Paper 24

[Accueil] [Remonter] [Intro 1] [Paper 2] [Paper 3] [Paper 4] [Paper 5] [Paper 6] [Paper 7]
[Paper 8] [Paper 9] [Paper 10] [Paper 11] [Paper 12] [Paper 13] [Paper 14] [Paper 15] [Paper 16]
[Paper 17] [Paper 18] [Paper 19] [Paper 20] [Paper 21] [Paper 22] [Paper 23] [Paper 24]
[Paper 25] [Paper 26] [Paper 27] [Paper 28] [Paper 29] [Paper 30] [Paper 31] [Paper 32]
[Paper 33] [Paper 34] [Paper 35] [Paper 36] [Paper 37] [Paper 38] [Paper 39] [Paper 40]
[Paper 41] [Paper 42]

Rice grain quality aspects in Egypt

Authors :

TANTAWI BADAWI
M. le Directeur - Agricultural Research Center Rice Research & Development Program
12619 Giza - EGYPTE
Tel : +20 25 76 953
Fax:+ 20 25 73 65 70

A.A. EL-HISSEWY (
Rice Research and Training Center - A.R.C. RRC Sakha
Kafr el Sheikh 33717 - EGYPTE.
Tel : +20-47 22 36 83
Fax : +20- 47 22 50 99

A. EL-KADDY

Abstract

Grain size and shape, milling quality and recovery ability of head rice, absence of white areas, appropriate amylose content, gel consistency, and cooking and eating quality are studied. Physicochemical qualities preferred by consumers, and the effect of environmental conditions on these qualities are described. Simple, rapid, reliable tests for these characteristics are developed. The effect of various agronomic practices, pre-harvest and post-harvest operations on grain quality (time of harvest, parboiling) are determined.

Rice is consumed as a whole cooked milled grain and starch constitutes over 90 percent of its grain weight. There are some cooking and eating quality characters that affect the structure and properties of the starch components during cooking. Also, an important effect of moist heat on rice is the swelling and solubilization of starch, which leads to changes like increase in volume, splitting and fragmentation, or sloughing and development of various textural qualities. Amylose content, gel consistency, gelatinization temperature and grain elongation are the main characters for measuring cooking and eating quality of rice grain and affect directly on the palatability characters.

These characters are usually tested on late generations. Egyptian consumers prefer short grain varieties with low amylose content, low gelatinization temperature and soft gel consistency. Therefore, the breeding

efforts are concentrated towards releasing new varieties with excellent grain quality and improvement of some commercial varieties to face the consumers demand. Table 5 presents the results of cooking and eating properties for the Egyptian varieties and elite lines in the Preliminary Yield Trials.

Keywords

- Rice quality, physiochemical, cooking, eating, qualities
- Egypt.

Introduction

Rice is one of the most important crops in Egypt and its production plays a significant part in the strategy to overcome food shortage and improvement of self sufficiency for local consumption and export. It occupies annually, about 0.60 million hectares. Because of the limited land available for cultivation in Egypt, rice area produce approximately 5.0 million metric tons, with a national average of about 8.3 tons/ha. Further increase in rice production from increased yield per unit area is needed. This can be achieved through varietal improvement, optimizing of cultural practices as well as controlling of weed, diseases, insects and improved rice grain quality for consumption and export. Quality of rice grains in turn depends on : the growth of rice plants during its vegetative phase, the growth of the panicles and food flow to the grains and ripening stage of grains.

Breeders are currently working to develop new rice varieties with improved agronomic characters that will be reflected in higher grain yields. Since many years, Egypt has achieved the high yield target per ha. Therefore, grain quality has become a priority of research in rice breeding program objectives. Breeders should look for evaluation of early breeding lines for grain quality and also for nutritional factors in more advanced lines.

Cooking and eating quality of rice have never been serious problems in Egypt as nearly more than 95% of the rice area is planted with Japonica rice varieties because of their moistness, tendeness, gloss and taste. Recently, however, emphasis of development of long grain Indica rice has been brought into focus with respect to cooking and eating quality in breeding program quality. Newly released Japonica hybrids (Giza 177, Giza 178, Sakha 101 and Sakha 102) mostly have low amylose content (17-18%) which its cooking quality are acceptable to the local consumers. Amylose content, gel consistency, gelatinization temperature and grain elongation are the main factors that affect the cooking and eating quality of rice grain.

Rice grain quality characteristics

Physical Characters

Visual Characters

Most of the farmers and consumers depend mainly on visual characters for differentiation and evaluation of rice varieties. Visual characters comprise grain dimension, grain appearance, and chalkiness. However, grain dimension consists of grain length, width and shape. Some countries use a grain thickness also as addition of component of grain dimension.

Grain dimension :

Grain dimension is a primary quality factor in any breeding program. In early generation, close visual comparisons are made to ensure that grain dimension conforms to the requirements of each grain type. The Egyptian breeding program starts selection for grain size and shape from F2 generation and continues until the line develops into a variety on the basis of visual characters in early generation, but more exact measurements are made in the advanced generations. Grain dimension such as grain length, width and shape are controlled by genetic factors. Grain dimension affects rice price and also determines the planted area under different varieties.

The short bold grain varieties are commonly preferred in Egypt. The farmers prefer short, bold and heavy grain varieties whereas, the consumers prefer short, bold, sticky and soft rice grain varieties.

Table (1) shows means of the different components of grain dimension for different Egyptian rice groups. The best grain dimension according to the farmers and consumers preference is found in Japonica varieties group.

There are differences between rough rice and milled rice in grain dimension, these differences are affected by hull content of different varieties and not correlated to rice groups. Therefore, most of breeding programs depend on milled rice in grain dimension classification.

