and that the recommendations will need to be adjusted individually. This process could be more efficient and efficacious if the recommendations were carried out based on genetic and molecular knowledge. Moreover, adherence to dietary advice may increase when it is supported with information based on nutritional genomics, and the patient feels that the advice is personalized. However, a number of important changes in the provision of health care are needed to achieve the potential benefits associated with this concept, including a teamwork approach, with greater integration among physicians and nutrition professionals. Once more experience is gained from patients and/or individuals at high risk, these approaches could be applied towards primary prevention.

The discovery of the cardioprotective and other healthy properties of the Mediterranean diet has popularized beyond its geographical boundaries the consumption of Mediterranean products such as olive oil. Molecular, clinical, and epidemiological studies have begun to shed some light about how various components of this diet may protect the cardiovascular system and to decrease the risk of other diseases such as cancer. However, still many unknowns remain. Can the same healthy effects of those dietary components be obtained in other regions of the globe? Or alternatively, the right combination of genetic, physico-geographical, socioeconomic and culture is also needed (Mackenbach, 2007). It has been proposed that the Mediterranean diet may be closer to the ancestral foods that were part of human development.

Therefore, our metabolism may have evolved to work optimally on such a diet rather than to the current diets richer in saturated fat and highly refined and processed foods. It is possible that alleles that are associated with increase disease risk may be silenced in the presence of that more ancestral and traditional diet and lifestyle. This knowledge may provide the basis for successful public health as well individual approaches for disease prevention.

Acknowledgements

This work was supported by NIH grants HL72524, HL54776 and DK075030 and by contracts 53-K06-5-10 and 58-1950-9-001 from the US Department of Agriculture Research Service, and contracts 53-K06-5-10 and 58-1950-9-001 from the US Department of Agriculture Research Service, and by grants from the Ministerio de Ciencia e Innovación and Fondo Europeo de Desarrollo Regional: CIBER CB06/03/0035, PI07-0954, CNIC-06 and AGL2010-22319-C03-03, PFU-AP2007-04663 and the Generalitat Valenciana (GVACOMP2011-151 and AP111/10).

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Nutraceutical, cosmetic, health products derived from olive

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Abstract. It is widely recognized that the Mediterranean diet is associated with a reduced rates of chronic disease (i.e. cardiovascular disease, atherosclerosis, some types of cancers, and Alzheimer's disease), and a higher life expectancy. These health benefits have been partially attributed to the dietary consumption of olive oil by populations residing in the Mediterranean region, and more specifically the phenolic compounds naturally present in olive fruit and oil. *In vitro* and *in vivo* studies have demonstrated that these phenolic compounds have potentially beneficial biological effects resulting from their antimicrobial, antioxidant and anti-inflammatory activities. This paper summarizes the modes of action by which olive phenolic compounds beneficially influence health parameters.

Keywords. Health product – Olive – Nutraceuticals – Cosmetic.

Produits nutraceutiques, cosmétiques et de santé dérivés de l'olive

Résumé. *Il est largement reconnu que le régime méditerranéen est associé à un taux réduit de maladies chroniques (i.e. les maladies cardiovasculaires, l'athérosclérose, certains types de cancers et la maladie d'Alzheimer), et à une espérance de vie plus élevée. Ces avantages pour la santé sont partiellement attribuables à la consommation alimentaire de l'huile d'olive par les populations résidant dans la région méditerranéenne, et plus particulièrement aux composés phénoliques naturellement présents dans les fruits et l'huile d'olive. Des études,* in vitro *et* in vivo*, ont démontré que ces composés phénoliques ont des effets biologiques potentiellement bénéfiques résultant de leurs activités antimicrobiennes, anti-oxydantes et anti-inflammatoires. Cet article résume le mode d'action par lequel les composés phénoliques présents dans les olives, ont un effet bénéfique sur les paramètres de la santé.*

Mots-clés. *Produits de santé – Olive – Nutraceutiques – Cosmétiques.*

I – Introduction

It is widely recognised that those residing in the Mediterranean region experience reduced rates of chronic disease [i.e. cardiovascular disease (CVD), atherosclerosis, some types of cancers, and Alzheimer's disease)], and a higher life expectancy in comparison to other worldwide populations (Trichopoulou *et al.,* 2003). The Mediterranean style of eating encompasses a number of dietary components that are thought to contribute protective health effects, including the consumption of 25-50 ml/day of olive oil. Recently, Trichopoulou *et al.* (2009) using a prospective cohort study, investigated the relative importance of the individual components of the Mediterranean diet in relation to overall mortality. The dominant components of the Mediterranean diet that were predictors of lower mortality were moderate consumption of ethanol, low consumption of meat and meat products, and high consumption of vegetables, fruits and nuts, olive oil and legumes.

In addition, scientists, investigating these positive "disease preventing" properties of Mediterranean diet, have begun to identify specific food components, called phytochemicals, that may better explain the role of some foods in the prevention and treatment of diseases.

Although phytochemicals are not yet classified as nutrients, they are substances that can positively affect human function and reduce the risk of disease.

About 30 classes of chemicals with disease-preventive effects that may have practical implications also in reducing cancer incidence in human population have been described, such as carotenoids, chlorophyll, flavonoids, indoles, polyphenolic compounds, protease inhibitors, sulphides, and terpens.

In particular, olive fruit's average composition includes water (50%), protein (1.6%), oil (22%), carbohydrate (19.1%), cellulose (5.8%), inorganic substances (1.5%) and phenolic compounds (1-3%). Other important compounds present in olive fruit are pectin, organic acids, and pigments (Cicerale *et al.*, 2009). Organic acids show metabolic activity and are intermediate products resulting from formation and degradation of other compounds (Cunha *et al.*, 2001). Variation in the amount of these compounds may be caused by numerous factors including: variety, region in which the olive is grown, agricultural techniques used to cultivate the olive, maturity of the olive fruit at harvest, and processing (Covas, 2008).

II – Phenolic components

Phenolic components of olive fruits, present in large amounts also in olive oil, are currently receiving much attention because of their beneficial health effects related to their antioxidant, anti-inflammatory, antiestrogenic, cardioprotective, cancer chemopreventive, and neuroprotective properties. Historically, the healthful properties of virgin olive oil were attributed to a high proportion of monounsaturated fatty acids (MUFAs), namely oleic acid, which represents 55-83% of the fatty acids present in virgin olive oil (Tripoli *et al.*, 2005). However, several seed oils (including sunflower, soybean, and rapeseed) rich in MUFA have been demonstrated to be ineffective in beneficially altering chronic disease risk factors (Aguilera *et al.*, 2004; Harper *et al.*, 2006). In addition to MUFA, virgin olive oil contains a minor, yet significant phenolic component that other seed oils lack. Thus, the phenolic fraction of virgin olive oil has generated much interest regarding its health promoting properties. Subsequent studies (human, animal, in vivo and in vitro) have demonstrated that olive oil phenolics have positive effects on certain physiological parameters, possibly reducing the risk of chronic disease development (Boskou *et al.*, 2006).

Plant phenolic compounds are well known secondary metabolites and they are synthesized naturally by plants in response to stress conditions such as infection, wounding, and UV radiation (Naczk *et al.*, 2004).

Both lipophilic and hydrophilic phenolics are distributed in olive fruit. The main lipophilic phenols are cresols while the major hydrophilic phenols include phenolic acids, phenolic alchohols, flavonoids and secoiridoids; they are present in almost all parts of the plant and in olive oil. However, their nature and concentration varies greatly depending on several factors including maturation stage, part of the fruit, variety, season, packaging, storage, climatologic conditions and the degree of technology used in olive oil production (Covas *et al.*,2006).

Many factors can have a marked effect on phenolic composition and concentration in olive fruit and oil (Table 1). The 3,4-dihydroxyphenyl-ethanol (3,4-DHPEA) and *p*-hydroxyphenyl-ethanol (*p*-HPEA) are the main phenolic alcohols of virgin olive oil (VOO). Their concentration is usually low in fresh oils but increases during oil storage due to the hydrolysis of VOO secoiridoids such as 3,4-DHPEA-EDA 3,4-dihydroxyphenyl-ethanol linked to dialdehydic form of elenolic acid, *p*-HPEA-EDA (*p*-hydroxyphenylethanol linked to dialdehydic form of elenolic acid) and 3,4-DHPEA-EA (3,4-dihydroxyphenyl-ethanol linked to elenolic acid) into hydroxytyrosol (3,4-dihydroxyphenylethanol) (3,4-DHPEA) and tyrosol (*p*-Hydroxyphenylethanol) (*p*-HPEA). During ripening of olives, oleuropein is completely degraded, and is almost undetectable when the fruit darkens, but hydroxytyrosol, tyrosol, and verbascoside increase.

Table 1. Main classes of phenolic compounds in olive fruit and olive oil

Phenolic acids (i.e. Caffeic acid, *p*-Hydroxybenzoic acid, Vanilic acid, Syringic acid, Ferulic acid, Cinnamic acid, Gallic acid) divided into three subgroups:		
1. benzoic acid derivatives (basic skeleton C_6-C_1)	2. cinnamic acid derivatives (basic skeleton of C_6–C_3)	3. Others
Phenolic alcohols • characterized by a hydroxyl group attached to an aromatic hydrocarbon group		
Secoiridoids (i.e. Oleuropein, Demethyloteuropein, Ligstroside, Nuzhenide) • phenolic group characterized by the presence of either elenolic acid or elenolic acid derivatives in their molecular structure		
Flavonoids (i.e. Quercetin-3-rutinoside, Luteolin-7-glucoside, Luteolin-5-glucoside, Apigenin-7-glucoside) • polyphenolic compounds containing two benzene rings joined by a linear three carbon chain. (chemical structure of C_6–C_3–C_6), divided into two groups:		
1. flavones	2. flavanols	
Hydroxy-isocromans (i.e. Verbascoside) • 3,4-dihydro-1H-benzo[*c*]pyran derivatives mainly naturally occurring in nature as part of a complex fused ring system		
Lignans (i.e. (+)-1-acetoxypinoresinol, (+)-pinoresinol) • the exact structure not well understood but based on the condensation of aromatic aldehydes		

III – Bioavailabity of olive phenolics

The degree to which phenolic components are bioavailable (absorbed, metabolised, distributed and eliminated) is pivotal in understanding and evaluating the health benefits associated with such compounds. The majority of research regarding the bioavailability of olive phenolics has focused on the absorption and excretion of two major components: hydroxytyrosol and tyrosol (Cicerale *et al.*, 2010). It has been recently reported the presence of metabolites for the majority of olive phenolic compounds (i.e. secoiridoids, flavonoids and phenolic alcohols) in human urine, suggesting that these compounds are metabolised and absorbed post-ingestion (García-Villalba *et al.*, 2010).

However, it has been suggested that also poorly absorbed phenolic compounds may exert local antioxidant activities in the gastrointestinal tract and this hypothesis is supported by research demonstrating the free radical scavenging capacity of olive phenolics in both the fecal matrix and intestinal epithelial cells (Selma *et al.*, 2009).

In addition, unabsorbed dietary phenolics remain in the gut where intestinal bacteria can metabolize them generating active metabolites. Indeed, germfree or antibiotic-treated animals no longer form the phenolic acid metabolites (ring-fission products) of apigenin, myricetin, hesperidin, naringin, rutin, etc. (Griffiths and Barrow, 1972).

Only a few species of intestinal bacteria responsible for phenolic metabolism have been identified, and there is scarce knowledge of the mechanisms involved. In addition, the transformation of the native phenolics into their metabolites depends on the individuals, and both metabolite "producers" and "nonproducers" have been reported (Cerdá *et al.*, 2005).

Certain gut bacteria including some already recognized as potentially health-promoting ones (i.e. some species belonging to the genera *Bifidobacterium* and *Lactobacillus*) seem to be involved in the release of bioactive hydroxycinnamic acids in the human colon. The use of dietary supplements of beneficial bacteria, which modify the colonic microbiota by increasing the number of specific microbial strains able to transform some phenolics, could have, therefore, wide-ranging implications for the health of the host, resulting in beneficial effects.

On the other hand, unabsorbed dietary phenolics and their metabolites, may exert significant effects on the intestinal environment by modulation of the microbiota (Lee *et al.*, 2006). Several phenolics have been recognized as potential antibacterial compounds able to repress pathogenic bacteria in the human gut by bacteriostatic or bactericidal actions or also by inhibition of the adhesion of infection-causing bacteria within cells of the intestinal and urinary tract. In conclusion, a better understanding of the dietary phenolic and gut microbiota relationship should help in the prevention of intestinal diseases, such as inflammatory bowel diseases and colon cancer, as well as in improvement of human health avoiding diseases in other tissues.

IV – Biological activities and potential health benefits of dietary phenolics

Reactive oxygen species (ROS), formed as a result of oxidative stress, are known to be responsible for the development of some diseases targeting lipids, proteins and deoxyribonucleic acid (DNA) in living organisms. Diseases attributed to ROS include, for example, aging, arteriosclerosis, cancer and neurodegenerative diseases such as Parkinson's (Uttara *et al.*, 2009; Rezaie *et al.*, 2007).

Oxidative stress is imposed on the body' s cells when the level of ROS outweighs the reducing capacity of antioxidant and antioxidative stress mechanisms. While a low level of stress is always present, an increase in the amplitude and duration of stress can result in damage to cell membranes, proteins, and DNA. This in turn can set the conditions for a new disease or can exacerbate an existing condition. Inflammatory bowel disease, ischemia/reperfusion disorders, and cancer have all been linked to oxidative stress. Biomarkers of oxidative damage in diseased tissues are often disproportionately altered and in most cases, are higher than that present in healthy cells (Aw, 1999).

In eukaryotes, superoxide anion is primarily produced: when electrons leaking from the mitochondrial electron transport chain reduce oxygen, during tissue injury by xanthine oxidase, via auto-oxidation reactions in the presence of transition metal ions, during cytochrome P450 cycling, and at inflammatory sites by activated neutrophils and phagocytes via nicotinamide adenine dinucleotide phosphate (NADPH) oxidase (Halliwell *et al.*, 2007).

Although endogenous antioxidants and antioxidative stress enzymes are effective in the removal of ROS, the added burden of environmental ROS and the reduction of plasma and cellular antioxidant potential during aging and mitochondrial dysfunction stretches the body antioxidant defenses to the limit (Rizvi *et al.*, 2006).

Various studies (*in vivo* and *in vitro*) have demonstrated that olive phenolic compounds beneficially alter oxidative processes and inflammation. In vitro olive oil phenolics have been found to decrease ROS production and elicit significant free-radical scavenging effects (Goya *et al.*, 2007).

Further in vitro research has shown that olive oil phenolic compounds reduce detrimental oxidative damage to red blood, renal and intestinal cells as measured by red blood cell lysis morphology, membrane-bound haemoglobin, membrane protein profile and changes to the membrane lipid fraction (Paiva-Martins *et al.*, 2009; Loru *et al.*, 2009; Deiana *et al.*, 2010).

