EFFECT OF SOME STORAGE CONDITIONS ON SOME COOKING AND EATING RICE QUALITY CHARACTERISTICS

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ABSTRACT

Egyptian paddy rice Sakha 102 and Giza 179 as a short variety and Egyptian Yasmine local aromatic as a long variety were used to discuss investigate the effect of different initial moisture content (12, 14, 16 and 18%) after storage period (12 months) on cooking and eating characteristics of rice grain. Significant differences between the three rice varieties were observed for all studied characters except cooking time character. Also the effect of different storage period (3,6,9,12 months) at constant initial moisture content in same storage conditions and well ventilated were-house for on cooking and eating characters for three Egyptian variety were also investigated. No significant differences in most studied characters mean values were estimated up to 6 months storage period on virtually all measured characters.

INTRODUCTION

Rice (*Oryza sativa* L.) occupies second position in production amongst the cereal crops on global basis. It is grown in many parts of the world but mainly concentrated in Asia (Bangladesh Rice Research Institute: Gazipur, Bangladesh. 2002). It constitutes more than 50% of world's staple diet and contributes up to 70% of the dietary energy and protein requirement in the daily diet of about 2.5 billion of Asia (Juliano, 1985), (Juliano, 1990).

Rice has been considered one of the best foods among all cereals for its nutritional quality. It has higher digestibility, biological value and protein efficiency ratio owning to presence of higher percentage of lysine than that of wheat. Minerals like calcium, magnesium, phosphorus and silicon are present along with some traces of iron, zinc, copper, and manganese (Yousaf, M. 1992). The storage of food grain is practiced from the era of the beginning of civilization.

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It is an important problem because the production of grain crops is seasonal and location specific (Sawant, 1994); however, consumption of food grain is throughout the year and is not location specific. Storage of food grain is necessary in order to ensure constant supply for the year and also to provide to distant areas.

Storage of rice is very important in Egypt because it is also grown once a year during summer season, and is consumed during the same year. Therefore, the producers and some of consumers store their needs under different conditions.Yang *et al.,* (1995) indicated that total amylose content and soluble amylose content of rice starch decreased with increasing storage period. Holcomb *et al.,* (1997) reported that longer storage and higher temperature caused loss of rice whiteness and increased cohesiveness. Donahaye *et al.,* (2000) evaluated the cooking and acceptability parameters after 1, 3 and 6 months of storage, and found that after 1 month, quality of sealed paddy stored at 18% m.c. had not deteriorated perceptibly. However, he reported that paddy stored hermetically for 1, 3 and 6 months under both laboratory and field conditions confirmed that after the first month of storage the quality of moist paddy (16-18% m.c.) deteriorated progressively. Jinshui *et al.*, (2000) indicated that the amylose content and cooked rice hardness increased after storage, while the stickiness and stickiness/hardness ratio of cooked rice declined. The increase of cooked rice hardness after rice storage was positively correlated to the increase of insoluble amylose. Chao (2001) determined the differences in nutrient quality characteristics for seven cultivars stored for about eight months at room temperature.The mean amy1ose content of new and stored rice was 19.7 and 19.4, respectively. The mean protein content of new and stored rice was 6.4 and 6.2 % respectively.

The freshly harvested rice cooks sticky, more solids are leached out during cooking, and it swells less as compared to aged rice. Significant changes occur in the cooking characteristics in the months following harvest because of number of physicochemical changes in the grain. Storage is an inevitable step that results in decreased cohesiveness, large

volume and fine texture of the cooked rice. The cost of aged rice is normally 25–30% higher than fresh rice Rajendran *et al*., (2002).

Storage induced changes in the physicochemical properties of rice, and may be both desirable and undesirable depending on storage conditions, variety, and end-user requirements. Moisture content, storage temperature, and storage time are the key factors influencing the chemical, physical, and functional qualities of rice during post-harvest storage.
The overall changes may depend on the variety, storing conditions, and further treatment;however, it is common consensus that aging of rice improves the eating quality Zhou, *et al*., (2003).

The objective of the current work was setup to investigate the effect of some storage conditions on some cooking and eating rice quality characteristics for three rice varieties.

MATERIALS AND METHODS

The present investigation was carried out at the Rice Training Technology Center, Field Crops Research Institute, Agricultural Research Center, Alexandria, during 2013 and 2014 rice seasons. Three Egyptian rice varieties were selected, Sakha 102, Giza 179 as a short variety and Egyptian Yasmine as a long variety. Paddy rice varieties were obtained from experimental farm of rice research training center (RRTC) at Sakha Kafr-El Sheikh governorate at 22 % and 20 % moisture content wet bases.

The grain were cleaned and the foreign matter, as stones, straw and silt was removed in the laboratories of rice technology training center (RTTC), Alexandria.

The experimental phase was divided into two stages. The first phase was to investigate the effect of the initial moisture content of the three rice varieties on the cooking and eating qualities while storing under the same condition.