Table (1) : Mean values of grain dimension for rough and milled rice groups

Group Shape	Type	Grain length	Grain width	Grain
Japonica Indica Japonica/Indica	Rough Rice	7.47 9.26 7.37	3.31 2.64 2.96	2.26 3.50 2.56
Japonica Indica Japonica/Indica	Milled Rice	5.16 6.36 5.20	2.73 2.15 2.38	1.89 2.97 2.20

Grain length

Grain length has long been used in most rice breeding programs as a characteristic for classifying rice varieties. Milled rice is classified on the basis of average length into four classes : short, medium, long, and extra long. The Japonica varieties are mostly short grained while Indicas are long or medium grained such as IR 28. Also Japonica/Indica varieties range between short and medium grains.

Grain width

Grain width is an important factor in determining the shape and grain weight. The grain width helps in classifying the rice grain for mill processing and separate the immatured grains from whole grains. Japonica grain has greater width than the other two rice groups.

Grain shape

Grain shape is expressed as the ratio between grain length and width. Grain shape is classified into round, bold, medium and slender. The Egyptian rice grain shape varies from medium to slender in case of Indica or Japonica/Indica varieties while in Japonica (short grain) it varies from bold to medium shape.

The following scale is used for classifying the milled rice on the basis of grain length and shape.

Milled Rice Classification

Milled rice are classified on the basis of average length as follows :

Size category	Length in mm
Short	< 5.50
Medium	5.51 - 6.50
Long	6.61 - 7.50
Extra long	> 7.50

For grain shape classified into :

Shape	L/W Ratio
Round	< 1.0
Bold	1.1 - 2.0
Medium	2.1 - 3.0
Slender	> 3.0

Grain appearance and chalkiness

The grain appearance depends on endosperm opacity and the amount of chalkiness. According to the endosperm opacity rice grain is classified into waxy or opaque that mostly contains amylopectin and few of amylose content, and non waxy or translucent grains contain higher amylose content and have different type of chalkiness.

The site of chalkiness are termed white center, white belly or white back and the degree of chalkiness varies greatly among cultivars and within a cultivar also. Chalkiness is caused by loose arrangement of starch granules with airspaces, and it usually results in lower milling recover.

Chalkiness is influenced by environmental factors such as drought stress during ripening and blast disease. But there is some evidence that this trait is under genetic control also. Therefore, in Egyptian breeding program there is an evaluation system for the degree of chalkiness from F3 generation. Chalkiness reduced milling recovery of rice grain by increasing the breakage ratio and by decreasing the head rice output. It also affects directly rice storage period because it is more susceptible to attack by insects. But chalkiness does not affect the cooking and eating quality because it disappears during cooking.

Generally, most of the Egyptian rice varieties have good translucency and less chalkiness under normal growing condition, and with heavier milling pressures, the short grain types show a white color. Among the Egyptian rice varieties, Giza 181 variety is considered ideal in grain appearance because it is highly translucent. On the other hand, IR 28 and Giza 175 show higher chalkiness than the other rice varieties.

Milling recovery

Milling combined series of mechanical processes that remove the hull, the outer layers and the embryo of rice grain. Milling recovery is one of the most important factors that affects rice price. There are numerous factors that affect the milling quality. Varieties with long, slender grains, produce more breakage than the short, bold grain varieties. Also, purity of the variety affects the milling quality because the huller cannot efficiently mill different kinds of rice grain. The presence of foreign matter such as red rice, unfilled grains and pebbles reduces the total milling recovery. Moisture content of rough rice is considered to be the main factor affecting milling quality. The grain with high moisture content is too soft to bear hulling pressure, and the grain is too dry, it becomes brittle, hence is prone to greater breakage. Therefore, attempts should be made to breed rice varieties for tolerance to moisture absorption stress for improving the milling quality. Selection for improving milling quality in Egyptian breeding program begins from F4 generation and onward. Short grains varieties (Japonica group) have higher milling recovery than other rice groups (Table 2).

Hulling percentage

Hulling involves removing of the husk from the paddy with a minimum damage to the grain and separating the husk from the paddy to produce the brown rice. Hull percentage in different varieties varies from 16-24%. Egyptian rice varieties of Japonica group have a highest hulling recovery followed by varieties of Japonica/Indica group. However, the Indica rice varieties have the lowest value (Table 2). Some sheller produces a mixture of brown rice, unhusked grain, husks and some broken rice and germ. The main factor affecting the hull processing is the moisture content of rough rice during hull processing. Baddy and brown rice have different characteristics. The average weight of paddy by volume is less than brown rice, although paddy grains are bigger in size than the brown rice grains.

Milling processes

The process of removing the embryo and the outer bran layer from the brown rice is termed as whitening or milling. Polishing refers to the process for removing subaleurone layer after whitening which gives the rice grain a shining appearance. The friction and abrasion are two main processes. These are used to remove the bran layer from the brown rice grain. The friction process uses the friction between the grains to break and peel off the bran. While in abrasive process, stone rough surface when used, peels off the bran.

The degree of milling may vary to suit the taste of the consumer or to conform with official regulations and it is usually estimated from the color of the milled grains and broken ratio. However, milled rice contain whole grain and broken grains of different size. Rice bran and embryo compose 8-10% of the total grain weight. The Japonica varieties usually have higher milling percentage than the Indica varieties.

Head rice percentage

Milled rice consists of unbroken, broken rice in different size and some bran. Some consumers and markets refuse a total milled rice and prefer head rice only. The separation of these particles is termed as grading. However, the brokens are fragments of grain, the length of which are less than 3/4 of the whole grain and are after separated into two different sizes.

Head rice production varies widely, depending on different factors such as type of grain, variety, chalkiness, environment during ripening, and some agronomic practices. Head rice percentage is also affected by post-harvest handling, storage period, and condition and milling process. The Egyptian Indica varieties have very low head rice content than the Japonica rice varieties.

Table (2) : Average milling recovery of Egyptian rice groups

Rice Group	Hulling %	Milling %	Head Rice %
Japonica	81.1	71.3	65.2
Indica	78.4	69.2	58.0
Japonica / Indica	79.8	69.3	61.2

Chemical component

The chemical composition, starch, protein, lipid, ash and mineral content, crude fiber and moisture affect nutritional quality of rice grain including cooking and eating quality also.