In vivo human and animal studies have demonstrated a decrease in LDL oxidation with an increased ingestion of olive oil phenolic compounds (Gimeno *et al.*, 2007). An explanation of this effect is that olive phenolic compounds are able to bind to LDL and this may account for the increased resistance to LDL oxidation.

Research concerning DNA damage (as measured by the comet assay and 8-oxo-deoxyguanosine) shows the intake of phenol-rich olive oil (up to592 mg/kg) decreases oxidative DNA damage in vivo in humans and in animals (Machowetz *et al.*, 2007; Jacomelli *et al.*, 2010).

Additional beneficial effects on inflammation have been demonstrated by olive oil phenolics, such as: (i) inhibition of both cyclooxygenase-1 (COX-1) and cyclooxygenase-2 (COX-2) inflammatory enzymes in a dose-dependent manner; (ii) decrease of Tumor Necrosis Factor a and interleukin 1b expression; and (iii) decrease of the expression of several inflammatory genes including NFkb and COX-2. Some olive phenolic compounds have shown also a direct effect on cancer cell proliferation in human breast, prostate and intestinal cancer lines, on cell transformation in mouse epidermal JB6 Cl41 cells, and on the modulation of apoptosis in normal and transformed cells (Fig. 1) (Cicerale *et al.*, 2012).

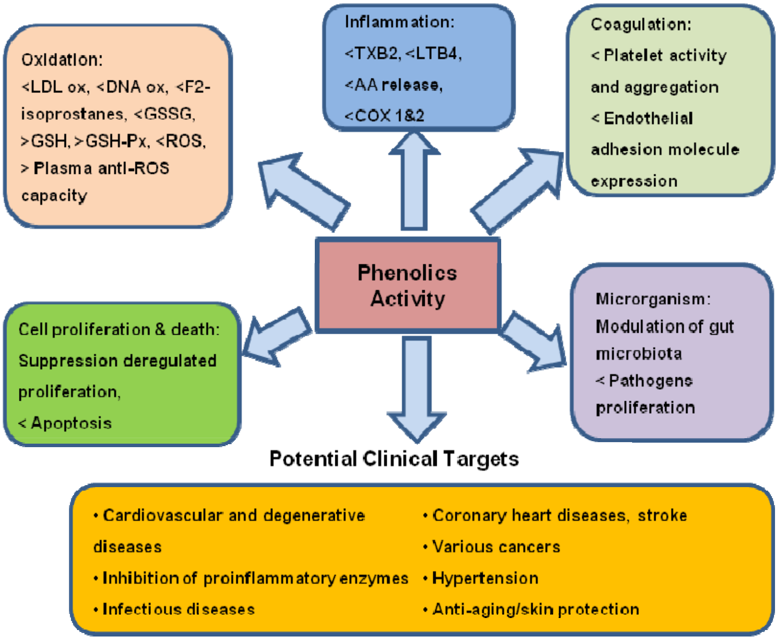

Fig. 1. Biological activities of olive phenolic compounds.

V – Anti-ageing effects of olive derivatives in the skin

Human skin is the potential anatomical barrier for pathogens and damage, which acts as an important fence between internal and external environment in the bodily defense. Continuous exposure to UV light leads to numerous complications that are correlated with various pathological consequences of the skin damage and sunburn occurs when exposure to UV light exceeds the protective capacity of an individual's melanin (Agar *et al.*, 2004).

UV radiation is a potent initiator of ROS generation in the skin. The type(s) of ROS generated, however, depends on the UV wavelength. UVB mainly stimulates the production of $^{\bullet}O_2^-$ through the activation of NADPH oxidase and respiratory chain reactions, while UVA produces $^1O_2$ through a photosensitizing reaction with internal chromophores such as riboflavin and porphyrin. UVA also generates $^{\bullet}O_2^-$ through NADPH oxidase activation and photosensitization of advanced glycation products (Masaki, *et al.* 1995; Valencia and Kochevar, 2008). The major type of ROS produced on the skin surface is $^1O_2$, which is generated by a photosensitizing reaction with UVA and porphyrins from bacterial flora living in the skin (Ryu *et al.*, 2009). $^1O_2$ is oxidized to squalene, cholesterol, and to unsaturated acyl residues in the sebum to yield lipid hydroperoxides (Fig. 2).

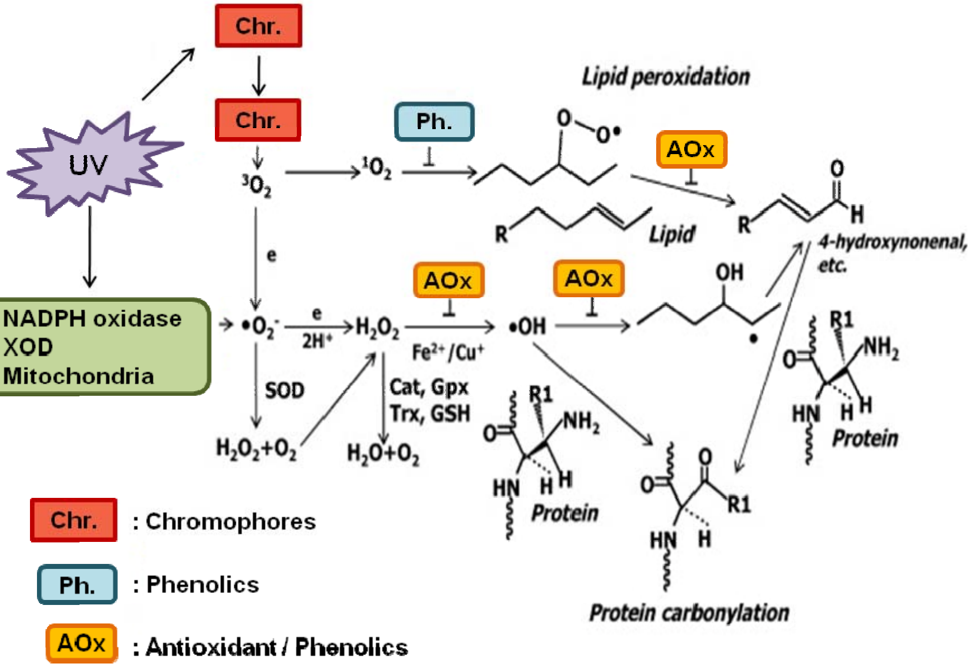

Fig. 2. ROS-initiated oxidative chain reactions and scavengers.

UV irradiation induces photo-damage of the skin, which is characterized by distinct alterations in the composition of the dermal extracellular matrix (ECM), resulting in wrinkles, laxity, coarseness, mottled pigmentation and histological changes that include increased epidermal thickness and connective tissue alteration. Breakdown of a balance of combination between the connective tissue components (biomolecules including collagens, proteoglycans and glycoproteins) leads to the detrimental effects i.e. photoaging in dermal fibroblasts. Skin contains antioxidant defenses, which nullify reactive oxygen species (ROS) including free radicals, but these defenses will be overwhelmed if the dose of UV light is high enough, and this result in free radical damage to cellular components such as proteins, lipids and DNA. ROS induced by oxidative stress can ultimately lead to apoptotic or necrotic cell death. Especially, the accumulated ROS plays a critical role in the intrinsic aging and photoaging of human skin *in vivo*, thus suggested to be responsible for various skin cancers and other cutaneous inflammatory disorders (Kawaguchi *et al.*,1996).

Several investigations have revealed that collagen gets degraded in photoaged skin due to the inhibition of collagen synthesis mediated by matrix metalloproteinases (MMPs), which are a family of secreted or transmembrane zinc endopeptidases that are capable of digesting ECM. MMPs are divided into subclasses of collagenases, gelatinases, stromelysins, matrilysins and membrane-type MMPs (MT-MMPs) according to their substrate specificity and domain structure. It is reported that ROS effects the MMP gene expression through signal transduction pathway. Expression of MMPs is usually induced by various extracellular stimuli such as growth factors, cytokines, tumor promoters and UV. Over expression of MMPs has been observed in tissue remodeling, repair and destruction by many extracellular stimuli and among the MMPs, MMP-2 and MMP-9 degrade the ECM and they influence skin wrinkle formation and skin thickness (Inomata *et al*., 2003).

Moreover, the MMP-9 proteolytic system may also modulate active VEGF. It has been reported that inflammatory cells, including neutrophils, macrophages, and mast cells, especially those expressing MMP-9, can be accomplices to neoplastic cells during squamous carcinogenesis (Bergers *et al.,* 2000). COX-2 expression is critical for chronic UV-induced murine skin carcinogenesis (Chun and Langenbach, 2007). One of the most frequent events in carcinogenesis is the uncontrolled activation of the Ras signaling pathway and Lee *et al.* (2006) reported that H-Ras upregulated MMP-9 and COX-2 expression through the activation of extracellular signal-regulated kinase and the I*κ*B kinase-I*κ*B*α*-nuclear factor-*κ*B signaling pathway, which may contribute to the malignant progression of WB-F344 rat liver epithelial cells. Thus, UVB-induced skin carcinogenesis and tumor growth might be closely associated with the systems of MMP, VEGF, and COX-2 expression.

Therefore, protecting the skin against UV radiation is vital. Photoprotection is a group of mechanisms that nature has developed to minimize the damages that an organism suffers, when exposed to UV radiation. These mechanisms can be controlled or organized by certain organic and inorganic compounds or substances (i.e. melanin) produced by different terrestrial and aquatic sources. In a series of studies of the effects of natural products on UV-induced skin damage, it was found that olive extract, and in particular, oleuropein, inhibited increases in skin thickness and reductions in elasticity induced by long-term exposure to UVB in hairless mice. In addition, oleuropein reduced the incidence and growth of tumors in chronically UVB-irradiated mice (Kimura and Sumiyoshi, 2009).

Recently, it was demonstrated the involvement of the antioxidant response element (ARE), a transcriptional control element that meditates a family of phase 2 enzymes and antioxidant proteins, under control of the transcription factor NRF2, in skin protection. Induction of ARE-dependent genes plays an important role in protection of cells against oxidative damage (Aleksunes and Manautou, 2007).

Again, transcription of this family of enzymes provides a powerful repair mechanism for skin against ROS, caused through UV exposure or inflammation associated with ageing. Previous work with olive phenolics has demonstrated that these compounds, being free radical scavengers, contribute positively towards skin health by preventing the oxidative damage linked with the formation of wrinkles and other such disorders, such as skin dryness and hyperproliferation (Aldini *et al*., 2006). Recently, gene expression profiling of age spots has also provided an understanding of the role of olive oil derivatives in inducing antiageing skin benefits, by upregulating the transcription of the antioxidant response element, and antihyperpigmentation benefits, by downregulating the transcription of beta adrenergic receptors (Osborne *et al*., 2012).

IV – Conclusions

In summary, the bioavailable nature of olive oil phenolic compounds supports evidence for their health promoting properties. However, in this regard, significant efforts should also be focused on the isolation and structural elucidation of olive phenolics and other bioactive derivatives. This can promote application of olive in the food, pharmaceutical and cosmetic industries and provide sound clinical basis for assessment of potential anti-atherosclerotic, anti-hypertensive, anticancer, anti-platelet aggregation and immune-modulatory functionalities of olive bioactives.

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The genie in the bottle

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I – Introduction

The American journalist and writer Mort Rosenblum, author of the book "Olives", says that "An olive, to many, is no more than a humble lump at the bottom of a martini. Yet a closer look reveals a portrait in miniature of the richest parts of our world. The olive trees have oiled the wheels of civilization since Jericho built its walls and ancient Greece was morning news. From the first Egyptians, they have symbolized everything happy and holy in the Mediterranean. But it is simpler than all that. Next time the sun is bright and the tomatoes are ripe, take a hunk of bread, sprinkle it with fresh thyme and think about where to dunk it. I rest my case".

Over the past ten years I have had the opportunity of observing at close quarters many extra-virgin olive oils, namely those from Southern Aragon, and learning from outstanding figures such as Juan Baseda, CRDOP technical director, –from whom I have learned almost everything I know about oil–, his wife María Ángeles Calvo, head of the Catalonia tasting panel, and Alfredo Caldú, president of Regulatory Council of the Designation of Origin "Bajo Aragón Oil", who has taught me the direct relationship between the olive tree and man, something we cannot understand unless you are close to them.

Out of their interests and concerns, of the day-to-day contact with them but also with other manufacturers in the area, a link with the extra virgin olive oil was established that has become my passion, something that also happens to another good friend of mine and an expert on the subject: José Carlos Capel, president of the International Gastronomy Congress "Madrid Fusión" and food critic for El País newspaper, from whom I take some words of one of his books on oil:

"The more delicate, sweet, slightly astringent and not spicy oils are well adapted to be used uncooked to dress salads or season vegetables and to boil white fish; the same oils that are used to set omelettes, prepare scrambled eggs, fry eggs, sauté mushrooms, enrich vegetable creams or to add a final touch of refinement to a great variety of dishes in modern and contemporary cuisine.

Oils of distinguished appearance offer greater versatility and can be adapted to all kind of preparations and because of their fineness they can be used as irreplaceable ingredients in mayonnaise sauces and confectionery recipes. No one disputes that the fruity and more or less fragrant, and sometime subtly bitter, oils enhance the flavour of fried food, especially potatoes, and improve most sautéed ingredients and stew bases. Within this group, the mildest oils with a medium level of fruity flavour may work out superbly with salads and, above all, they are irreplaceable in elaborating traditional dishes of our regional gastronomy: cod with pil-pil sauce, fish in green sauce, marinades and *gazpachos*, cold tomato soups.

Because olive oil is capable of changing the result of a dish it has to be used sensitively and judiciously. A salad dressed with an olive oil tinged with a hint of bitter almonds offers numerous sapid sensations: tastes change, the olfactory scale and even the style of the ingredients used may be modified. Wherever the presence of garlic is noted, the oils from Andalusia stand out on their own merit, namely those from Jaén and Córdoba. In egg sauces, such as mayonnaise, oils from Southern Aragon are just amazing. Thus, our culinary culture clings to and is founded on the olive oil.

The golden rule for cooking with olive oil is moderation. Never waste it or soak dishes in fat".

Extra virgin olive oil occupies the throne of quality oils. Just as with fine wines, olive oil has a very strong personality. Its colour is clear and has fruity flavours, enhanced by a multitude of secondary nuances. In the kitchen it is the oil that better enriches the taste of dishes and the best for fried food. Besides, it has health beneficial effects, since it prevents arteriosclerosis and cancer. Spain produces and consumes olive oil in abundance, but the average consumer is little acquainted with this part of the nation's gastronomy.

At first glance, there seems to be no difference between olive oils, except for the bright and colourful labels and the increasingly fanciful shapes and designs of bottles used to sell the best olive juices, particularly those at the top of the quality ranking, extra virgin olive oils.

However, apart from the media hype aiming at capturing consumers' attention, no other external feature yields clues as to what is to be found inside the containers. Typically, the varied colours of the oils, ranging from grass green to the finest gold, mean very little to buyers not knowledgeable on the subject.

The bottles of good oils do not unravel their mystery at first sight. The genie they enclosed, in other words, their culinary and health potentials, remain hidden for the uninitiated consumers.