The moisture content of grain was determined using a standard moisture oven and then dried by using mechanical Testing dryer model (TDR24A)

till it reached to the five levels of moisture content. These levels were 20, 18, 16, 14 and 12% moisture content. Three replications of every level for each variety were randomly taken in 25 kg capacity jute sacks.The samples were stored in a well protected clean closed and well ventilated ware house for one year.

The second experiment was conducted to study the effect of storage period at constant moisture content on cooking and eating characteristics of rice. Four storage periods 3, 6, 9 and 12 months were the main target of this experiment. Samples were taken in 36 random treatments (3 replication / 4 periods/ 3 cultivars) at 14 % moisture content from the three utilized rice cultivars. These samples were 25 kg weight bagged in jute sacks which directly stored in well aerated warehouse. Ten random samples were chosen from each stored time (every 3 months).These samples were subjected to determine all studied cooking and eating characteristics.

Throughout the study duration, all precautions were paid to protect the stored samples from rodents, birds and / or insects attack. The samples taken in each period of the storage periods for a process hulling, milling by SATAKE machine model Testing Husker (THU35A), Testing Mill (TMO5).

Studied characteristics:

Ten random samples were obtained from each replication for each treatment and they were used to test the cooking and eating quality characteristics :

1-Kernel elongation:

It was determined according to the method Hayman,(1955).

2- Gel consistency:

It was estimated, accordingly to Cagampang *et al*. (1973).

3- Amylose content %:

It was determined by the method described by Williams *el al.*, 1958).

4- Cooking time (min).

RESULTS AND DISCUSSION

A brief information about the grain quality characteristics for the three rice varieties is presented in table (1).

Table (1) **:** Cooking and Eating rice grain quality characteristics of used cultivars in the present study.

Statement	Varieties					
	Short grain				Long grain	
	Sahka 102		Giza 179		E.Yasmine	
	2013	2014	2013	2014	2013	2014
Kernel elongation %	68.39	67.87	67.68	68.88	66.93	71.99
Gel consistency(mm)	92.73	96.20	91.13	90.60	94.40	94.67
Amylose content %	18.84	18.43	18.51	18.43	21.00	21.07
Cooking time (min)	22.13	22.67	22.33	21.66	24.33	24.66
Origin	Egypt					

The effect of different grain moisture content levels on four cooking and eating quality characters for three rice cultivars in 2013 and 2014 seasons during storage are presented in table (2). Significant differences between the three rice cultivars were observed for all studied characters except cooking time character in 2013 and 2014 seasons. Results indicated that the highest values of all studied characters were found for the rice varieties E. Yasmine, meanwhile the lowest values were detected for the rice variety Giza 179 in the two seasons of study. These findings prove that these three rice cultivars were genetically different regarding their response to moisture content levels. These findings were in close agreement with those of El-Kady and El-Hissewy (1999), Chao (2001), Chung et al. (2001) , El-Hissewy et al. (2002)and Butt et al.(2008).

The analysis of variance revealed that the differences between different initial moisture content levels under study were significant for all cooking and eating quality characters in the two seasons of study. To clarify this point the mean values of these moisture content levels were illustrated in table (2).

Table (2): The effect of grain moisture content on cooking and eating quality characters of three rice varieties in 2013 and 2014seasons.

A- Kernel elongation (%)

Moisture content (%)	2013 Season				2014 Season			
	Sakha 102	Giza 179	E. yasmine	Mean	Sakha 102	Giza 179	E. yasmine	Mean
12	73.33	72.40	73.66	73.13	73.10	73.60	78.32	75.01
14	74.98	73.63	75.06	74.56	74.80	74.43	80.33	76.52
16	69.02	66.70	70.32	68.68	67.20	67.47	75.40	70.02
18	63.59	52.28	65.95	60.61	63.87	54.17	70.60	62.88
20	58.64	51.39	59.22	56.42	58.43	52.00	63.70	58.04
Mean	67.91	63.28	68.84	66.68	67.48	64.33	73.67	68.49

L.S.D at 5% level for		
Varieties (V)	1.98	2.50
Moisture content (M)	2.65	3.23
V x M	4.43	N.S

Table (2): The effect of grain moisture content on cooking and eating quality characters of three rice varieties in 2013 and 2014seasons.

B- Gel consistency (mm)

Moisture content (%)	2013 Season				201٤ Season			
	Sakha 102	Giza 179	E. yasmine	Mean	Sakha 102	Giza 179	E. yasmine	Mean
12	88.10	81.32	88.26	85.90	88.00	83.07	89.00	86.69
14	89.50	84.78	89.26	87.85	89.67	85.13	89.67	88.16
16	83.46	76.97	87.66	82.70	82.00	77.65	86.53	82.06
18	78.00	71.14	84.86	78.00	74.67	71.25	83.33	76.42
20	72.60	60.87	76.40	69.93	72.00	62.70	76.40	70.37
Mean	82.33	75.02	85.29	80.88	81.27	75.96	84.99	80.74

L.S.D at 5% level for		
Varieties (V)	1.92	2.03
Moisture content (M)	2.48	2.62
V x M	4.34	N.S

C- Amylose content (%)