The chemical components of rice grain do not differ widely from other cereal grains. The gross chemical composition of rice grains varies according to the variety, the environmental conditions and some agronomic practices. Rough and brown rice have higher content of most of the chemical components than milled rice.

Moisture

All rice plants are different in moisture content in the field because the maturity stage is not the same for all. Usually, at harvesting time the moisture content is over 20% but after few days and during threshing and harvesting processing, it reduces quickly to 15-18%. Therefore, moisture content is a transitory factor, affected by maturity stage and drying conditions. The moisture content influences some quality characters such as milling and head rice recovery, cooking quality and storage period. However, during storage, high moisture rices quality characteristics may change faster than those with lower moisture content. On the other hand, too dried grain becomes brittle and shows greater breakage. The optimum moisture content showed range between 12-14% for safe storage and keeping qualities.

Starch

Starch is the principal constituent of rice, comprising about 90% of total dry matter of the milled rice. Starch consists mainly of two molecular types, amylose and amylopectin. The amylose molecule has a straight chain structure containing about 500 dextrose units while the amylopectin-molecule is highly branched and has overloss dextrose units. The amylose amylopectin ratio is the major factor involved in determining cooking and eating quality. Starch molecular types affect directly the stickiness and the texture after cooking, tendency of the grains to break and different processing characteristics. Also, the reaction of rice to cooking is largely dependent on the starch type. As the amylose-amylopectin ratio increases, gelatinization temperature also increases whereas the water uptake decreases. Most of the Egyptian rice varieties have great amount of amylopectin. Therefore, these varieties are sticky and soft after cooking. There is negative correlation between rice starch and protein content as the increase in rice starch is followed with decrease in protein content.

Protein

The quantity and kind of proteins are important factors of rice nutrition. Some factors are affecting protein content of rice such as climate and environment, kind and quantity of fertilizer applied, duration of maturity, degree of milling and varietal characteristics. The protein content of the Egyptian rice varieties ranges from 6.2% to 8.3%. The Indica rices have higher protein content than the other two groups, however, the Japonicas showing the lowest value. On the other hand, the rices derived from Indica-Japonica crosses show intermediate values for protein content. Therefore, large variation in protein content exist among the rice cultivars which occurred by genetical and environmental factors but mostly depend on the genetic factors. The correlation between protein content and grain yield of rice is negative. IRRI (1973) has reported that the negative association between grain yield and protein content is caused more by the environmental component than the genetic component.

Amino acid composition such as level of limiting essential amino acids like lysine and the proportion of non-essential to essential amino acids, determines the protein quality. Some differences are observed among Egyptian cultivars in one or more essential and non-essential amino acids. The three rice groups contain high values of these essential amino acids composition in comparison with FAO/WHO recommended values. Also, there are no correlation between amino acid composition and rice groups, it mainly depend on the protein fraction content in the grains. Lysine content of all Egyptian varieties is less than the FAO/WHO pattern except in case of the rice variety Giza 171.

Lipid

Rice is a poor source of lipid, the content of which ranges from 1.6 to 2.8% in brown rice and from 0.2 to 0.5% in milled rice. Therefore, the lipid content of the rice chiefly occurs in the bran and embryo which are almost removed during milling. The greater the milling, the more the content of lipid is removed as rice bran, particularly the surface lipids which average about 60% of the total grain lipids. Most of the lipids in the endosperm are associated with protein bodies, but starch granules also have bound lipids. In general, lipid content in all Egyptian rice varieties are almost identical, although there is variation in the individual varieties.

Ash and minerals

Ash and minerals content of rice grain are similar to those of other cereal grains. Ash content of different rice groups has the same average value. However, variation in ash content arise as result of soil condition, kind and amount of fertilizers applied and irrigation water during the crop growth. The principal source of ash and minerals is from the hull and the bran layer. Therefore, they are generally higher in rough and brown than in milled rice. The ash content of rice caryopsis contains phosphorus, nitrogen, potassium, magnesium and silicon. However, silica is the major element in hull ash.

Crude fiber

Fiber is another cereal grain constituent which is known to affect protein utilization. Most of the crude fibers of rice are in the bran and outer layers. For this reason the brown rice have a higher crude fiber content than the milled rice. Although there may be varietal differences, the fiber content of milled rice is largely a function of the degree of milling. Crude fiber content in the Egyptian rice varieties ranges from 0.20 to 0.65%.

.

Cooking and eating quality characters

The Egyptian consumers prefer cooked rice to be moist and sticky. Therefore, cooking and eating quality of rice has never been serious problem in Egypt since nearly more than 95% of the rice area is planted by Japonica rice varieties because of their moistness, tenderness, gloss and taste.

Rice is consumed as a whole cooked milled grain and starch constitutes over 90 percent of its grain weight. There are some cooking and eating quality characters that affect the structure and properties of the starch components during cooking. Also, an important effect of moist heat on rice is the swelling and solubilization of starch, which leads to changes like increase in volume, splitting and fragmentation or sloughing and development of various textural qualities. Amylose content, gel consistency, gelatinization temperature and grain elongation are the main characters for measuring cooking and eating quality of rice grain and affect directly on the palatability characters. Also, protein content has the same effect because of its negative correlation with amylose content. Environmental and cultural practices affecting cooking and eating quality characters comprise soil and location, date of seeding and harvest, fertilizers, maturity and post harvesting process.

Some characters vary greatly by different factors, others seem unaffected. It depends on degree of differentiation among varieties. Also, cooking and eating quality characters are affected by the crop season. However, all these properties in new crop differ more than the old crop, even for the same variety. Therefore, we cannot differentiate between rice groups for cooking and eating quality characters. Table 3 shows the mean values of cooking and eating properties of some Egyptian rice cultivars.