However, olive oil is a condiment and dressing daily used in the Spanish cuisine. The objective of this presentation is to provide some keys to help identifying and appreciating the king of Mediterranean tables: olive oil, which in its maximum expression, is always extra virgin quality oil.

Among the top categories, no two oils are alike just as there are no two wines alike. Wines and oils, by the way, have quite a lot in common. In both cases there are types of processing, areas of origin, cultivated varieties, bouquet or even gradation; although in this latter case the degree of acidity and that of alcohol bear different meanings.

II – Acidity: What does it mean?

Acidity is measured in degrees and has been the main parameter used to classify the different types of olive oils. Nowadays the level of acidity cannot exceed 0.8 degree in extra virgin olive oil, that is, the equivalent to 0.8 grams of free fatty acids, expressed as oleic acid, per 100 grams of oil.

Some more stringent rules, such as that regulating extra virgin olive oil under the "Bajo Aragón" Designation of Origin, set up a lower acceptance threshold, at 0.5 degrees. In general, virgin oils, which do not reach the extra category, may reach 2 degrees of free acidity.

In scientific terms, acidity refers to the amount of free fatty acids present in olive oil, although it is necessary to stress that this parameter has nothing to do with neither flavour nor colour of the olive juice; within certain limits it is just an indicator of the product *healthiness*. Acidity is the result of anomalies in the harvested fruits, during the oil elaboration process or its storage. Similarly, acidity is not a measure of more or less intense flavours.

Extra virgin oils, however, stand out because their flavour, odour and colour are irreproachable, perfect, so to speak. When savouring them, they only taste as fresh olives, even though a professional taster could discover secondary aromas, textures and flavours, thus allowing for a more in-depth organoleptic (sensorial) analysis, which will not invalidate the layman's who finds that extra virgin olive oil is, simply, olive juice.

Due to a deep-rooted but erroneous belief, the Spanish often suppose that low acidity means mild flavours and that more acidity refers to fruity, stronger flavours; a big mistake, as shown by many extra virgin oils of great quality and intense flavour, whose acidity is lower than 0.2º or 0.3º, or even less.

Acidity is a parameter that will probably be removed from labels in the future. So, why do oil-producing companies insist on providing this disconcerting information? There is a simple explanation. There is a direct relation between the biological condition of the olives and the free acidity of the oil they produce. Low acidity means that the oil comes from healthy fruit and has been processed in optimum conditions, but only when talking about virgin or extra virgin oils. This is obviously something worth boasting about.

III – Classes of virgin olive oil

Extra virgin olive oil is at the top of all virgin olive oils. To deserve the first place in the ranking, as pointed out above, it should not exceed 0.8 degree of acidity. Also it has to comply with other, even more important analytical indexes, like peroxide index, UV absorbency, stability, humidity, etc. However, the sensorial analysis performed by an approved testing panel is also mandatory for establishing the quality of a virgin oil

In terms of quality, there are other classes of oils classified below the extra virgin: (fine) virgin olive oil, ordinary virgin olive oil and lampante virgin olive oil. On a lower rank we find olive oil and pomace olive oil.

Fine or virgin olive oil does not exceed 2 degrees of acidity. Those showing higher acidity are called lampante virgin olive oil and must be refined.

On the other hand, the olive oil category is the result of a mixture between refined olive oil and virgin oils that are added in order to improve it and add flavour in an operation called blending.

Oils classified as ordinary virgin oil are commonly used to blend with refined oils. The mixture final acidity cannot exceed 1.0 degrees.

Refining is carried out with oils of more than 2 degrees or even less if they have some sensorial defects. When performing this operation oils are subjected to a series of processes which diminish their taste and aroma properties and bleach them. The virgin oils added to the refined oil before they are marketed make them suitable for consumption while giving them some of the characteristic sensorial properties of the virgin oils.

Finally, olive pomace oils are a blend of refined pomace oil and non-lampant virgin olive oils. As in the previous case, its acidity must not exceed 1.0 degree. Pomace is an olive byproduct which is used to make lower quality olive oils.

However, as stated above, the olive sensorial characteristics are more important than acidity in classifying the different kinds of olive oil, established by the European Union. These are specifications that must appear clearly on the labels, bearing several factors in mind, as stated above.

The commercial categories are as follows:

A/ EXTRA VIRGIN OLIVE OIL: It is the best one, just olive juice of irreproachable taste, adequately obtained from olives harvested in their best ripening stage, thus reproducing the fruit odours and flavours. Its organoleptic score, assigned by a tasting panel, should be equal to or higher than 6.5. Its acidity must not be higher than 0.8º

B/ VIRGIN OLIVE OIL: It is oil that may present slight deteriotation, either in the sensorial analysis or in the analytical indexes. Its organoleptic score should be equal to or higher than 5.5. Its acidity should not be in excess of 2º

C/ OLIVE OIL: It consists of variable proportions of refined olive oil and virgin olive oil. Its acidity cannot be in excess of 1.0º.

D/ OLIVE POMACE OIL: This oil is a mixture of variable proportions of refined pomace olive oil and virgin olive oil. Its acidity cannot be in excess of 1.0º.

The EXTRA VIRGIN OLIVE OIL FROM Southern Aragon is of exquisite and mild, fluid texture, fruity at the start of the campaign, becoming sweeter and more delicate as the campaign progresses. That mildness makes it different from the other extra virgin olive oils on the market. It is so mild that it can be consumed by children, who will not perceive any strong or unpleasant taste.

IV – A matter of colour

Although the colour is not considered as a quality characteristic by the tasting panel, consumers normally appreciate it.

The colour of virgin olive oils shows, although not only, the maturation level of the olives used, the time when they were harvested. Thus, a golden yellow tone indicates a late harvest, whereas a dark green colour means that the fruit was harvested early, when the ripening process was not completed.

It should be noted that in the case of 'Empeltre', the most widely farmed variety in Southern Aragon, its characteristic golden colour does not depend on the time the tree was harvested, but it is the natural colour of this oil. Besides, it should be borne in mind that the coloured-glass bottles used by certain brands mask the real colour of the oil. In any case, the more fruity and aromatic oils are obtained at the beginning of the maturation period. It has been verified that the wealth of flavours decreases as the harvest is delayed, which in the "early harvesting" areas of Aragon region starts in November and finishes in February.

V – From the olive tree to the table

The supreme quality of extra virgin olive oil is the result of a summary of factors: the weather, the soil, the olive variety, the cultivation techniques, the processing and even the type of container in which the oil is marketed. Indeed, the virtues of the oil are better preserved in glass or tin containers.

Another essential feature of extra virgin and virgin olive oils is that they go directly to consumers, whereas in the case of lampante oils they have to be subjected to a refining process which delays the moment they reach the consumers' table and kitchen. In accordance with regulations, only virgin oils of less than 2 degrees of acidity can be used for direct consumption.

Once in the mill, the olives from which extra virgin olive oil will be extracted, that have to be harvested from the olive tree branches and never from the ground, have to be milled immediately to avoid its storage before milling, since that practice results in a loss of oil quality, including higher acidity.

The principle that rules the elaboration of top quality oils is that raw material will not be subjected to any process that may alter its composition.

VI – Homeland of the olive oil

The olive cultivation and the elaboration and conservation of extra virgin olive oil follow standard methods that take into account all minute details. From such a thorough control an homogeneous product with identical flavour, colour and aroma would be expected. This would be the case in these high-quality oils if there were no other more or less random factors such as the climate, the type of soil or the olive variety cultivated, which vary from county to county or even from town to town.

Suffice it to say that 262 olive varieties are catalogued in Spain. Seven of them stand out from the rest because they are widely grown. These varieties are named 'Picual', 'Cornicabra', 'Hojiblanca', 'Lechín de Sevilla', 'Empeltre', 'Arbequina' and 'Blanqueta'. And the picture becomes more complicated when oils are blended, an art that opens up a whole new world of flavour possibilities to those mastering the art of "coupage". At present you can find on the market extra virgin olive oils from one single variety (single varietal oils) or blended oils.

Certain regions where the olive trees have been traditionally grown have achieved great reputation in the processing of high quality oils and thus have protected designations of origin (PDO). Bajo Aragón, Les Garrigues, Siurana, Priego de Córdoba, Sierra de Segura, Sierra de Mágina and Baena are among the Spanish PDOs. These Spanish regions, located in the northeast and south of the country, enjoy worldwide recognition.

VII – The tasting: the realm of the senses

The interaction between climatic, geological and biological conditions yields an incredible variety of flavours and textures that fit the extra virgin category. Moreover, it can be said that one of the distinguishing features of the best oils is their multiplicity of flavours, from the sweetest and mildest to those with a bitter or spicy palate, through the entire scale of intermediate nuances.

Oil and wine are similar in another way: they offer an endless range of flavours, aroma and colours that have to be unveiled by tasters, although gourmands may detect and enjoy them if they set their minds to it.

The purpose of any tasting is to classify oils based on parameters such as flavour, appearance, colour, aroma, taste and, as strange as it may seem, touch. The term flavour refers to the sum of two sensory impressions: the taste and smell of oil.

The appearance may be clean, as in the case of extra virgin olive oil, but also veiled or dark, which entails a negative assessment.

Colour includes all shades of yellow and green in quality oils, whereas the whitish, reddish, brownish or dark colours are considered defective.

Aroma and taste are also assessed independently and have resulted in a vast list of metaphoric expressions which are used, as is the case of wine, to define in a practical manner the enormous variety of secondary flavours that a trained palate is able to distinguish when tasting extra virgin olive oil; of course bearing in mind that primary flavour and aroma are only and exclusively derived from good olives in liquid state.

From the "a" of almondy, to the "s" of soil, oils can have many qualifying adjectives, both positive and negative, which help defining flavour in exact terms: almondy, fruity, bitter, fusty, herbal, metallic, etc.

The oil also leaves a tactile impression as it passes through the mouth. It leaves a trace of some density, of a more or less thick structure which is analysed by the taster.

VIII – The essence of the kitchen: cooking with olive oil

There are plenty of reasons to recommend the use of extra virgin olive oil for cooking, where it proves to be extremely versatile. In the sphere of gastronomy, there is also a parallelism between oil and wine; gourmets maintain that there is an appropriate oil for each kind of food. The oil must be chosen carefully because, regardless of whether it is used as seasoning or for frying, it is of decisive influence in the flavour of the dish.

Ultimately, the choice of one oil type or another depends on each individual's taste, but even so an unwritten rule insists on the fact that smoother extra virgin olive oils are ideal for salads and vegetables, while more strongly flavoured oils are more suitable for frying, grills and roasts.

One thing that is generally accepted as true is that virgin olive oil is perfect for frying because it is not damaged at high temperatures, it does not lose its qualities and it can be reused, unlike other vegetable oils. It also goes further on the frying pan: it increases (its volume) visibly through the effect of heat. When frying, virgin olive oil does not penetrate into the food; in other words the food does not become oily, also implying that a certain quantity of food does take less oil if it is olive oil instead of any other vegetable oil.

The olive oil of highest quality is best appreciated if taken raw, when it allows one to savour all the nuances that make up its flavour. In this respect it is clearly differentiated from insipid oils made from seeds whose taste is neutral and standardised.

It should not be forgotten that more intensely flavoured oils run the risk of drowning the flavour of the food or that lighter texture oils are hardly noticed if they accompany strongly-flavoured dishes.

Unlike good wines, oils do not mature or improve with the passage of time. The indication "Best before..." means that the oil inside will not deteriorate noticeably before the stated date, more or less than one year since the packaging, mainly depending on the variety. But once open, the bottle should be used up fairly quickly because the oil will not be so protected from oxidation during much time since that opening, thus becoming deteriorated and rancid. Therefore, when buying a bottle of extra virgin olive oil it is very important to check the packaging date.

Bottles or cans of virgin olive oil should be stored in a cool dry place away from light and heat.

IX – A very healthy habit

The benefits of extra virgin olive oil go further than gastronomy. The juice from olives, which is being used in the Mediterranean Basin since around 6000 years ago, decorates the dishes, provides healthiness and energy for the body and lubricates arteries, protecting against cardiovascular diseases.

Olive oils contain monounsaturated fatty acids which help controlling blood cholesterol levels. Medical research has shown that in olive oil consuming countries there is a lower incidence of heart attacks than in those countries using animal fats or butter.

Together with fish, fruits and vegetables, the juice from olives is an essential component of the Mediterranean Diet, which offers unquestionable benefits for the health and prevents coronary problems. Olive oil is a customary ingredient in the more balanced diets. It contains vitamin E, a kind of tocopherol, an antioxidant which plays an important role in protecting against cancer.

Olive oil also stimulates bone growth and mineralization, and thus is recommendable both for children and the elderly.

Because of its cell regeneration capacity, olive oil keeps skin smooth and young. Since it has moisturizing and lubricating properties, a spoon of olive oil –better if virgin– on an empty stomach can help avoiding the discomfort caused by constipation. If externally applied as a liniment it acts as a healing balm for burns.

Phytotherapy treatments, where herbal healing is used, only utilize extra virgin olive oil.

The best of olive juices, the extra virgin olive oil has multiple beneficial effects and is a never-ending source of health, a natural medicine which is also and above all a daily gastronomic delicacy in Spain.

X – Learning to read the labels

Labels on the packages provide increasingly accurate information of interest regarding the packed oil. There are also booklets tied to the neck of the bottles in which recommendations and cooking advices are given and the sensorial characteristics of the oils are described; these are real taste cards and provide basic data to help you choose the oil you are looking for.

It should be borne in mind that within the commercial categories –extra virgin, virgin and olive oil– the reference to acidity on the labels is unrelated to taste and even quality, as a virgin olive oil of 2º is better than an olive oil of 0.4º. Oil of low acidity simply means it comes from healthy fruit, but only if it is a virgin or an extra virgin oil.

To be sure that the oil in a bottle is in good condition, one must be sure that it has been properly stored. In any event, it is essential to observe the best before date ("Best before ..."), which is usually indicated in very small lettering.

Table olives – A natural source of health-promoting bioactive nutrients and probiotics

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Abstract. A new generation of natural and healthy foods has been on the rise – and fermented olives are part of that new trend. Concerted public health policies triggered by budgetary restrictions will require investment on prevention rather than bearing – especially as the human life expectancy is becoming longer and longer; and the aforementioned types of foods are nuclear vectors of this strategy as applied to the Mediterranean countries. Some of the components of the olive fruit may by itself function as prebiotics, viz. dietary fibers (with beneficial effects toward prevention of several pathologies), besides such nutraceuticals as essential fatty acids (with anti-cancer features) and antioxidant sterols, polyphenols and glycosides (with general anti-ageing activities). Moreover, some of the adventitious lactic acid bacteria of table olives apparently can survive passage through the gastrointestinal tract – and fully i.e. they resist digestion and even survive in the gut, so they have a chance to act against pathogens installed therein ward showing probiotic capacities. Production of fermented olives with selected (wild) probiotic bacteria therefore constitutes indeed a new avenue to enrichment of the existing olive-based product portfolio, by generating a new food containing probiotics aimed at improving consumers' health without hampering its original sensory characteristics of that have accounted for their success so far.

Keywords. Table olives – Bioactive compound – Probiotics –- Health-promoting.