Cooking and eating properties

1) Amylose content

Amylose content is a major determinant of cooking and eating quality characters of rice. The amylose molecule has a straight chain structure containing about 500 dextrose units. The amylose-amylopectin ratio is the major factor of classifying rice into waxy (glutinous) ad nonwaxy (nonglutinous). Rice is classified according to amylose content into :

Waxy :

Amylose content	< 7%

Nonwaxy :

Very low amylose content	7-10%
Low amylose content	10-20%
Intermediate amylose content	20-25%
High amylose content	> 25%

There is no correlation between amylose content and grain type. However, some short grain varieties have high amylose content (Giza 175) while some long grain varieties have intermediate amylose content (Giza 181).

Amylose content directly affects a water absorption, volume expansion, tenderness and stickiness. Amylose content of the Egyptian rice varieties varies from 18.1% to 27.1%. All Japonica rice varieties have low amylose content which become moist and sticky when cooked while the Indica varieties have high amylose content and are relatively dry, separate and less tender when cooked and become hard upon cooling, therefore the Egyptian consumers do not accept it. The Japonica/Indica varieties also have high amylose content.

2) Gel consistency

Gel consistency is a good measure of gel viscosity of milled rice and determines the softness after cooking. Gel consistency is rapid, simple and sensitive test for determining eating quality of rice complementary for amylose content. It is measured by the length of cold milled rice pasta in a test tube in a horizontal position and classified into :

Hard gel consistency	26-40 mm
>Medium gel consistency	41-60 mm
Soft gel consistency	61-100 mm

Rices of similar amylose content can be differentiated according to tenderness as measured by gel consistency. However, amylose content is negatively correlated with gel consistency. Gel consistency directly affects the texture of cooked rice. Therefore, cooked rice with a hard gel consistency hardens faster than that with a soft gel consistency. Moreover, the later one is more tender. Because of the higher lipid content of the outer layers of the rice grain, the degree of milling is important factor affecting gel consistency. Also, high protein rices are harder and hardly affects gel consistency. Indica and Japonica/Indica rice varieties have harder gel consistency than the Egyptian Japonicas.

3) Gelatinization temperature

Gelatinization temperature (G.T.) determines water uptake and the time required for cooking. Gelatinization temperature is the temperature at which aqueous starch granules begin to swell irreversibly. An alkali test is used to measure gelatinization temperature by spreading value with the following scale :

1	No effect	
2-3	High and high intermediate G.T.	(75-79 °C)
4-5	Intermediate G.T.	(70-74 °C)
6-7	Low G.T.	(55-69 °C)

Nonwaxy starch gives lower G.T. values than waxy starch and varieties with desirable cooking and eating characters fall in low and intermediate gelatinization scale. All the Egyptian rice varieties are low in gelatinization temperature except Giza 175 and IR 28 which are intermediate. It indicates that the Egyptian varieties are less resistant and take short time for cooking.

4) Grain elongation

Elongation ratio is defined as the ratio of length of cooked rice grains to the length of milled rice grains. So, elongation is the expansion of rice grains upon cooking. Rice varieties differ in elongation. Grain elongation is considered important cooking quality for some special consumers, but without increase in girth. High volume expansion of milled rice upon cooking is not necessarily a result of grain elongation. Some rice varieties elongate 100% upon cooking. All Egyptian rice varieties elongate between 50 to 70% of its size.

Table (3) : Mean values of cooking and eating properties and protein of grain for ten Egyptian rice varieties and strains

Group	Varieties	Amylose content (%)	Gel consistency (mm)	Gelatinization temperature	Grain elongation (%)	Protein content (%)
Japonica	Giza 171	19.5	91	5	64	6.3
	Giza 172	19.7	95	6	67	7.2
	Giza 159	20.1	100	6	58	7.1
	Giza 176	18.9	100	7	66	6.2
	Reiho	18.1	100	7	60	6.6
Indica	Giza 181	20.7	82	5	55	7.6
	IR 28	27.1	37	1	64	8.2
Japonica/ Indica	Giza 175	25.5	36	3	61	8.3
	GZ 1368 S-5-2	26.1	32	4	60	7.6

Palatability characters

Palatability characters are the main indication of the consumers preference for the different rice varieties. It is affected by some factors such as variety, grain dimensions, degree of milling, cooking and eating properties and cooking methods. Palatability characters differ from place to place according to the consumer's nutrient habit and rice consumption.

Data presented in Table (4) revealed that the rice water ratio was 1:1 for all the Japonica type except the variety Giza 175, 1:1.5 for the long grain variety and the new line GZ 1368. The ratio for Giza 181 only was 1:2 . The cooking time varied with the rice water ratio, which 1:1 ratio the cooking time ranged between 19 min. and 33 min. and from 21 min. to 32 min. with 1:1.5 ratio, while with 1:2 ratio has the highest cooking time in the Indica varieties.

The expansion of the grains after cooking was the highest for the Japonica varieties, while with the lowest was recorded for the Indica and Japonica/Indica varieties. Moreover, the breakage percentage was the highest for all the tested varieties when the rice :water ratio was increased. The main score for whiteness was the highest for cooked Giza 181 (Indica variety) and the lowest for the Japonica/Indica variety Giza 175. The differences in whiteness between the other varieties were not significant. The acceptable score for hardness was the lowest for Giza 175 and highest for Giza 172.

Data revealed that stickiness increased with increasing rice water ratio for the Japonica rice varieties which indicated that, these varieties do not need an increased amount of water during cooking. Moreover, varieties Reiho, Giza 171, Giza 172 and Giza 181 were the most acceptable varieties due to their odor and taste, while the lowest acceptable varieties were Giza 175 and IR 19743. The overall acceptability showed that the short grain varieties with low amylose content have more attractive taste than the long grain with high amylose content for the Egyptian consumers. Also, the consumer prefers moist, sticky and soft rice varieties after cooking.

Table (4) : Means of palatability characters of some Egyptian rice cultivars and strains

Group	Varieties	Rice: Water	Cooking time (mn)	Expan-sion	Break-age	White-ness	Hard-ness	Sticki-ness
Japonica	Giza 171	1:1	20.00	9.00	8.00	9.00	7.00	8.00
		1:1.5	22.00	8.00	7.00	9.00	6.00	8.00
		1:2	19.00	5.00	5.00	9.00	5.00	5.00
	Giza 172	1:1	23.00	8.00	9.00	9.00	8.00	8.00
		1:1.5	22.00	7.00	8.00	9.00	9.00	7.00
		1:2	22.00	6.00	6.00	9.00	5.00	6.00
	Giza 159	1:1	20.00	7.00	8.00	7.00	7.00	7.00
		1:1.5	24.00	6.00	6.00	7.00	6.00	6.00
		1:2	23.00	5.00	7.00	7.00	6.00	6.00
	Reiho	1:1	19.00	8.00	8.00	9.00	8.00	8.00
		1:1.5	23.00	7.00	8.00	9.00	7.00	6.00
		1:2	22.00	7.00	6.00	9.00	5.00	9.00
	Giza 176	1:1	20.00	9.00	9.00	9.00	8.00	8.00
		1:1.5	21.00	8.00	7.00	9.00	7.00	7.00
		1:2	21.00	6.00	5.00	9.00	6.00	6.00
	Giza 181	1:1	23.00	5.00	7.00	10.00	7.00	6.00
		1:1.5	25.00	6.00	7.00	10.00	6.00	7.00
		1:2	20.00	7.00	6.00	10.00	6.00	8.00
Indica	IR 28	1:1	33.00	5.00	7.00	8.00	7.00	4.00
		1:1.5	32.00	7.00	6.00	8.00	6.00	6.00
		1:2	25.00	6.00	5.00	8.00	6.00	5.00
	IR 19713	1:1	23.00	7.00	7.00	8.00	7.00	6.00
		1:1.5	23.00	8.00	6.00	8.00	6.00	8.00
		1:2	23.00	8.00	6.00	8.00	6.00	7.00
	Giza 175	1:1	22.00	4.50	8.00	6.50	5.00	5.00
		1:1.5	22.00	4.50	8.00	6.50	5.00	5.00
		1:2	21.00	4.50	5.50	7.00	4.50	4.50
Japonica/ Indica	GZ 1368	1:1	24.00	7.50	8.00	7.00	8.50	7.50
		1:1.5	24.00	6.50	5.50	7.00	7.50	6.50
		1:2	22.00	6.00	6.00	7.00	6.00	5.00

.

Crack resistance

Head rice is the main factor affecting milling quality while milling quality influences the economic value of rice grain. Head rice production varies widely depending on different factors such as type of grain, variety, chalkiness, environment during ripening and also affected by post-harvest handling, storage period and condition and milling process. Most of these factors cause crack formation which reduce head rice percentage. Data presented in (Table 5) recorded small variation for crack resistance between 16 Egyptian rice varieties and new lines in both two methods for drying. However, all varieties showed high resistance to cracking except the long grain varieties IR 28 and Giza 181 in case of oven-dried only. On the other hand all the new lines were resistant to fissuring. Sun drying for all remoistening rice samples showed higher head rice percentage than oven drying. It defines that sun drying had dropped the moisture content and relative humidity without fissuring. However, with increase the moisture absorption by dry rice is a definite cause for the fissuring of the rice grain. Therefore, the soaking treatment used as a screening method to define varietal reaction to moisture absorption or unfavourable post harvest environments. Table (6) defined varietal differences in both drying methods.

Table (5) : Some cooking and eating quality characters of preliminary yield trial early, 1991

No.	Entries	Amylose	G.C.	G.T.	Elong.
1	Giza 171	17.4	95	Low	66
2	Giza 172	18.0	90	-	62
3	Giza 175	27.2	35	-	42
4	Giza 176	17.4	96	-	55
5	Giza 181	18.0	92	-	46
6	IR 28	26.2	40	Intermediate	40
7	GZ 1368 S-5-4	25.6	37	Low	86
8	GZ 4071-9-2-1	18.0	95	-	70
9	GZ 4071-9-3-1	18.0	100	-	54
10	GZ 4071-16-2-1	17.8	96	-	50
11	GZ 4071-16-2-1	17.8	96	-	56
12	GZ 4101-5-3-1	17.8	88	-	52
13	GZ 4151-11-2-1	17.3	88	-	70
14	GZ 4151-11-2-2	21.0	85	-	45
15	GZ 4172-1-3-3	19.4	92	-	45
16	GZ 4172-2-1-1	19.0	99	-	53
17	GZ 4191-1-1-1	18.2	89	-	45
18	GZ 4193-5-1-1	18.0	89	-	49
19	GZ 4255-3-1	17.8	92	-	48
20	GZ 4255-6-1	17.4	100	-	75
21	GZ 4255-6-2	18.0	100	-	86
22	GZ 4255-6-3	17.6	100	-	79
23	GZ 4255-6-4	17.2	100	-	89
24	GZ 4255-8-1	17.2	100	-	92
25	GZ 4255-8-2	17.0	100	-	78
26	GZ 4255-9-1	17.6	100	-	73
27	GZ 4256-1-1	17.0	100	-	81
28	GZ 4386-34-3	19.0	97	-	60
29	GZ 4462-10-2	19.2	84	-	57
30	GZ 4462-49-1	19.2	81	-	52

Giza 176 variety showed highest head rice yield followed by the new line GZ 4120-205 in sun and oven dried methods. Also, the other Japonica varieties Giza 172 and Giza 171 showed resistance to fissuring while the Indica variety IR 28 and Giza 181 and Japonica/Indica hybrids Giza 175 and GZ 1368 showed difference between the two drying methods used, and also appeared more susceptible to fissuring than Japonica rice varieties. Some differences were observed between the new lines however the two salinity lines GZ 4565-6 and GZ 4565-10 showed the lowest head rice yield in both drying methods. Accordingly, the Egyptian new lines are resistant to cracking which influences the milling quality, therefore studies should be undertaken on varietal improvement for low cracking and breakage properties.