Les olives de table – Une source naturelle de composés bioactifs et de probiotiques pour la promotion de la santé

Résumé. *Une nouvelle génération d'aliments naturels et sains est à la hausse - et les olives fermentées en font clairement partie. Suite aux politiques de santé publique concertées visant à faire face efficacement aux restrictions budgétaires, il faudra investir sur les approches de santé préventives - d'autant plus que l'espérance de vie humaine s'allonge ; et les types d'aliments mentionnés ci-dessus sont des vecteurs essentiels pour cette stratégie appliquée dans le bassin méditerranéen. Les olives de table traditionnelles semblent un produit cible ayant un bon potentiel pour la promotion de la santé ; les composants du fruit peuvent aussi agir comme prébiotiques, à savoir, les fibres alimentaires (ayant des effets bénéfiques en matière de prévention de pathologies humaines), outre les produits nutraceutiques tels que les acides gras essentiels (avec activité anticancéreuse) et les antioxydants tels que stérols, polyphénols et glucosides (avec activités antivieillissement). En outre, certaines bactéries lactiques indigènes des olives de table peuvent survivre au passage dans le tractus gastro-intestinal - résistant ainsi à la digestion, et pouvant en conséquence agir contre les agents pathogènes qui y sont installés, montrant ainsi un potentiel probiotique. La production d'olives fermentées par des bactéries probiotiques sélectionnées (indigènes) constitue en effet une nouvelle voie pour enrichir le portefeuille de produits à base d'olives et permettre d'obtenir un nouvel aliment contenant des probiotiques pour améliorer la santé des consommateurs, sans pour autant entraver les caractéristiques sensorielles des olives fermentées.*

Mots-clés. *Olives de table – Composés bioactifs – Probiotiques – Favorisant la santé.*

I – Introduction

Besides responding to nutritional needs and providing organoleptic pleasure, foods may play a third role following regular inclusion in a balanced diet (that is gaining worldwide interest): carrying extra protection against degenerative diseases, and delaying incidence (and severity) of chronic health conditions. As a consequence of the rising consumer awareness on the beneficial effects of functional foods, worldwide consumption of olives and olive products has significantly increased –especially in the USA, Europe, Japan, Canada and Australia; this has accordingly led development of complementing olive-based products. Meanwhile, the market share of traditional fermented food products is steadily growing in Europe, as consumer's value cultural heritage, and gastronomic quality– so proof of an extra functional status may reinforce this trend, especially with regard to olives (IOC, 2008).

Table olives are probably the most popular fermented vegetable in the Western world, and cannot be told apart from the Mediterranean diet (together with olive oil). Its preservation process encompasses a spontaneous fermentation, and it produces a sensory profile that depends on the cultivar and the native microbiota – besides the degree of maturity at harvest and any postharvest steps. During fermentation, wild lactic acid bacteria (LAB) and yeasts (Marquina *et al.,* 1992; Garrido-Fernández *et al*., 1997; Oliveira *et al*., 2004; Tassou *et al*., 2002) eventually dominate over contaminating microbiota that would otherwise pose sensory and health hazards (Delgado *et al*., 2005; Silva *et al*., 2011); despite the spoilage related to yeast growth during storage and package, the presence of yeasts during olive fermentation is crucial because of the production of relevant compounds that determines special organoleptic attributes in final product (Arroyo-López *et al.,* 2008); enzymes indigenous to the raw materials may also play a role in enhancing taste and safety (Hammes, 1990).

Regarding the fruit itself, some of its components may play a prebiotic role: e.g., carbohydrate polymers as dietary fibers, essential fatty acids, and anti-oxidant sterols and polyphenols. Besides the intrinsic nutritional features of table olives derived from their original composition, the metabolites resulting from the phenomena associated with fermentation also being about nutritive and safety benefits. Addition and preferential promotion of growth of probiotic LAB isolates (among the complex native microbiota) may further improve the functional properties of table olives in the future.

II – Nutritional properties of table olives

Several advances have been made in recent years on the scientific understanding of how diet –and specific foods if included regularly in a balanced diet– promote human health and prevent chronic illnesses, such as cardiovascular diseases, cancers, and neurodegenerative disorders. Consumers are accordingly turning their attention toward foods with health-promoting properties as promising tools in disease prevention and health maintenance. A focus on the Mediterranean diet has been witnessed, and a few foods that are nuclear to this diet have grown significantly in demand olives and olive oil.

Nutritional benefits of table olives have been claimed to be associated with major and minor constituents, the concentration of which depend on the cultivar, the maturation state and the type of processing (Garrido-Fernández *et al*., 1997). The most abundant compounds in table olives are water, and lipids to a lesser extent. With regard to fatty acid profile, monounsaturated and polyunsaturated fatty acids represent 78.9% and 4.8%, respectively. Triglycerides (ca. 82%) are represented chiefly by monounsaturated residues (e.g. oleic acid), along with a small amount of saturated and a considerable fraction of polyunsaturated which are known as essential for human nutrition, e.g. linoleic and α-linolenic (Salas *et al*., 2000). Although indispensable for cell structure development and function, they cannot be synthesized by the human body (Garrido-Fernandéz and Lopez-Lopez, 2008). The sterolic fraction is mainly constituted by ß-sitosterol (94.0%), Δ-5-avenasterol (6.3%), erytrodiol plus uvaol (3.4%), campesterol (3.0%) and stigmasterol (1.1 %) (López-López *et al*., 2009). Fermented action does not affect the fatty acid profile, or the sterol and triterpenic dialcohol profile (EUC, 2003). Fatty acids and sterols in olives play an important role in human nutrition in prevention of several degenerative diseases (Awad *et al*., 2000; Escrich *et al*., 2006). The beneficial effects of consumption of these fatty acids with regard to cardiovascular diseases has been demonstrated in primary prevention, since it reduces the risk of occurring the disease; and in secondary prevention, since it reduces the probabilities of occurrence of a second coronary event (Covas *et al*., 2006).

Olives are also a good source of fibre; they contain all essential amino acids in their proteins and a high concentration of polyphenols (TDC Olive, 2006). The levels of vitamins in olive pulp are important; the dominant ones are (the water-soluble) ascorbic acid and thiamine; (the oil-soluble) tocopherols and carotenes are considered the most important lipid-soluble antioxidants in nature; they prevent lipid peroxidation, and α-tocopherol protects the body against free radical attacks, skin disorders, cancer and atherosclerosis (Lavelli and Bondesan, 2005).

No changes on the cellular structure are observed during olive processing; the most important transformations related to fermentation are the loss of hydrosoluble compounds (Ekinci, 2005; TDC Olive, 2006). Due to the relative instability of hydrosoluble compounds despite their role in nutrition, they should be monitored throughout the food chain. On the other hand, vitamins of the complex B (e.g. thiamine, riboflavin, niacin, pantothenic acid, biotin, pyridoxine, folic acid and cyanocobalamin) are hydrosoluble, so they are more susceptible to fermentation; these compounds play specific and vital functions in all forms of life. They can be synthesized by bacteria, yeasts, moulds, algae and some even plant species. Human beings cannot store most of them (except B12 and folate that are stored in the liver), so they need a daily allowance to be ingested (FAO/WHO, 2002). The vitamin requirements of *Lactobacillus pentosus* DSM 16366 isolated from olive brines were determined – and the riboflavin level in the brines did not suffer significant changes, unlike pantothenic acid and biotin, conversely, observed adventitious strains *Pichia membranaefaciens* produce vitamins of the B complex, whereas strains of *Saccharomyces cerevisiae* produced only riboflavin, vitamin B6 and folic acid (Reto *et al.,* 2006).

The mineral composition of table olives depends significantly on the cultivars and the mode of preparation. As expected for a brined food product, Na is the most abundant element, but olives are also a good source of Ca, K, Mg and P. Levels of Fe are also high in ripe olives, but relatively low in green and directly brined ones, whereas such microelements as Cu, Zn, Se and Mn appear at levels similar to other plants (Fernández-Diez *et al*., 1985).

The phenol components contribute to sensory characteristics of olive products, further to their pharmaceutical and physiological benefits (Covas *et al*., 2006); the main classes of phenols in olive oil are phenolic acids, phenolic alcohols, hydroxy-isocromans, flavonoids, secoiridoids and lignans (Bianchi, 2003). Phenols have been proven to play several biological properties; for instance, hydroxytyrosol inhibits platelet aggregation and is an anti-inflammatory agent, while oleuropein promotes formation of nitric acid which is a powerful vasodilator and exerts a strong anti-bacterial effect (Visioli *et al*., 1998; Andreadou *et al*., 2007). The antioxidant properties of olives are associated with their free phenols and corresponding glycosides. Oleuropein is responsible mainly for bitterness, but its content decreases along maturation. Lactobacilli have an important role in the (biological) debittering process of naturally ripened olives (Rozès and Peres, 1996; Ghabbour *et al*., 2011); their metabolism leads to accumulation of derivatives with even higher anti-oxidant capacity, e.g. hydroxytyrosol (Marsilio *et al.,* 1998). This trait is a result of β-glucosidase activity of those microorganisms (Silva *et al*., 2011). Hydroxytyrosol appears to be safe – and has even been recognized as GRAS. Additional support for of olive oil effect on cardio-health was apparent when EFSA approved a 'heart health' claim for hydroxytyrosol (EFSA, 2011). Tyrosol and hydroxytyrosol are absorbed by humans after ingestion (e.g. via olive matrices) in a dose-dependent manner, and they are excreted in the urine as glucuronide conjugates (Visioli *et al*., 2000). Other phenolic constituents of olives have been associated with potent biological activities *in vitro*, including (but not limited to) antioxidant action (Pereira *et al*., 2006; Landete *et al.,* 2007).

III – Probiotic attributes of native lactic acid bacteria

Lactic acid fermentation has been for centuries the dominant method of biological preservation of vegetables around the world. Demand for lactic acid fermented products has never ceased – and is expected to rise in the near future. It is generally agreed among food scientists that 'fermented plant products' are nuclear 'foods of the future', because of their unique properties. Of particular interest for food fermentation indeed olives which remain one of the most important food industries in the Mediterranean Basin, with Spain, Italy, Greece, Portugal and France sharing the market as leaders (Patterson and Josling, 2005).

Despite its local and overall economic impacts, most olive brining is still carried out following artisanal practices, with a moderate degree of technological innovation. However, the uniqueness of fermented olives has made them unavoidable ingredients for gourmet recipes and gastronomic excellence; nowadays health-aware consumers seek them also for their biological origin and functional features (Garrido-Fernandéz and Lopez-Lopez, 2008).

Microorganisms bearing a health impact will likely remain important functional ingredients in the coming future; new strains will probably be identified, and foods will accordingly be developed to fulfil the needs of an ever increasing number of specific consumer groups. Increased understanding of the interactions prevailing between the gut microbiota, the diet and the physiological conditions in the host will open up new possibilities of producing new tailor-made ingredients and nutritionally optimised foods – both of which are expected to promote consumer health at large, namely via favourable microbial activities in the gut (Mattila-Sandholm *et al.,* 1999).

According to the FAO/WHO (2009), probiotics are live microorganisms which, when administered in adequate amount, confer a health benefit on the host; this implies passing through the gastrointestinal to sufficiently high viable numbers. Probiotic microorganisms alter favourably the intestinal microbial balance, promote intestinal integrity and mobility, inhibit the growth of harmful bacteria and increase resistance to infection. The effectiveness of probiotic microorganisms is considered to be population-specific –due to variations in gut microbiota, food habits and specific host-microbial interactions.

Most probiotic strains available in the market are of Western (or at least European) origin, so seeking for new indigenous probiotic organisms is in order. Fermented foods of plant origin have been increasingly considered as vectors for incorporation of probiotic cultures (Soccol *et al*., 2010), following the well-established worldwide know-how on manufacture of LAB-fermented vegetables. Native LAB can bring about health-promoting features (Kohajdová *et al.,* 2006).

Despite most probiotic strains employed commercially being originated on the gastrointestinal tract (Haller *et al*., 2001), plant matrices may be an alternative source. Unfortunately, only a few successful probiotic cultures in dairy products exhibit acceptable viabilities in plant matrices by the time of consumption; screening for LAB strains of plant origin for potential probiotic features may help overcome such technological challenges (Karasu *et al*., 2010).

The European olive production and export numbers are already impressive – but competition involving low-added value, traditional agricultural commodities developed by less developed countries in the Mediterranean basin and elsewhere has been on the rise. The production of probiotic olives fermented with (potential) probiotic bacteria isolated among their native microbiota and added so as become dominant raises new opportunities (Fernández-Diez *et al*., 1985; Oliveira *et al*., 2004); the selected bacteria may then be introduced into brines at the onset of fermentation so that thus can act as starters, and hence dominate the population and ensure proper fermentation while inhibiting undesirable microorganisms (Peres, 2011).

IV – Opportunity for product innovation

The primary role of diet is to provide enough nutrients to fulfil body building and energy requirements, yet pleasing the sensory organs and assuring convenience – while providing a feeling of social satisfaction and well-being, have also appeared as complementary roles. Recent scientific evidence has proven that diet may modulate several functions in the human body, as well as delay, or even decrease incidence of a few chronic diseases and health conditions (Newell-Mc Gloughlin, 2008).

A significant challenge for traditional food production is thus to improve its competitiveness by finding opportunities for innovation that may guarantee the safety of the products, while meeting general consumer demands and specific consumer expectations and attitudes (including towards traditional food). Integration of the rich history of European cuisine with the innovation-driven market is a particularly challenging task for food manufactures; and ensuring that the European food industry remains ahead in the value chain through use of appropriate advanced and innovative technologies in traditional food processing is a main priority for competitiveness (Peres *et al.,* 2012).

Over recent decades, consumption and development of probiotic foods has been increasing, as a result of the awareness of their beneficial effects towards gut health, as well as disease prevention and therapy. Food processes are now focusing on new non-dairy foods that can contribute to regular assumption of probiotics – e.g. by individuals with lactose intolerance, or subjected to diets lacking milk-derived products. Health-proactive ingredients – or nutraceuticals, and matrices that incorporate them – or functional foods, will accordingly be the major food trend of the 21st century. This may be accounted by a global population growing older and state health budgets increasing dramatically – besides realization that health-related items are sold at premium prices and have interesting profit margins. The food industry has thus been urged to design novel food matrices for use as vectors for delivery of probiotic strains – but claims can be used in labelling only after establishing their role beyond reasonable doubt (Peres *et al.,* 2012). Future studies are in great needs that collect data to definitely assess, by *in vivo* studies, whether the living bacteria, as well as the fruit beneficial components significantly improve health of consumers. If so, allegations can be proposed for certain types of table-olives be classified as functional foods, and thus develop a share in a much more interesting food market.

Acknowledgements

EU project Probiolives (contract 243471); Project NEW PROTECTION (ref. PTDC/AGRALI/117658/2010); Doctoral fellowship (ref. SFRH/BD/81997/2011); Master fellowship (ref. PTDC/AGRALI/117658/2010); and Master fellowship (ref. 243471).