Table (6) : Milling recovery of some Egyptian rices after crack stress treatment

Entries	Control			Sun-dried			Oven-dried		
	B %	M %	HR %	B %	M %	HR %	B %	M %	HR %
Giza 171	79.2	70.5	66.7	82.0	73.5	69.0	77.5	70.1	66.8
Giza 172	78.6	72.5	66.05	80.4	70.7	67.7	77.3	69.9	67.6
Giza 175	77.2	70.4	61.6	79.6	71.6	63.5	74.7	67.0	62.1
Giza 176	77.2	68.1	64.2	80.2	72.2	69.0	77.4	70.9	68.8
Giza 181	76.3	68.9	64.8	78.0	72.5	68.0	75.7	70.8	62.1
IR 28	76.1	69.3	58.2	78.4	72.6	54.1	78.2	71.0	58.2
GZ 1368 S-5-4	75.6	69.2	66.9	77.0	70.0	66.5	76.9	69.3	61.8
GZ 3766-38	80.4	72.6	66.8	81.5	73.5	65.6	80.1	72.3	68.8
GZ 4120-205	81.6	74.2	69.8	82.5	78.5	69.0	80.6	72.7	67.5
GZ 4120-298	81.2	73.3	58.3	83.0	77.0	66.5	81.0	73.1	66.1
GZ 4196-36	78.1	67.7	62.6	81.0	72.0	63.6	81.6	70.7	67.0
GZ 3707-4	79.6	71.7	69.7	80.0	73.4	68.3	78.9	72.1	62.8
GZ 4565 S-6	81.0	71.4	68.8	81.0	71.0	63.5	79.8	73.2	62.6
GZ 4565 S-10	79.7	71.1	69.5	79.9	70.9	63.4	79.2	72.2	62.4
GZ 4071-9	77.7	69.9	67.8	78.2	71.6	67.0	77.3	70.4	65.9
GZ 4255-6	80.0	70.7	69.1	79.0	76.0	69.0	78.4	72.5	62.8

.

Rice grain quality as affected by agronomic practices

The protein content of parboiled and milled rice increased as the nitrogen level increased. Increasing the spacing or reducing plant population caused increase in protein contents of both parboiled and milled rice. Karim et al. (1992) reported that milling recovery and head rice % were decreased as plant density increased but amylose content was not consistent. El-Rewainy (1996) found that all grain quality characters except the brown rice percentage and broken rice percentage were reduced with increasing the seeding rate from 30 to 60 kg/feddan. Singh et al. (1995) reported that delaying sowing date gave maximum hulling % and head rice % while it decreased the milling % and amylose content. Delaying sowing date, decreased the brown rice %, milling %, head rice %, amylose content and protein content, while it increased the broken rice percentage. Early harvesting (at 25-30 days after heading) decreased significantly hulling %, milling %, head rice % and amylose content, was reported by Sunil and Nurul (1984), El-Wekil (1991) and El-Kady et al. (1992). Similarly, delaying the harvest from 30 to 40 or to 50 days from heading caused significant reduction in protein contents of parboiled and milled rice (Table 7).

Table (7) : Protein content % of brown rice and milled rice as affected by nitrogen levels, spacing and harvesting time

Treatments	Parboiled rice		Milled rice	
	Giza 171	IR 579	Giza 171	IR 579
Nitrogen :				
Control	6.75	7.49	5.24	6.28
72 kg/ha	7.79	9.00	5.95	6.96
144 kg/ha	8.45	9.31	6.57	7.11
F. Test	**	**	**	**
Spacings :				
15 x 10 cm	7.29	8.33	5.70	6.52
15 x 20 cm	7.72	8.62	5.86	6.26
15 x 30 cm	7.99	8.85	6.20	6.97
F. Test	**	**	**	**
Harvesting time :				
30 days	7.95	8.87	5.94	7.06
40 days	7.66	8.48	5.94	6.76
50 days	7.38	8.44	5.88	6.53
F. Test	**	**	**	**

The amylose content of parboiled rice decreased as the soil was fertilized with 72 kg N/ha. Parboiled rice amylose reduced by the increment of nitrogen level (144 kg N/ha). The amylose content of milled rice showed the same behaviour. Widening the spacing from 15x10 cm to 15x20 cm caused a significant increase in amylose content of parboiled rice and a reduction in that of milled rice. delaying the time of harvest from 30 to 40 and then to 50 days from heading caused decreasing the amylose contents of parboiled and milled rice (Table 8).

Table (8) : Amylose content of brown rice and milled rice as affected by nitrogen levels, spacing and harvesting time

Treatments	Parboiled rice		Milled rice	
	Giza 171	IR 579	Giza 171	IR 579
Nitrogen :				
Control	15.70	21.11	18.23	27.26
72 kg/ha	15.42	20.91	17.61	26.72
144 kg/ha	15.20	20.80	17.45	26.92
F. Test	**	**	**	**
Spacings :				
15 x 10 cm	15.27	20.72	17.53	27.05
15 x 20 cm	15.71	21.06	18.01	27.01
15 x 30 cm	15.34	21.03	17.75	26.85
F. Test	**	**	**	**
Harvesting time :				
30 days	16.09	21.36	17.77	27.05
40 days	15.48	21.15	17.84	27.28
50 days	14.75	20.30	17.67	26.57
F. Test	**	**	**	**

The nitrogen caused delaying the heading, so it is expected that the percentage of translucency decreased as the nitrogen level increased in the soil. Increasing the level from control to 72 kg N/ha to 144 kg N/ha caused a reduction in translucency percentage. Delaying harvest resulted in increasing the percentage of translucency (Table 9).

As the nitrogen level increased, the percentage of chalky grains decreased. delayed harvest time from 30 to 40 and to 50 days after heading the percentage of chalky grains went on increasing (Table 9).

Increasing N levels and wider spacing caused delay in heading. Expectedly, application of nitrogen fertilizer increased the percentage of green grains. Likewise, wider spacing tended the green grains percentage to increase. Delaying in harvesting time reduced markedly the percentage of green grains, (Table 9).

Increasing hulling percentage with increasing nitrogen fertilizer level, was found by Ghash et al. (1971), Rewakta and Nugpure (1974), Milad (1983) and Shaalan et al. (1987). With respect to milling output % many investigators such as Balal et al. (1979), Milad (1983), Shaalan et al. (1987), El-Bably (1990), Nguyen (1994) and El-Rewainy (1996) found that milling percentage were significantly decreased by increasing the nitrogen levels. On the other hand, increasing in milling % with increasing nitrogen fertilizer, was obtained by Fallah and Gavidia (1974) and Teckchandani et al. (1985).

Table (9) : Percentages of translucent grains, chalky grains and green grains of rice cultivars as affected by nitrogen level, spacing and harvesting time

Treatments	Translucent		Chalky grains		Green grains	
	Giza 171	IR 579	Giza 171	IR 579	Giza 171	IR 579
Nitrogen :						
Control	79.37	89.94	5.29	6.13	8.28	8.63
72 kg/ha	78.21	81.38	3.78	4.95	13.49	7.23
144 kg/ha	72.41	79.82	3.15	4.09	18.20	10.09
F. Test	**	**	**	**N.S.**	**	*
Spacings :						
15 x 10 cm	77.36	82.80	4.54	5.30	12.14	7.47
15 x 20 cm	77.36	81.61	4.00	5.61	21.49	8.37
15 x 30 cm	75.27	81.74	3.68	4.27	15.34	10.11
F. Test	**N.S.**	**N.S.**	**N.S.**	**N.S.**	**	**
Harvesting time :						
30 days	57.35	71.54	2.30	2.44	23.84	15.35
40 days	83.23	86.13	4.07	4.65	11.93	8.12
50 days	89.41	88.47	5.84	8.10	11.93	2.48
F. Test	**	**	**	**	**	**

The milling out-put increased as the level of N increased from control to 72 and 144 kg N/ha. Delaying harvest from 30 to 40 days after heading caused significant increases in milling out-put. Further, delay to 50 days after heading caused significant increases in milling output of the Indica and Japonica rice varieties, (Table 10).

Fertilizing the rice cultivars with 72 kg N/ha increased significantly the head rice percentage. While, Indica variety IR 579 responded to the increment in nitrogen level up to 144 kg/ha. Wider spacing caused a significant increase in head rice percentage. Delaying harvest of Giza 171 increased significantly the head rice percentage. The harvest done after 40 days gave higher HRP than that done 30 days after heading, (Table 10).

Increased head rice recovery with increasing nitrogen level was achieved by Balal et al. (1979), Gill and Shahi (1987), Dilday (1988) and El-Bably (1990), since they obtained a reduction in broken rice percentage with increasing the nitrogen fertilizer.

The short grain variety Giza 171 gave the less broken rice percentage when fertilized with 72 kg N/ha as compared to the non fertilized plants. Additional dose of N (144 kg N/ha) had no effect on BRP as compared with that under 72 kg N/ha. Indica rice variety IR 579 responded to 144 kg N/ha, it gave statistically less BRP under 144 kg N/ha. While, with 72 kg N/ha the BRP was significantly less than that under control. BRP decreased with the delay from 30 to 40 days after heading and with further delay the BRP again increased significantly, (Table 10).

Increasing the level of nitrogen fertilizer, increased the broken rice % and protein content while decreased the other grain quality traits. However, the milling %, head rice %, broken rice % and amylose content were not affected by nitrogen application. (El-Bably, 1990; Sada et al., 1993 and El-Rewainy, 1996).

Application of 72 kg N/ha increased significantly hulling recovery percentage. Further increment of nitrogen fertilizer (144 kg N/ha) had no effect on hulling recovery percentage.

Yamashita and Fujimoto (1974) and El-Rewainy (1996) reported that application of nitrogen fertilizer increased slightly the amylose content.

Ghosh et al. (1971), El-Kalla et al. (1988), Reddy et al. (1988), El-Bably (1990) and El-Rewainy et al. (1996) reported that increasing protein percentage in rice grains was detected with increasing the nitrogen levels.

Delaying harvest from 30 days after heading to 40 or 50 days caused significant reduction in husk percentage. The application of 72 kg N/ha increased significantly the bran percentage. Significant reductions in bran percentage were recorded with the delay in harvest from 30 days to 50 days after heading, (Table 11). Delaying the harvest time from 30 days to 40 days after heading exercised a marked effect on hulling recovery percentage. Hulling recovery percentage increased significantly in all cases by shifting the harvest to 40 days after heading. Further delay of more 10 days (50 days) increased the hulling recovery percentage of Giza 171, (Table 11).

Table (10) : Percentages of head rice, broken rice and milling output as affected by nitrogen level, spacing and harvesting time

Treatments	Head rice %		Broken rice %		Milling out-put %	
	Giza 171	IR 579	Giza 171	IR 579	Giza 171	IR 579
Nitrogen :						
Control	67.10	59.07	4.98	8.48	72.35	67.55
72 kg/ha	69.06	60.69	3.17	7.57	72.23	68.26
144 kg/ha	69.52	61.79	3.29	7.04	72.44	68.83
F. Test	**	**	**	**	N.S.	*
Spacings :						
15 x 10 cm	68.42	60.40	4.00	7.77	72.39	68.18
15 x 20 cm	68.44	60.33	3.97	7.70	72.23	68.04
15 x 30 cm	68.83	60.81	3.48	7.61	72.41	68.43
F. Test	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Harvesting time :						
30 days	67.21	60.70	4.77	6.43	72.05	67.13
40 days	69.58	60.91	2.84	7.82	72.75	68.74
50 days	68.89	59.94	3.83	8.84	72.22	68.78
F. Test	**	**	**	**	**	**

Table (11) : Percentages of hulling recovery, bran and husk of rice cultivars as affected by nitrogen level, spacing and harvesting time