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The place of scientific information in the promotional activities of the International Olive Council.
Olive oil and health: Consumers' perception

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Abstract. The characteristics of olive oil are the main factor associated with the quality of the product. The Mediterranean Diet, health and taste are the aspects with which olive oils are most closely identified. In the minds of consumers, olive oils are chiefly seen as being healthy, nutritional, natural and easy to digest. All these properties make it the ideal choice of fat, not just because of its myriad health-promoting benefits but also because of its organoleptic and culinary attributes. One of the key aims of the IOC is to assert the sound nutritional and dietary benefits of olive oil, which is a core element of the Mediterranean Diet. Collecting and disseminating scientific knowledge on the nutritional and health related advantages of olive oil is central to the task of informing consumers about this product and promoting its consumption. Olive oil is the chief source of fat in the Mediterranean diet. In recent years there has been a surge of interest in this dietary model, which has been "rediscovered" as a result of studies on disease prevention. The key to the biological potential, nutritional properties and organoleptic characteristics of olive oil lies in its composition, which is also central to understanding its functions. Being a natural fruit juice, it retains the taste, aroma, vitamins and properties of the olive. The component fatty acids of the triglycerides in olive oil differ to a certain extent according to variety and growing conditions. Monounsaturated oleic acid is clearly the predominant fatty acid, accounting for between 55 and 83 per cent. Coupled with the large amount of antioxidants it contains, this adequate degree of unsaturation is what gives olive oil its distinctive heat resistance and stability. The presence of minor components, particularly large amounts of antioxidants and vitamins (tocopherols, carotenoids and phenolics), lend it very important protective properties. Extensive research has produced new data on the metabolism, bioavailability and numerous biological effects of olive oil, as well as on its effects in preventing cell oxidation, protecting against free radical damage and in preventing cancer and ageing. On top of its sensory and gastronomic properties, olive oil has numerous medical benefits in disease prevention which are being constantly corroborated by science. As a consequence of this combination of factors, today's ever better informed consumers view olive oil as a product that is unique, healthy and natural.

El papel de la información científica en las actividades de promoción del Consejo Oleícola Internacional. Aceite de oliva y salud: percepción de los consumidores

Resumen. *Las características del aceite de oliva son el principal elemento asociado a la calidad del producto. Dieta mediterránea, salud y sabor son los aspectos con los que más se identifica a los aceites de oliva. Para el consumidor la principal propiedad de los aceites de oliva son sus beneficios para la salud, sus características nutricionales, su carácter natural y su fácil digestión le convierten en grasa de elección no sólo debido a sus múltiples bondades para la salud sino también organolépticas y gastronómicas. Uno de los objetivos prioritarios del Consejo Oleícola Internacional (COI) es afirmar la validez y los beneficios nutricionales y dietéticos del aceite de oliva, considerado componente esencial de la dieta mediterránea. La recopilación y divulgación de los conocimientos científicos sobre el valor nutricional y los beneficios para la salud del aceite de oliva constituyen la base de las acciones de información y promoción del consumo de éste a nivel mundial. El aceite de oliva es la fuente principal de grasa de la dieta mediterránea. En los últimos años ha habido un creciente interés por este tipo de alimentación que ha sido «redescubierta» gracias a diferentes estudios sobre prevención de algunas enfermedades. La composición del aceite de oliva es de gran importancia para explicar su potencial biológico y aspectos nutricionales así como sus características organolépticas; es, asimismo, fundamental para conocer sus distintas funciones. Al ser un zumo natural conserva el sabor, aroma, vitaminas y propiedades de la aceituna. Los ácidos grasos que*

componen los triglicéridos del aceite de oliva presentan una cierta variabilidad según la variedad y las condiciones de cultivo. Existe un claro predominio del ácido oleico que puede llegar hasta un 55-83%, es monoinsaturado. Este adecuado grado de insaturación unido a la gran cantidad de sustancias antioxidantes del aceite de oliva es lo que le confiere su particular estabilidad y resistencia al calor. La presencia de componentes menores, en particular los antioxidantes y vitaminas (tocoferoles, carotenoides y compuestos fenólicos), de los que posee una gran cantidad y le confieren propiedades especialmente importantes. Gracias a numerosas investigaciones, se tienen nuevos datos sobre su metabolismo, biodisponibilidad y numerosos efectos biológicos, previenen la oxidación celular, protegen contra la lesión de los radicales libres y previenen la carcinogénesis y el envejecimiento. Además de sus propiedades sensoriales y gastronómicas se han demostrado numerosos beneficios en el ámbito de la medicina en la prevención de distintas enfermedades que la ciencia confirma día a día. Todo ello contribuye a que el consumidor, cada vez más informado, considere al aceite de oliva como un producto único, sano y natural.

Summary and conclusions

The International Seminar on "Present and future of the Mediterranean olive sector" was held from 26 to 28 November 2012 at the Mediterranean Agronomic Institute of Zaragoza, and was jointly organized by the Mediterranean Agronomic Institute of Zaragoza, from the International Centre of Advanced Mediterranean Agronomic Studies (IAMZ-CIHEAM) and the International Olive Council (IOC), both of which have recently celebrated their 50 anniversary and are always willing to promote the Mediterranean region and the olive sector.

The objective of this Seminar was to prospect the future of the olive sector in the Mediterranean and the world, in an attempt to answer the following key questions: Are intensive production systems sustainable and will they be the basis of olive development in the future or should traditional systems still have an important role? Which are the key elements to be improved in processing technologies, especially in those countries where a large part of their production cannot gain access to the markets demanding high quality products? In addition to the well known nutritional and functional properties of olive products, what are their prospects as a raw material base for the nutraceutical industry? Which are the keys to open new markets and to increase the share in consolidated markets?

The Seminar was held over three days, two days devoted to scientific presentations and discussions structured in three sessions and a round-table discussion, with invited conferences and case-studies, and one day for the technical visit.

102 experts attended the Seminar from 18 countries: Albania, Algeria, Argentina, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Jordan, Lebanon, Morocco, Montenegro, Portugal, Spain, Tunisia and Turkey.

Session 1 was titled "Challenges and trends in olive growing and processing" and was chaired by Luis Rallo from Cordoba University (Spain). Five presentations were made, two involved a review of the situation concerning sustainable olive production technologies and olive oil processing and quality and three referred to significant case-studies (influence of soil on the quality of virgin olive oil in an Italian province, processing of table olives in Turkey and agricultural use of by-products from the olive oil industry in Tunisia). At the end of the presentations a general discussion was held.

The first paper was presented by Ricardo Fernández Escobar from Cordoba University (Spain) who analysed the evolution of olive farming systems in the past 50 years. The conclusion drawn was that the co-existence of traditional and intensive olive farming systems in Mediterranean production areas will require specific agricultural policies and measures in different countries. The biggest environmental threat for olive groves planted on slopes –as is the case for most traditional olive groves in Mediterranean countries– is erosion. Likewise, because of the expected water shortage, the efficient use of water, based on controlled deficit irrigation and drought tolerance, seems to be a determining factor for yield in olive plantations and olive oil producing areas. Besides, the new highly yielding, early producing and mechanized intensive systems will require more investments, scientific knowledge and technology transfer. Amongst the technological requirements, the following are emerging critical issues: variety testing and plant breeding, planting density, mechanized harvesting in different planting systems (including traditional plantations that can be harvested mechanically), changes of farming systems, and the extension of olive growing to regions where the climate is not strictly Mediterranean. Finally, crop production and protection systems should be based on the concept of integrated production which includes different methods that are compatible with the sustainable use of inputs.

The second paper was presented by Maurizio Servili, from the University of Perugia (Italy), who analysed the influence of processing technologies on Extra-Virgin Olive Oil (EVOO) quality and on the valorization of derived by-products. Special attention was paid to issues related to the concept of commercial quality of EVOO which is based on parameters describing changes or others that confer them this authentic nature but which are not considered by indicators related to sensorial and heath attributes. In his presentation, Dr. Servili detailed the variation in the composition in monounsaturated fatty acids and phenolic and volatile compounds, which are responsible for the above-mentioned attributes. He also highlighted the fact that phenolic compounds confer antioxidant properties to EVOO and are related to disease prevention in humans. Whereas lipophilic phenols are common to other plant oils, hydrophilic phenols are only found in EVOO, secoridoids standing out among them, which are also responsible for the bitter and spicy attributes in sensorial analysis panels. The influence of EVOO extraction technologies was also analysed in order to valorize by-products from the olive industry.

The third paper, delivered by Antonio Leone, from CNR-ISAFoM of Ercolano (Italy), presented a study conducted in the Italian province of Benevento to determine the relationship between soil parameters and olive quality of the local variety 'Ortice'. This study concludes that 'Ortice' olive oil composition and organoleptic attributes are affected by soil differences between different production areas in Benevento, which could be a good opportunity to add value to the place of origin of olive oil in many olive producing districts.

The fourth paper, presented by Sevda Isil Çillidag, from Taris Cooperative Union in Izmir (Turkey), characterized the different processing modes of table olives in Turkey. The main industrial processing of table olives is common to other producing countries, although the prevailing method is to harvest black olives whose pulp is naturally blackened close to the endocarp and subjected to pressure before fermentation and preserved in brine at a 10-12% concentration for 6-10 weeks. This process allows for the preservation of a certain degree of bitterness. Another special feature in the production of green olives in Turkey is the crushing or cracking of the fruits. This is carried out in local varieties 'Domat', 'Memecik' and 'Yamalak' that have previously been washed several times to get rid of bitterness. Subsequent fermentation is conducted in brines of increasing concentration, up to a concentration of 5-6%.

Tha last paper, presented by Kamel Gargouri from Sfax' Institut de l'Olivier (Tunisia), analysed the case of the valorization of by-products from the olive industry (vegetable waters and pomace) in the region of Sfax in Tunisia. Direct spread of vegetable waters in the field and pomace composted with cattle manure indicates their value as organic and mineral fertilizers. The positive impact on soils and plants, with little environmental impact, should be considered as part of an integrated process in which logistics assures competitive and profitable cost prices for the industry and for the farmers.

Session 2 was titled "Marketing Strategies" and was chaired by Mario Alejandro Zogbi, from Mendoza Provincial Government (Argentina). The first presentation was made by Manuel Parras, from Jaen University (Spain) and revolved around the topic of new marketing strategies. The speaker stressed the need to know the market and consumers. By knowing the latter new products could be developed for them, oriented to market segments, and achieve differentation. The example used to illustrate this point was to position olive oil as a type of oil suitable for frying or cooking for longer periods, since this perception is not well consolidated in many cultures, such as in France. The speaker also highlighted the improvements made in communications through labels, and the support of "silent" sellers such as packages and the company's web site.

Next, Eva María Murgado, from Jaen University (Spain), presented a paper on oil tourism and spoke about the added value of actions related to services revolving around olive oil. These efforts should not only focus on visits to oil mills, but integrate "tasting" activities, museums, specialty shops, festivals, gastronomy, rural hostels, purchases, etc., making it a comprehensive and valid experience for the customers. The speaker mentioned several examples of current mistakes made due to a lack of integration.

Esteban Carneros, from Grupo Hojiblanca (Antequera, Spain), presented the success case of this cooperative group. He highlighted the way member cooperatives are integrated in Hojiblanca as well as the new marketing strategies. Hojiblanca markets 8% of the world's oil production, a salient fact.

Electronic commerce could be a fundamental tool to boost consumption of olive oil. Enrique Bernal from Jaen University (Spain) spoke about its importance and the potential positive impact. Although access to the internet exists, it is not used for electronic commerce. The speaker explained how this tool could help differentiation against competitors. Supporting Enrique Bernal's presentation, Ángel Martínez, also from Jaen University, spoke about regulations protecting consumers who purchase on the internet, as well as the companies' obligation to inform when engaged in electronic commerce.

To conclude, Raffaele Zanoli from Politécnico Delle Marche (Italy) presented a few cases of success and failure in selling organic oils. Mistakes made by an Australian company and good decisions made by a small family-run business who used a subscription and customer relation model. His recommendation was to build "customer relations" ("avon" case).

Session 3 was titled "Olive oil and olives, human health and nutrition" and chaired by José López Miranda from Cordoba University (Spain). The first presentation was delivered by José María Ordovás, from Tufts University (United States), who presented results of the current knowledge on nutrigenomics regarding lipid metabolism as well as nutrients in the diet that may influence gene expression and determine interactions between genes and the diet, in general, and the Mediterranean Diet, in particular. The Mediterranean Diet could be closer to ancestral foods that were part of human development and our metabolism might have evolved to behave optimally, contrary to current diets that are rich in saturated fats and refined and industrialized food products. It would then be possible that certain alleles associated to an increase in the risk of certain diseases might be silenced in the presence of a more ancestral and traditional diet and life style. In the not too distant future, this knowledge may result in the development of personalized nutrition as a key element for preventing and treating chronic diseases related to food.

The second paper was presented by Gianfranco Peluso, from CNR-IBP in Naples (Italy), and showed that olive oil is much more than a monounsaturated acid-rich fat. It is rich in many bioactive compounds, mainly phenolic compounds, which exert various beneficial biological effects on health derived from its antimicrobial, antioxidant and antiinflammatory properties, and this makes olive oil a healthy functional food.

The third paper, related to consumers' perceptions about the health benefits of olive oil, was presented by Mercedes Fernández from the IOC. The main properties of olive oils for consumers are their benefits for health, their nutritional characteristics, their natural character, and digestibility. For these reasons, this is the fat of choice not only because of the health benefits but also because of the organoleptic and gastronomic properties. According to this perception, one of the prioritary objectives of the International Olive Council (IOC) is to state the validity and nutritional and dietary benefits of olive oil, which is considered an essential component of the Mediterranean Diet. The compilation and dissemination of scientific knowledge regarding the nutritional values and health benefits of olive oil are the basis for actions aiming to inform of and promote the consumption of olive oil all over the world.

Juan Barbacil, from Barbacil Comunicación, Zaragoza (Spain) in his presentation about olive oil and gastronomy, described some of the most appropriate uses of olive oil depending on the type of oil, The more delicate, sweet, slightly astringent and unspicy oils are well adapted to be used uncooked to dress salads or season vegetables and boiled white fish; the same oils that are used to set omelettes, prepare scrambled eggs, fry eggs, sauté mushrooms, enrich vegetable creams or to add a final touch of refinement to a great variety of dishes in modern and contemporary cuisine. The fruity and more or less fragrant, and sometime subtly bitter, oils enhance the flavour of fried food, especially potatoes, and improve most sautéed ingredients and stew bases. Because olive oil is capable of changing the result of a dish it has to be used sensitively and judiciously. A salad dressed with an olive tinged with a hint of bitter almonds offers numerous sapid sensations: tastes change, the olfactory scale and even the style of the ingredients used may be modified. Wherever the presence of garlic is noted, the oils from Andalusia stand out on their own merit, namely those from Jaén and Córdoba. In egg sauces, such as mayonnaise, oils from Southern Aragon are amazing. Thus, our culinary culture embraces and is founded on the olive oil. Likewise, he pointed out that the golden rule for cooking with olive oil is moderation. Never waste it or soak dishes in fat. He also described how olive oil tastings work, where oils are classified based on certain parameters such as "flavour" (English term that refers to the sum of two sensory impressions: the taste and smell of oil), appearance, colour, aroma, taste and, strange as it may seem, touch. Lastly, a recommendation: for reasons related to hygiene, gastronomy and image the use of cruets should not be allowed in restaurants.

The last presentation of this Session, by Cidalia Peres from INIAV de Oeiras (Portugal), was about the properties of table olives as a natural source of health-promoting bioactive and prebiotic nutrients. The fibre found in table olives is a prebiotic with beneficial effects to prevent different pathologies. Essential fatty acids, with effects against cancer, sterols, poliphenols and glycosides with antioxidant effects, and adventitious lactic acid bacteria with probiotic effects are some of the components of table olives which are beneficial for health.

The last Session of the Seminar was a round-table discussion on "Development and promotion of olives and olive oil: policies and strategies", chaired by the editor of Mercacei, Juan A. Peñamil. In this round-table, the director of ASOLIVA (Asociación Española de la Industria y el Comercio Exportador del Aceite de Oliva), Rafael Picó, explained that the Asoliva member companies account for 90% of all Spanish exports of botelled oil porduced, and between 40% and 45% of bulk produce. Among other activities, Asoliva is in charge of providing information, promoting and representing the industry. Regarding the target of Spanish exports, he reported that the European Union concentrates 75%, and within the EU Italy stands out with 63.9%. In the case of the main markets for Spanish botteled olive oil, Australia with 11.3% and the USA with 10.9% are noteworthy, whereas in the case of olive oil in bulk, the main target is Italy with 32.2%, followed by Portugal, with 16%. On the other hand, he referred to the brand Spain which, in his opinion, should be promoted through the inter-professional association of the Spanish olive oil and the companies themselves in order for Spanish oils to be present on the shelves worldwide.

The Deputy Director of the International Olive Council (IOC), Ammar Assabah, spoke about the future of this organization for the horizon 2020 and reviewed the consequences of the economic crisis and its effects on the sector.

Among the priorities of the IOC, he made reference to quality, protection and control, promotion (support to activities in member countries, specific regional programmes and campaigns in countries showing high consumer potential), support policies and implementation of technical and technological programmes.

On 28 November a technical visit was organized within the framework of the Seminar. The first stop was Alcañiz, where Juan Baseda, Technical Director of the Regulatory Council of the Designation of Origin "Bajo Aragón Oil", made an excellent presentation of the objectives and working of this Regulatory Council, followed by numerous questions, made mainly by foreign participants. Later, the group was taken on a tour of Alcañiz. Prior to lunch in a restaurant in Caspe, a tasting was organized of oils from different regions and varieties from Spain, as well as from Algeria, Tunisia and Turkey. In the afternoon, the group had the opportunity to visit the estate 'Hacienda Iber', an agro-industrial business focused on obtaining and marketing extra virgin olive oil of the highest quality. The plantation itself, with a total area of 650 ha, accommodates new olive groves framed within a Mediterranean pine tree landscape of great environmental value. Plantings were carried out under a super intensive system, with densities of some 1000 trees/ha and in hedgerows, allowing for mechanized harvesting in a rapid and efficient manner at the right moment to obtain olives of high quality, the time between harvesting and grinding never being longer than three hours. The timing of the visit was very fortunate since the group could see the harvesters and oil mill in full activity, and thus getting a good picture of the technological and infrastructure requirements for this type of super intensive farms.

In summary, the Seminar has been a splendid opportunity to review and discuss with experts from the Mediterranean and elsewhere about the current and future challenges of the Mediterranean olive and give response to key questions that were raised when the programme was developed and designed. On the other hand, while the seminar was organized by IAMZ-CIHEAM and IOC, there has been excellent collaboration from many of the most relevant institutions, organizations, companies and media of the Spanish and Mediterranean olive sector.

Resumen y conclusiones

Los días 26 a 28 de Noviembre de 2012 tuvo lugar en el Instituto Agronómico Mediterráneo de Zaragoza el Seminario Internacional sobre «Presente y futuro del sector olivarero mediterráneo» organizado conjuntamente por el Instituto Agronómico Mediterráneo de Zaragoza, perteneciente al Centro Internacional de Altos Estudios Agronómicos Mediterráneos (IAMZ-CIHEAM) y el Consejo Oleícola Internacional (COI), instituciones ambas que han alcanzado recientemente su 50 aniversario esforzándose por promocionar la región mediterránea y el sector olivarero.

El objetivo del Seminario fue explorar el futuro del sector olivarero en el Mediterráneo y en el mundo, tratando de contestar las siguientes preguntas clave: ¿Resultan sostenibles los sistemas intensivos de producción? ¿Se basará en estos sistemas el futuro desarrollo del sector olivarero o seguirán manteniendo un lugar relevante los sistemas tradicionales? ¿Cuáles son los elementos determinantes que tendrán que mejorarse en las tecnologías de procesado, especialmente en aquellos países en que una gran parte de su producción no puede acceder a mercados muy exigentes en aspectos de calidad? Además de las ya muy difundidas propiedades nutritivas y funcionales de los productos del olivo, ¿cuáles son sus perspectivas como materia prima básica para la industria nutracéutica? ¿Cuáles son las claves para abrir nuevos mercados y para incrementar su cuota en mercados consolidados?

El Seminario tuvo una duración de dos días para presentaciones y discusiones científicas y técnicas, estructuradas en tres sesiones y una mesa redonda, con ponencias invitadas y estudios de casos, y una visita técnica en la tercera jornada del Seminario.

Participaron en el Seminario 102 expertos procedentes de 18 países: Albania, Argelia, Argentina, Croacia, Chipre, Egipto, España, Francia, Grecia, Israel, Italia, Jordania, Líbano, Marruecos, Montenegro, Portugal, Túnez y Turquía.

La Sesión 1 tuvo por título «Desafíos y tendencias en el cultivo del olivo y del procesado de sus productos» y fue presidida por Luis Rallo de la Universidad de Córdoba (España). En ella se presentaron cinco ponencias, dos de revisión de la situación de las tecnologías de la producción sostenible de aceitunas y del procesado y calidad del aceite de oliva y tres referentes al estudio de casos singulares (influencia del suelo en la calidad del aceite de oliva virgen en una provincia italiana, elaboración de aceitunas de mesa en Turquía y uso agrícola de los subproductos de la industria oleícola en Túnez). Al final de las presentaciones tuvo lugar una discusión general.

En la primera ponencia, presentada por Ricardo Fernández Escobar de la Universidad de Córdoba (España), se analizó la evolución de los sistemas de cultivo del olivar en los últimos 50 años. Se concluyó que la coexistencia entre la olivicultura tradicional y la intensiva en las zonas mediterráneas de producción va a requerir medidas específicas de política agraria en los distintos países. En los olivares en pendiente, que representan la mayor parte del olivar tradicional en los países mediterráneos, la mayor amenaza medioambiental es la erosión. También, debido a la prevista escasez del agua, su uso eficiente, basado en estrategias de riego deficitario controlado y tolerancia a la sequía, aparece como el eje más determinante de la productividad de las plantaciones y de las regiones oleícolas. Además, los nuevos sistemas intensivos, de elevada productividad, precoz entrada en producción y mecanizados van a exigir mayores inversiones, conocimiento científico y transferencia de tecnología. Entre las demandas tecnológicas, la experimentación varietal y la mejora genética, la densidad de plantación, la mecanización de la recolección en los distintos sistemas de plantación, incluidas las plantaciones tradicionales susceptibles de cosecharse mecánicamente, los cambios de los sistemas de cultivo y la extensión del olivar a nuevas regiones de clima no estrictamente mediterráneo emergen como aspectos críticos. Finalmente, los sistemas de producción y protección del cultivo deben basarse en el concepto de Control Integrado, que incluye diversos métodos compatibles con un uso sostenible de los insumos.

La segunda ponencia, presentada por Maurizio Servili de la Universidad de Perugia (Italia), analizó la influencia de las tecnologías de procesado en la calidad del Aceite de Oliva Extravirgen (EVOO) y en la valorización de los subproductos. Se prestó especial atención a las cuestiones relativas al concepto de la calidad comercial del EVOO que se basa en parámetros descriptores de las alteraciones u de otros que le confieren su carácter genuino pero que, sin embargo, no consideran los indicadores relacionados con sus atributos sensoriales y saludables. En la ponencia se describió en profundidad la variación en la composición en ácidos grasos monoinsaturados y en compuestos fenólicos y volátiles, responsables de los atributos reseñados, resaltando que los compuestos fenólicos confieren el carácter antioxidante del EVOO y están relacionados con la prevención de enfermedades en el hombre. Mientras que los fenoles lipófilos son comunes con otros aceites vegetales, los hidrófilos son exclusivos del EVOO, destacando entre los mismos los secoridoides, que son a su vez responsables de los atributos amargo y picante en los paneles de evaluación sensorial. También se analizó la influencia de las tecnologías de extracción del EVOO para valorizar los subproductos de la industria oleícola.

La tercera ponencia, expuesta por Antonio Leone, del CNR-ISAFoM de Ercolano (Italia), presentó el estudio realizado en la provincia italiana de Benevento para determinar la relación entre parámetros edafológicos y la calidad del aceite de oliva de la variedad local 'Ortice'. Este estudio ha permitido concluir que la composición y los atributos organolépticos del aceite de oliva de 'Ortice' se ven afectados por las diferencias edafológicas de diferentes zonas de producción de Benevento lo que puede representar una oportunidad para añadir valor al lugar de origen del aceite de oliva virgen en numerosas comarcas olivareras.

La cuarta ponencia, presentada por Sevda Isil Çillidag, de la Unión de Cooperativas Taris de Izmir (Turquía), caracterizó las diferentes modalidades de procesado de aceitunas de mesa en Turquía. Las principales formas de elaboración industrial de aceitunas de mesa son comunes con las de otros países productores, si bien dominan las aceitunas negras naturales que cosechan con la pulpa ennegrecida naturalmente hasta la proximidad del endocarpio y se someten a presión antes de su fermentación y conservación en salmuera de 10-12% de concentración durante 6-10 semanas. Este procesado permite conservar cierto grado de amargor. Otra particularidad de la producción de aceitunas verdes en Turquía es el machacado o rajado de las mismas. Éste se lleva a cabo en las variedades locales 'Domat', 'Memecik' y 'Yamalak' previamente a sucesivos lavados para eliminar el amargor. La posterior fermentación se lleva a cabo en salmueras de concentración creciente, hasta alcanzar una concentración del 5-6%.

La última ponencia, a cargo de Kamel Gargouri del Institut de l'Olivier de Sfax (Túnez), analizó el caso de la valorización de los subproductos de la industria oleícola (Alpechines y orujos) en la región de Sfax en Túnez. La aplicación directa de alpechines en el campo y la de los orujos compostados con estiércol de vaca indica su valor como fertilizante orgánico y mineral. El impacto positivo en suelo y planta, con escaso efecto contaminante para el medioambiente, debe ser complementado con un proceso integrado en el que la logística garantice precios de costes competitivos y rentables para la industria y los agricultores.

La Sesión 2 tuvo por título «Estrategias de Marketing» y fue presidida por Mario Alejandro Zogbi, del Gobierno de la Provincia de Mendoza (Argentina). La primera exposición corrió a cargo de Manuel Parras, de la Universidad de Jaén (España), y tuvo como tema principal las nuevas estrategias de marketing. El ponente acentuó la necesidad de conocer el mercado y a los consumidores. Conociendo a estos últimos se podrán desarrollar los productos orientados a ellos, orientados a la segmentación de mercado, y así diferenciarnos. Un ejemplo que dio al auditorio para acentuar la orientación de los esfuerzos de marketing fue en posicionar el aceite de oliva como un aceite apto para freír o cocinar por un largo tiempo, ya que es una percepción del mercado que no está afianzada en algunas sociedades, como por ejemplo en Francia. Hizo hincapié en la mejora de la comunicación en etiquetas, y el apoyo en los vendedores «silenciosos» como son los envases y el sitio web de la compañía.

A continuación Eva María Murgado, de la Universidad de Jaén, en su presentación sobre el oleoturismo, presentó el valor agregado de la integralidad de esfuerzos de los servicios vinculados al aceite de oliva. No es suficiente enfocar esfuerzos solamente en las visitas a las fábricas de aceite, sino integrar los «tasting», museos, comercios especializados, festivales, gastronomía, albergues rurales, compra, etc, a la experiencia del cliente para lograr una experiencia integral y valedera. Dio ejemplos de los errores actuales de la no integralidad.

Esteban Carneros, del grupo Hojiblanca de Antequera (España), expuso el caso de éxito de su Grupo Cooperativo. Destacó la forma de integración de las cooperativas miembros de Hojiblanca y las nuevas formas de comercialización de la misma. Hojiblanca comercializa el 8% de la producción de aceite mundial, un dato a destacar.

El comercio electrónico en el aceite de oliva puede ser una herramienta fundamental para incrementar el consumo. Enrique Bernal de la Universidad de Jaén (España) comentó su importancia y el impacto positivo que puede alcanzar, y que está subutilizado. Se tiene acceso a Internet, pero no se utiliza para comercio electrónico. Explicó cómo esta herramienta nos puede diferenciar de nuestra competencia. Apoyando la presentación de Enrique Bernal, Ángel Martínez, también de la Universidad de Jaén, presentó la regulación legal que protege al consumidor que realiza compras vía Internet, y la obligación de informar que tenemos al hacer comercio electrónico.

Para terminar, Raffaele Zanoli del Politécnico Delle Marche (Italia) nos mostró unos casos de éxito y de fracaso, en venta de aceites orgánicos. Errores cometidos por una empresa australiana y los aciertos de una pequeña empresa familiar que utilizó un modelo de suscripción y de relación con el cliente. Su recomendación es la de crear «relación con el cliente» (caso « avon»).

La Sesión 3 tuvo por título «Aceite de oliva y aceitunas, salud humana y nutrición» y fue presidida por José López Miranda de la Universidad de Córdoba (España). La primera ponencia corrió a cargo de José María Ordovás de la Universidad de Tufts (Estados Unidos de América). En ella se presentaron resultados del conocimiento actual en la nutrigenómica relativa al metabolismo de los lípidos así como respecto a los nutrientes de la dieta que pueden influir en la expresión génica y determinar las interacciones entre los genes y la dieta en general y la Dieta Mediterránea en particular. Esta Dieta Mediterránea podría ser más próxima a los alimentos ancestrales que fueron parte del desarrollo humano y nuestro metabolismo pudo evolucionar para comportarse de forma óptima con ella, al contrario que con las dietas actuales ricas en grasas saturadas y en alimentos refinados e industrializados. Sería por tanto posible que ciertos alelos que están asociados con un incremento en el riesgo de enfermedades sean silenciados en presencia de una dieta y un estilo de vida más ancestral y tradicional. Todos estos conocimientos podrán llevar en un futuro no muy lejano al desarrollo de una nutrición personalizada como elemento clave en la prevención y tratamiento de las enfermedades crónicas relacionadas con la alimentación.