Treatments	Bran %		Husk %		Hulling recovery %	
	Giza 171	IR 579	Giza 171	IR 579	Giza 171	IR 579
Nitrogen :						
Control	8.23	9.36	18.42	21.50	82.08	76.99
72 kg/ha	8.88	9.63	18.18	21.44	82.27	77.96
144 kg/ha	9.34	9.69	18.10	20.89	82.50	78.09
F. Test	**	**	N.S.	*	**	**
Spacings :						
15 x 10 cm	8.63	9.44	18.28	21.24	82.29	77.69
15 x 20 cm	8.89	9.64	18.27	21.40	82.32	77.78
15 x 30 cm	8.93	8.60	18.15	21.19	82.25	77.56
F. Test	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Harvesting time :						
30 days	9.59	9.99	18.31	22.08	81.84	76.30
40 days	8.53	9.42	17.92	20.92	82.28	78.25
50 days	8.33	9.28	18.47	20.82	82.73	78.49
F. Test	**	**	*	**	**	**

References

Balal, M.S.; A.A. Ibrahim; A.A. Assey and A.T. Badawi (1979). Influence of N levels, planting densities and time of harvest on milling properties of rice. Agric. Res. Rev. Vol. 57(8) : 91-102.
Dilday, R.H. (1988). Effect of nitrogen fertilizer on milling quality of rice (Oryza sativa). Proceeding of the Arkansas Academy of Science. Vol. 42: 26-27.
El-Bably, A.M. (1990). Effect of nitrogen levels and time of its application on the productivity of some rice varieties. M.Sc. Thesis, Fac. of Agric., Mansoura Univ., Egypt.
El-Kalla, S.E.; A.T. El-Kassaby; A.N. Atta and A.O. El-Sayed (1988). Response of rice cultivar (IR 50) to nitrogen and zinc sulphate application. J. Agric. Sci. Mansoura Univ., Vol. 13(2) : 629-634.
El-Rewainy, I.M.O. (1996). Effect of some cultural practices on rice. M.Sc. Thesis, Fac. of Agric., Minufiya Univ., Egypt.
El-Wekil, N.I.S. (1991). Studies on effect of some cultural practices on rice grain quality. M.Sc. Thesis, Fac. Agric., Univ. Alexandria.
Fallah, A. and A.O. Gavidia (1974). Effect of sowing date and nitrogen fertilization on the milling quality of three cultivars of rice (Oryza sativa L.). Arroze, Perov Vol. 8(4) : 41-44. (C.F. Field Crop Abst. Vol. 27(10) :5032, 1974).
Ghosh, A.K.; B.B. Nanda; S. Gonvindaswami and B.B. Nayak (1971). Influence of nitrogen on physico-chemical characteristics and rice grain. Oryza, Vol. 8: 87-100.
Gill, P.S. and N.H. Shahi (1987). Effect of nitrogen levels in relation to age and seedling of transplanting on the growth, yield and milling characteristics of rice. Indian J. of Agric. Sci. Vol. 57(9) : 630-634.
Karim, M.A.; A. Ali; S.S. Ali; A. Mahmoud; A. Majed and T.A. Akhtar (1992). Effect of plant density on rice grain quality. Int. Rice Res. Newsletter. Vol. 17: 6.
Milad, I.S. (1983). Agronomic and genetic evaluation of local and introduced rice cultivars (Oryza sativa L.) under two levels of N fertilization. M.Sc. Thesis, Fac. Agric., Alex. Univ., Egypt.
Nguyen, D.B. (1994). Stability of rice grain quality under different fertilizer levels. Int. Rice Res. Newsletter Vol. 19(4) : 9.
Ramakta, J.R. and N.S. Nagpure (1974). Effect of N and P on quality of three paddy rice varieties. P.K.V. Res. J. Vol. 2: 138-139.
Reddy, M.D.; M.M. Panda; B.C. Ghosh and B. Reddy (1988). Effect of nitrogen fertilizer on yield and nitrogen concentration on grain and straw of rice under semi-deep water condition. J. Agric. Sci. Vol. 110(1) : 53-59. U.K. (C.F. Rice Abst. Vol. 12(2) : 630, 1989).
Sada, J.; G. Shu; N.S. Marlin and J.E. Hill (1993). Effect of nitrogen and harvest grain moisture on head rice yield. Agron. J. Vol. 85: 1143-1146.
Shaalan, M.A.; A.E. Ali and J. Milad (1987). Agronomic performance of the Egyptian and Philippines rice cultivars under two nitrogen levels. Alex. J. Agric. Res. Vol. 32(1) : 125-135.
Singh, S.P.; K.G. Pillai; D. Pat and N.S. Rani (1995). Effect of planting date on grain yield and quality of semi-dwarf scented rice varieties. Int. Rice Res. Newsletter. Vol. 20 (1) : 24-25.
Sunil, K.B. and H.C. Nurul (1984). Properties of maturing rice grains. F.A.O. Dec. 92) : 64-66.
Techckandani, C.R.; S.P. Krchania; S.K. Sharma and S.V. Arya (1985). Effect of N, P, and K on grain yield and milling quality of paddy. Oryza. Vol. 22(1) : 32-36. India. (C.F. Field Crop Abst. Vol. 40:725, 1987).
Yamashita, K. and T. Fujimoto (1974). Studies on fertilizers and quality of rice. In the effects of fertilizers on physico-chemical properties of rice starch. Bulletin of the Tohuku Nat. Agric. Exp. Sta. Vol. 48: 55-63. (C.F. Fields Crop Abst. Vol. 28(9) : 5549, 1975).

Cahiers Options Méditerranéennes, Vol.24, n°3, **"Rice quality : a pluridisciplinary approach"**,
Proceedings of the international Symposium held in Nottingham, UK, November 24-27, 1997

EU Concerted Action for "Quality and Competitiveness of European Rices", EC-DG VI, AIR3-PL93-2518