La segunda ponencia fue expuesta por Gianfranco Peluso, del CNR-IBP de Nápoles (Italia). En ella se puso de manifiesto que el aceite de oliva es mucho más que una grasa rica en monoinsaturados. Su riqueza en múltiples componentes bioactivos fundamentalmente compuestos fenólicos que ejercen múltiples efectos biológicos beneficiosos sobre la salud derivados de sus propiedades antimicrobianas, antioxidantes y antiinflamatorias, convierten al aceite de oliva en un alimento funcional saludable.

La tercera ponencia, relativa a la percepción que los consumidores tienen sobre los efectos beneficiosos sobre la salud del aceite de oliva, fue presentada por Mercedes Fernández del COI. Para el consumidor, la principal propiedad de los aceites de oliva son sus beneficios para la salud, sus características nutricionales, su carácter natural y su fácil digestión todo lo cual le convierte en grasa de elección no sólo debido a sus múltiples bondades para la salud sino también organolépticas y gastronómicas. De acuerdo con esta percepción, uno de los objetivos prioritarios del Consejo Oleícola Internacional (COI) es afirmar la validez y los beneficios nutricionales y dietéticos del aceite de oliva, considerado componente esencial de la Dieta Mediterránea. La recopilación y divulgación de los conocimientos científicos sobre el valor nutricional y los beneficios para la salud del aceite de oliva constituyen la base de las acciones de información y promoción del consumo de éste a nivel mundial.

Juan Barbacil, de Barbacil Comunicación, Zaragoza (España) en su exposición sobre Aceite de oliva y gastronomía describió algunos de los usos más indicados según el tipo de aceite, como por ejemplo que los aceites más delicados, suaves, poco astringentes y nada picantes son los mejores para aliñar ensaladas, verduras y pescados blancos hervidos; los mismos que sirven para cuajar tortillas, preparar revueltos, freír huevos, saltear setas, enriquecer cremas de verduras prestar toques de refinamiento a gran número de platos de la cocina moderna y actual. Los aceites afrutados más o menos fragantes y en ocasiones sutilmente amargos, realzan el sabor de los fritos, en especial las patatas y mejoran casi todos los sofritos y bases de estofados. El hecho de que el aceite se revele capaz de trastocar el resultado de un plato obliga a utilizarlo con sensibilidad y criterio. Entre una ensalada aderezada con un aceite de matices almendrados o amargos existen abismos de sensaciones sápidas: cambian los sabores, varían la escala olfativa y hasta el estilo de los ingredientes empleados. Allí donde se hace notoria la presencia del ajo, brillan con mérito propio los aceites andaluces, en particular los de Jaén y Córdoba. En las salsas de huevo como la mahonesa, los del Bajo Aragón son impresionantes. Nuestra cultura culinaria se aferra, pues, y se sustenta en el aceite de oliva. Además resaltó que la regla de oro para cocinar con aceite de oliva es utilizarlo con mucha mesura, no derrocharlo nunca ni enchumbar los platos de grasa. También describió en qué consisten las catas de aceite, en las que se trata de clasificar los aceites en función de parámetros tales como el «flavor» (palabra inglesa que hace referencia a la suma de dos sensaciones: el gusto y el aroma del aceite), el aspecto, el color, el aroma, el gusto y, por extraño que parezca, el tacto. Por último una recomendación: por razones de higiene, gastronómicas y de imagen no debería permitirse el uso de las aceiteras en los restaurantes.

En la última ponencia de la sesión, Cidalia Peres, del INIAV de Oeiras (Portugal) presentó las propiedades de las aceitunas de mesa como fuente natural de nutrientes bioactivos y prebióticos promotores de salud. La propia fibra de las aceitunas de mesa es un prebiótico con efectos beneficiosos en la prevención de diversas patologías. Los ácidos grasos esenciales, con efectos contra el cáncer, los esteroles, polifenoles y glicosidos con efectos antioxidantes, y las bacterias acido-lácticas adventicias con efectos probióticos son algunos de los componentes de las aceitunas de mesa beneficiosos para la salud.

La última sesión del Seminario consistió en una Mesa redonda sobre «Desarrollo y promoción de las aceitunas y el aceite de oliva: políticas y estrategias», presidida por el editor de Mercacei, Juan A. Peñamil. En esta mesa, el director de la Asociación Española de la Industria y el Comercio Exportador del Aceite de Oliva (Asoliva) Rafael Picó, detalló que sus empresas asociadas representan el 90% del total de las exportaciones españolas de envasado, y entre el 40 y el 45% a granel. Entre sus actividades, figuran la información, la promoción y la representación de la industria. Respecto a los destinos de las exportaciones españolas, precisó que la Unión Europea (UE) concentra el 75%, y dentro de ella, Italia, con el 63,9%. En el caso de los principales mercados del aceite de oliva español envasado destaca Australia, con el 11,3%, y Estados Unidos, con el 10,9%, mientras que a granel los principales destinos son Italia con el 32,2%, seguido de Portugal, con el 16%. Por otro lado, se refirió a la Marca España que, en su opinión, debe potenciarse a través de la Interprofesional del Aceite de Oliva Español y de las propias empresas para estar en todos los lineales del mundo.

Por su parte, el director adjunto del Consejo Oleícola Internacional (COI), Ammar Assabah, habló sobre el futuro de este organismo de cara al año 2020 y realizó un repaso de las consecuencias de la crisis económica y los efectos que está teniendo en el sector.

Entre las prioridades del COI, se refirió a la calidad, la protección y el control, la promoción (apoyo a las actividades de los países miembros, programas regionales concretos y campañas en países con alto potencial de consumo), políticas de apoyo y puesta en marcha de programas técnicos y tecnológicos.

El día 28 de noviembre tuvo lugar la visita técnica programada en el marco del Seminario. La primera parada fue en Alcañiz, donde Juan Baseda, Director Técnico del Consejo Regulador del Aceite del Bajo Aragón, hizo una magnífica presentación sobre los objetivos y funcionamiento de este Consejo Regulador, la cual fue seguida de numerosas preguntas, sobre todo por parte de los participantes extranjeros. Posteriormente el grupo realizó una visita turística de Alcañiz. Previamente a la comida que tuvo lugar en un restaurante de Caspe, se organizó una degustación de aceites de diferentes regiones y variedades españolas, así como de Argelia, Túnez y Turquía. Por la tarde, el grupo tuvo la oportunidad de visitar la explotación Hacienda Iber, denominación de un desarrollo agroindustrial enfocado a la obtención y comercialización de aceite de oliva virgen extra de la más alta calidad. La finca, con una superficie de mas de 650 has, acoge un conjunto de nuevos olivares enmarcados en un paisaje de pinar mediterráneo de gran valor medioambiental. Las plantaciones se han realizado bajo el sistema superintensivo, con densidades de unos 1000 árboles por hectárea y en seto, lo que permite la recolección mecanizada, pudiendo así realizar la cosecha de forma rápida y eficaz en el momento más oportuno de producción y calidad de la oliva, con unos tiempos entre cosecha y elaboración inferiores, en todo caso, a las tres horas. El momento de la visita fue muy afortunado ya que el grupo pudo ver a las cosechadoras y la almazara en plena actividad, pudiendo hacerse una buena idea de las necesidades tecnológicas y de infraestructuras en este tipo de explotaciones superintensivas.

En resumen, el Seminario ha constituido una magnífica oportunidad de revisar y discutir con expertos mediterráneos y de otros continentes, los retos actuales y futuros del olivar mediterráneo y de dar respuesta a las cuestiones clave que se habían planteado al concebirlo y diseñar su programa. Por otro lado, si bien la organización ha corrido a cargo del IAMZ-CIHEAM y el COI, se ha recibido una magnífica colaboración de muchas de las instituciones, organizaciones, empresas y medios de comunicación más relevantes del sector olivarero español y mediterráneo.

Synthèse et conclusions

Du 26 au 28 novembre 2012 s'est déroulé à l'Institut Agronomique Méditerranéen de Zaragoza le Séminaire International sur « Présent et futur du secteur oléicole méditerranéen » organisé conjointement par l'Institut Agronomique Méditerranéen de Zaragoza, appartenant au Centre International de Hautes Études Agronomiques Méditerranéennes (IAMZ-CIHEAM), et par le Conseil Oléicole International (COI), ces deux institutions ayant récemment célébré leur cinquantième anniversaire d'un parcours consacré à la promotion de la région méditerranéenne et de la filière oléicole.

L'objectif du Séminaire était d'explorer l'avenir de la filière oléicole en Méditerranée et dans le monde pour tenter de répondre aux enjeux suivants : Les systèmes de production intensive sont-ils durables ? Le futur du développement oléicole sera-t-il fondé sur ces systèmes, ou bien les systèmes traditionnels auront-ils encore un grand rôle à jouer dans ce domaine ? Quels sont les éléments décisifs à optimiser concernant les technologies de transformation, en particulier dans les pays dont une part importante de la production ne peut pas accéder à des marchés exigeant une forte qualité ? En plus de leurs propriétés nutritionnelles et fonctionnelles bien connues, quelles perspectives se présentent aux produits de l'olivier en tant que matières premières pour l'industrie nutraceutique ? Quels sont les éléments décisifs pour trouver de nouveaux débouchés et pour augmenter les ventes de ces produits sur les marchés déjà consolidés ?

Le Séminaire était constitué de deux journées consacrées à des présentations et des échanges scientifiques et techniques, structurées en trois sessions et une table ronde, avec des présentations invitées et des cas d'étude, et d'une sortie de terrain pendant le troisième jour du Séminaire.

Un nombre de 102 experts ont participé au Séminaire, en provenance de 18 pays : Albanie, Algérie, Argentine, Croatie, Chypre, Égypte, Espagne, France, Grèce, Israël, Italie, Jordanie, Liban, Maroc, Monténégro, Portugal, Tunisie et Turquie.

La Session 1 avait pour titre « Défis et tendances de l'oliviculture et de la transformation des produits de l'olivier », et était présidée par Luis Rallo de l'Université de Cordoue (Espagne). Lors de cette session ont été données cinq conférences, dont deux faisant l'état des lieux des technologies de production durable d'olives de table, de leurs procédés d'élaboration, et de la qualité de l'huile d'olive, et les trois autres examinant des cas singuliers (influence du sol sur la qualité de l'huile d'olive vierge dans une province italienne, préparation d'olives de table en Turquie et utilisation agricole des sous-produits de l'industrie oléicole en Tunisie). À la fin des présentations, une discussion générale a eu lieu.

La première conférence, présentée par Ricardo Fernández Escobar de l'Université de Cordoue (Espagne), a analysé l'évolution des systèmes d'oliviculture sur les 50 dernières années. La conclusion qui s'en dégage est que, pour la coexistence de l'oliviculture traditionnelle et de l'oliviculture intensive dans les zones méditerranéennes de production, il faudra mettre en place des mesures spécifiques de politique agricole dans les différents pays. Quant aux oliveraies qui occupent des terrains en pente, c'est-à-dire la plupart des oliveraies traditionnelles des pays méditerranéens, leur plus grande menace environnementale est l'érosion. De même, en raison de la rareté que l'on prévoit pour les ressources en eau, il apparaît qu'une utilisation efficiente, basée sur des stratégies d'irrigation déficitaire contrôlée et sur la tolérance à la sécheresse, est l'axe le plus déterminant pour la productivité des plantations et pour les régions oléicoles. De surcroît, les nouveaux systèmes intensifs, à productivité élevée, à entrée en production précoce, et à forte mécanisation, vont nécessiter davantage d'investissements, de connaissances scientifiques et de transfert de technologie. Parmi les besoins en technologie se profilent certains éléments cruciaux: l'expérimentation variétale et l'amélioration génétique, la densité de plantation, la mécanisation de la récolte pour les différents systèmes de plantation, y compris dans les plantations traditionnelles susceptibles d'être récoltées mécaniquement, les modifications des systèmes culturaux et l'élargissement de l'aire de l'olivier à de nouvelles régions à climat non strictement méditerranéen. Finalement, les systèmes de production et de protection de cette culture doivent être fondés sur le concept de Contrôle Intégrée, qui englobe diverses méthodes compatibles avec une utilisation durable des intrants.

La deuxième conférence, présentée par Maurizio Servili de l'Université de Perugia (Italie), a analysé l'influence des technologies de fabrication pour la qualité de l'huile d'olive vierge extra (HOVE) et pour la valorisation des sous-produits. Une attention particulière a été accordée aux questions touchant au concept de la qualité commerciale de l'HOVE, qui est basée sur les paramètres décrivant les altérations ou sur d'autres éléments qui confèrent à cette huile son caractère authentique mais d'où sont exclus les indicateurs liés à ses attributs sensoriels et favorables à la santé. Cette présentation a décrit en profondeur la variation de la composition en acides gras mono-insaturés et en composés phénoliques et volatils, responsables des attributs cités auparavant, en soulignant que les composés phénoliques conférant à l'HOVE ses propriétés antioxydantes sont liés à la prévention de maladies chez l'homme. Tandis que les phénols lipophiles sont partagés avec les autres huiles végétales, les composés hydrophiles sont exclusifs de l'HOVE, notamment les séco-iridoïdes, qui, eux, sont responsables des attributs d'amertume et des notes piquantes étudiés par les panels d'évaluation sensorielle. L'influence des technologies d'extraction de l'HOVE a également été examinée en lien avec la valorisation des sous-produits de l'industrie oléicole.

La troisième conférence, donnée par Antonio Leone, du CNR-ISAFoM d'Ercolano (Italie), a présenté l'étude menée dans la province italienne de Benevento afin de faire le lien entre paramètres édaphologiques et qualité de l'huile d'olive pour la variété locale 'Ortice'. Cette étude a permis de conclure que la composition et les attributs organoleptiques de l'huile d'olive issue de 'Ortice' sont influencés par les différences édaphologiques des différentes zones de production de Benevento, ce qui pourrait constituer un atout pour de nombreux terroirs oléicoles car ajoutant de la valeur au lieu d'origine de l'huile d'olive vierge.

La quatrième conférence, présentée par Sevda Isil Çillidag, de l'Union de Coopératives Taris d'Izmir (Turquie), a caractérisé les différentes modalités d'élaboration des olives de table en Turquie. Les principaux modes d'élaboration industrielle des olives de table sont les mêmes que dans les autres pays producteurs, mais il y a prédominance, dans le cas présent, des olives noires naturelles récoltées lorsque la pulpe a noirci d'elle-même jusqu'à atteindre presque l'endocarpe, et soumises à pression avant de fermenter et d'être conservées dans une saumure à 10-12% de concentration durant 6-10 semaines. Ce processus permet de maintenir un certain degré d'amertume. Pour les olives vertes, une autre particularité de cette production en Turquie est le fait de concasser ou d'entailler les olives. Ce procédé est utilisé pour les variétés locales 'Domat', 'Memecik' et 'Yamalak', ensuite, plusieurs rinçages sont effectués afin d'éliminer l'amertume. La fermentation ultérieure a lieu dans une saumure de plus en plus forte jusqu'à atteindre une concentration de 5-6%.

La dernière conférence, présentée par Kamel Gargouri de l'Institut de l'Olivier de Sfax (Tunisie), a analysé le cas de la valorisation des sous-produits de l'industrie oléicole (margines et grignons) dans la région de Sfax en Tunisie. L'épandage direct des margines dans les champs et des grignons compostés avec du fumier de vache, s'est avéré avantageux en tant que fertilisant organique et minéral. L'impact positif sur le sol et sur les plantes, et la faible pollution environnementale, sont à compléter par un processus intégré où la logistique permette d'assurer un prix de revient compétitif et rentable pour l'industrie et pour les agriculteurs.

La Session 2 « Stratégies de Marketing » a été présidée par Mario Alejandro Zogbi, du Gouvernement de la Province de Mendoza (Argentine). Le premier exposé a été présenté par Manuel Parras, de l'Université de Jaén (Espagne), axé principalement sur les nouvelles stratégies de marketing. Le conférencier a insisté sur la nécessité de connaître le marché ainsi que les consommateurs. Cette connaissance étant approfondie, il sera alors possible de mettre au point des produits ciblant ces consommateurs et obéissant à une segmentation de marché, pour ainsi différencier notre produit. Comme exemple pour l'auditoire, concernant l'orientation des efforts de marketing, il a été cité le fait de positionner l'huile d'olive en tant qu'huile apte pour fritures ou pour cuissons longues, cette perception de marché n'étant pas bien implantée dans certaines sociétés, en France par exemple. Cette intervention a mis en avant l'utilité de l'étiquette pour une meilleure communication, et le recours à ces vendeurs « silencieux » que sont l'emballage et le site web de la compagnie.

Ensuite, Eva María Murgado, de l'Université de Jaén, dans sa présentation concernant l'oléotourisme, a mis en avant la valeur agrégée découlant d'une intégralité des efforts pour les services liés à l'huile d'olive. Il est insuffisant que ces efforts portent uniquement sur les visites aux huileries, ils doivent nécessairement intégrer les « tastings », les musées, les commerces spécialisés, les festivals, la gastronomie, les gîtes ruraux, les emplettes, etc., pour faire vivre au client une expérience intégrale d'épanouissement. Des exemples d'erreurs actuelles de non-intégralité ont été présentés.

Esteban Carneros, du groupe Hojiblanca d'Antequera (Espagne), a présenté la "success story" de son Groupe Coopératif. Il a mis en avant le mode d'intégration des coopératives adhérant à Hojiblanca ainsi que les nouvelles formes de commercialisation qui y sont pratiquées. Hojiblanca commercialise 8% de la production mondiale d'huile, un chiffre à souligner.

Le commerce électronique, dans le domaine de l'huile d'olive, peut être un outil déterminant pour accroître la consommation. Enrique Bernal de l'Université de Jaén (Espagne) a commenté son importance et l'impact positif qu'il peut atteindre, pourtant loin d'être pleinement exploité. L'Internet est accessible mais n'est pas utilisé pour le commerce électronique. L'intervenant a expliqué comment cet outil peut nous différencier de nos concurrents. À l'appui de la présentation de Enrique Bernal, Ángel Martínez, également de l'Université de Jaén, a présenté la réglementation légale qui protège le consommateur effectuant ses achats à travers l'Internet, et l'obligation d'informer qui incombe à ceux qui vendent via le commerce électronique.

Pour terminer, Raffaele Zanoli, de l'Université Polytechnique Delle Marche (Italie), nous a montré des cas de succès et d'échec en matière de vente d'huiles biologiques. Des erreurs commises par une entreprise australienne et les bonnes idées d'une petite entreprise familiale qui a utilisé un modèle d'abonnement et de partenariat avec le client. Sa recommandation est ainsi de créer une « relation avec le client » (comme le fait « Avon »).

La Session 3 « Huile d'olive et olives, santé humaine et nutrition » a été présidée par José López Miranda de l'Université de Cordoue (Espagne). La première conférence a été présentée par José María Ordovás de l'Université de Tufts (États-Unis). Ont été présentés les résultats des connaissances actuelles en nutrigénomique concernant le métabolisme des lipides et les nutriments de la diète qui peuvent influencer l'expression génique et déterminer les interactions entre les gènes et la diète en général, et la Diète Méditerranéenne en particulier. Cette Diète Méditerranéenne pourrait être plus proche des aliments ancestraux qui ont fait partie du développement humain, et ainsi notre métabolisme aurait pu évoluer pour se comporter d'une façon optimale avec elle, au contraire des régimes actuels riches en graisses saturées et en aliments raffinés et industrialisés. Ce serait donc possible que certains allèles qui sont liés à l'augmentation du risque de maladies, soient désactivés en présence d'une diète et d'un style de vie plus ancestraux et traditionnels. Toutes ces connaissances pourraient amener dans un avenir pas trop lointain au développement d'une nutrition personnalisée comme élément-clé pour la prévention et le traitement des maladies chroniques liées à l'alimentation.

La deuxième conférence était présentée par Gianfranco Peluso, du CNR-IBP de Naples (Italie). Dans le cadre de celle-ci, il a été mis en relief que l'huile d'olive est bien plus qu'une graisse riche en mono-insaturés. Sa richesse en multiples composantes bio-actives fondamentalement des composés phénoliques qui exercent de nombreux effets biologiques favorables à la santé en raison de leurs propriétés antimicrobiennes, anti-oxydantes et anti-inflammatoires, font de l'huile d'olive un aliment fonctionnel à valeur santé.

La troisième conférence, relative à la perception qu'ont les consommateurs quant aux effets bénéfiques de l'huile d'olive sur la santé, a été présentée par Mercedes Fernández du COI. Pour le consommateur, la principale propriété des huiles d'olive consiste en leurs bénéfices pour la santé, leurs caractéristiques nutritionnelles, leur caractère naturel et leur facilité de digestion, qui à elles toutes la transforment en une huile de choix non seulement pour ses nombreux atouts pour la santé mais aussi pour ses qualités organoleptiques et gastronomiques. Selon cette perception, un des objectifs prioritaires du Conseil Oléicole International (COI) est de réaffirmer la validité et les bénéfices nutritionnels et diététiques de l'huile d'olive, considérée comme une composante essentielle de la Diète Méditerranéenne. Le recueil et la diffusion des connaissances scientifiques concernant la valeur nutritionnelle et les bienfaits pour la santé de l'huile d'olive constituent la base des actions d'information et de promotion de la consommation de celle-ci au niveau mondial.

Juan Barbacil, de Barbacil Comunicación, Zaragoza (Espagne), dans son exposé sur l'huile d'olive et la gastronomie, a décrit certaines des utilisations les plus appropriées pour chaque type d'huile, comme par exemple le fait que, pour assaisonner salades, légumes et poissons blancs bouillis, les meilleures huiles sont les plus délicates, légères, peu astringentes et nullement piquantes ; ces mêmes huiles servent aussi à faire prendre les omelettes, préparer des œufs brouillés aux champignons, asperges, lardons ou autres, frire des œufs, faire sauter des champignons, enrichir des crèmes de légumes et ajouter une pointe de raffinement à un grand nombre de plats de la cuisine moderne actuelle. Les huiles fruitées plus ou moins parfumées et parfois subtilement amères, relèvent la saveur des fritures, en particulier les pommes de terre, et améliorent pratiquement tout ce que l'on fait revenir ainsi que les bases de ragoûts. Le fait que l'huile se révèle capable de déséquilibrer le résultat d'un plat nous oblige à l'utiliser avec sensibilité et bon sens. Entre une salade accommodée d'une huile à notes d'amande ou d'amertume, tout un abîme de sensations sapides s'ouvre à nous : les saveurs s'en trouvent modifiées, l'échelle olfactive varie de même que le style des ingrédients employés. Là où la présence de l'ail se fait sentir, les huiles d'Andalousie brillent de plein droit, en particulier celles de Jaén et de Cordoue. Dans les sauces où l'œuf est présent, telles que la mayonnaise, les huiles de la basse vallée de l'Aragon sont impressionnantes. Notre culture culinaire est ancrée et bâtie sur l'huile d'olive. De plus, il a été rappelé que la règle d'or de la cuisine à l'huile d'olive est de l'employer sans démesure, en évitant toujours de la prodiguer vainement ou d'y noyer les plats. L'intervenant a également décrit en quoi consistent les dégustations d'huile, car il s'agit dans ce cadre de classifier les huiles en fonction de paramètres tels que la « flaveur » (mot anglais qui fait référence à l'ensemble de deux sensations : le goût et l'arôme de l'huile), l'aspect, la couleur, l'arôme, le goût et, pour étrange que cela puisse paraître, le toucher. En dernier lieu, une recommandation : pour des raisons d'hygiène, de gastronomie et d'image, l'utilisation d'huiliers devrait être proscrite dans les restaurants.

Lors de la dernière conférence de la session, Cidalia Peres, de l'INIAV d'Oeiras (Portugal), a présenté les propriétés des olives de table en tant que source naturelle de nutriments bioactifs et probiotiques promoteurs de santé. La fibre des olives de table est en soi un prébiotique ayant des effets bénéfiques en matière de prévention de diverses pathologies. Les acides gras essentiels, agissant contre le cancer, les stérols, polyphénols et glycosides à effets anti-oxydants, et les bactéries acido-lactiques adventices à effets probiotiques, sont autant de composantes bénéfiques pour la santé que l'on rencontre chez les olives de table.

La dernière session du Séminaire a consisté en une table ronde sur « Développement et promotion de l'huile d'olive et des olives : politiques et stratégies », présidée par l'éditeur de Mercacei, Juan A. Peñamil. Lors de cette table ronde, le directeur de l'Association Espagnole de l'Industrie et du Commerce de l'Huile d'Olive à l'Exportation (Asoliva), Rafael Picó, a précisé que la part des entreprises adhérentes à cette association représente 90% du total des exportations espagnoles en bouteille, et de 40 à 45% pour les exportations en vrac. Parmi les activités de cette Association figurent l'information, la promotion et la représentation de l'industrie. Concernant les débouchés des exportations espagnoles, il a précisé que l'Union européenne (UE) en concentre 75%, dont l'Italie avec une part de 63,9%. Pour les principaux marchés de l'huile d'olive espagnole embouteillée, il convient de souligner l'Australie, avec 11,3%, et les États-Unis, avec 10,9%, tandis qu'en vrac les principaux destinataires sont l'Italie avec 32,2%, suivie du Portugal avec 16%. Par ailleurs, il s'est référé au Label Espagne qui, à son avis, doit être promu à travers l'Interprofession de l'Huile d'Olive Espagnole ainsi que les entreprises, pour être présent sur tous les linéaires du monde.

Pour sa part, le directeur adjoint du Conseil Oléicole International (COI), Ammar Assabah, a parlé de l'avenir de cet organisme à l'horizon 2020 et a passé en revue les conséquences de la crise économique et les effets qu'elle entraîne pour la filière. Parmi les priorités du COI, il s'est référé à la qualité, la protection et le contrôle, la promotion (appui aux activités des pays membres, programmes régionaux concrets et campagnes dans les pays à fort potentiel de consommation), politiques d'appui et de mise en place de programmes techniques et technologiques.

Le 28 novembre a eu lieu la visite technique programmée dans le cadre du Séminaire. Un premier arrêt a été fait dans la ville d'Alcañiz, où Juan Baseda, Directeur Technique du Conseil Régulateur (Syndicat de l'Appellation) de l'huile du Bas-Aragon, a réalisé une magnifique présentation sur les objectifs et le fonctionnement de ce Conseil, qui a donné lieu à de nombreuses questions, émanant notamment des participants étrangers. Ensuite le groupe a effectué une visite touristique d'Alcañiz. Juste avant le déjeuner dans un restaurant de Caspe, a eu lieu une dégustation d'huile de différentes régions et de plusieurs variétés espagnoles, ainsi que d'Algérie, de Tunisie et de Turquie. L'après-midi, le groupe a eu l'occasion de visiter l'exploitation Hacienda Iber, nom d'un complexe agro-industriel pour l'obtention et la commercialisation d'huile d'olive vierge extra de la plus haute qualité. Ce domaine, d'une superficie de plus de 650 ha, héberge un ensemble de nouvelles oliveraies entourées d'un paysage de pinèdes méditerranéennes de grande valeur environnementale. Les plantations sont menées sous le système superintensif, avec des densités d'environ 1000 arbres/ha, plantés en haie, permettant ainsi une récolte mécanisée rapide et efficace au moment le plus approprié pour la production et la qualité de l'olive, le temps écoulé entre la récolte et l'élaboration étant, dans tous les cas, inférieur à trois heures. La visite s'est déroulée à un moment particulièrement propice, car le groupe a eu l'occasion de voir les engins en train de récolter et l'huilerie en pleine activité, et a pu se faire une idée nette des besoins en technologie et infrastructures pour ce genre d'exploitations superintensives.

En résumé, le Séminaire s'est avéré une magnifique occasion d'examiner et de débattre avec des experts de la Méditerranée et d'autres continents, les défis actuels et futurs qui se posent à l'olivier méditerranéen et d'apporter des éléments de réponse aux questions déterminantes qui se faisaient jour lors de la conception et mise au point du programme du Séminaire. Par ailleurs, bien que l'organisation ait été assurée par l'IAMZ-CIHEAM et le COI, il convient de faire remarquer l'extraordinaire collaboration d'un grand nombre d'institutions, organisations, entreprises et médias parmi les plus importants du secteur oléicole espagnol et méditerranéen.

OPTIONS méditerranéennes

SERIES A: Mediterranean Seminars
2013 – Number 106

Present and future of the Mediterranean olive sector

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Olive cultivation constitutes a key element of the Mediterranean agricultural sector, and Mediterranean countries clearly dominate world olive oil and table olive production and consumption. Production has increased dramatically in the last decades, partly due to the establishment of intensive olive plantations using new production systems. Nevertheless, traditional olive production systems should not be forgotten, as these systems are multifunctional and contribute to rural development, landscape conservation and protect the environment against erosion and desertification. Consumption of olive products has followed similar patterns, and non-traditional consuming countries are becoming important consumers and importers. The growth of these markets is the result of the gastronomic qualities of olive products and their status as healthy food based on their nutritional and functional properties. There has also been an important improvement in post-harvest and processing in order to respond to the increasing demands for high quality standards.

In this context, the Mediterranean Agronomic Institute of Zaragoza (IAMZ-CIHEAM) and the International Olive Council (IOC) organized the Seminar on "Present and future of the Mediterranean olive sector" from 26 to 28 November 2012. The aim of the Seminar was to promote debate on key questions challenging the olive sector, and it was structured in three scientific sessions: (i) Challenges and trends in olive growing and processing; (ii) Marketing strategies; (iii) Olive oil and olives, human health and nutrition; and a round table on Olive and olive oil development and promotion: policies and strategies. The third day was devoted to a technical visit.

The current issue of *Options Méditerranéennes* includes the proceedings of the Seminar and contains 14 articles and 1 abstract of the contributions presented.

CIHEAM
MAI ZARAGOZA

Prix: 38,11 Euro

ISBN: 2-85352-512-0
ISSN: 1016-121-X

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