12	21.20	20.07	23.20	21.49	20.30	20.30	23.18	21.26
14	20.09	19.80	23.52	21.13	21.83	19.87	23.07	21.59
16	24.29	23.00	25.10	24.13	23.41	23.04	25.55	24.00
18	25.10	24.97	28.02	26.03	26.12	24.96	27.58	26.22
20	28.03	28.68	30.46	29.06	27.60	28.09	29.39	28.36
Mean	23.74	23.30	26.06	24.37	23.85	23.25	25.75	24.29

L.S.D at 5% level for		
Varieties (V)	1.05	0.65
Moisture content (M)	1.35	0.84
V x M	N.S	N.S

D- Cooking time (min)

12	26.50	25.00	28.00	26.50	26.33	25.67	26.67	26.22
14	25.43	24.33	26.36	25.37	25.00	24.33	25.67	25.00
16	28.20	28.66	27.46	28.11	28.33	28.00	28.00	28.11
18	30.80	33.33	30.80	31.64	31.33	30.33	30.00	30.56
20	33.40	35.66	33.00	34.02	33.00	33.00	32.00	32.67
Mean	28.87	29.40	29.12	29.13	28.80	28.27	28.47	28.51

L.S.D at 5% level for		
Varieties (V)	N.S	N.S
Moisture content (M)	0.96	0.69
V x M	1.66	N.S

It is worthy to note that no significant differences were computed between the mean values of both 12 and 14% moisture content in respect to all characters except cooking time. These two levels gave the highest mean values of kernel elongation (%) and gel consistency character, while they showed the lowest percentage of amylase content in the two seasons of study. However, the lowest cooking time was measured at 14% moisture content level. Meanwhile, the lowest mean values of kernel elongation (%) and gel consistency characters were obtained at the highest moisture content level (20%) which caused also significant increase in the mean values of both amylase content (%) and cooking time. These findings led to the conclusion that increasing grain moisture content at the beginning of storage caused gradual degradation in all cooking and eating quality characters and 14% moisture content was the most favourable condition for storing paddy rice with the lowest decrease of these characters. Daniel *et al*. (1998), Francois *et al*. (1999), Donahaye *et al*. (2000) and Chung *et al*. (2001) reached similar results. While, Nessrin Bassuony (2009) and Aboukhadra et al.(2013) found that there were no effects of moisture content on such characteristics were determined.

Obviously from table (2), the interaction between varieties and grain moisture content levels was significant in case of kernel elongation %, gel consistency and cooking time characters in 2013 season only, meanwhile the other interaction effects were not significant. It can be noticed that kernel elongation character declined gradually by increasing

moisture content from 12 to 20% for the three varieties generally. The highest value was determined for E. yasmine (75.06%) at 14% moisture content.

The same trend was observed for gel consistency character, while cooking time character showed different behaviour. It increased by increasing grain moisture content and it was ranged between 24.33 to 26.36 min. at 14% moisture content for Giza 179 and E.yasmine varieties respectively , however it differed from 33.00 min. (for E. yasmine) to 33. 66 min. (for Giza 179) at 20 % moisture content. These findings indicated that this type of interaction differs from season to another and from variety to another and it might be affected by another factors.

As a conclusion, the results showed that these were significant differences between varieties for all cooking and eating characters except cooking time where the differences between varieties were not significant in the two season of study. Further, significant differences between grain moisture content levels were also apparent. On the other hand, the interaction between varieties and moisture content levels was significant for kernel elongation (%), gel consistency and cooking time characters in 2013 season only. In general it can be concluded that cooking and eating quality characters declined dramatically by increasing grain moisture content and the best results could be achieved by storing paddy rice with 14% moisture content.

Also in studying the effect of storage period on rice cooking and eating quality characteristics, it is well known that the consumer acceptance of rice grain depends mainly on its cooking and eating quality characters i.e. kernel elongation (%), gel consistency, amylose content (%) and cooking time. Consequently, the present investigation aimed to determine the effect of different storage periods on such important characters. Significant differences between cultivars as affected by storage period were found for all studies characters in the two seasons except kernel elongation (%) character in 2014 season only table (3).

Table (3): The effect of grain storage period on cooking and eating quality characters for three rice varieties in 2013 and 2014 seasons.

A- Kernel elongation (%)

Storage period	2013 Season				2014 Season			
	Sakha 102	Giza 179	E. yasmine	Mean	Sakha 102	Giza 179	E. yasmine	Mean
Zero time	68.39	67.68	66.93	67.67	67.87	68.88	71.99	69.58
3 Month	69.12	68.15	67.76	68.34	68.67	70.27	72.33	70.42
6 Month	69.69	69.75	70.23	69.89	70.20	71.27	73.67	71.71
9 Month	73.37	72.17	73.43	72.99	71.93	73.26	76.51	73.90
12 month	75.50	73.60	75.52	74.87	74.40	75.17	79.50	76.36
Mean	71.21	70.27	70.77	70.75	70.61	71.77	74.80	72.39

L.S.D at 5% level for		
Varieties (V)	N.S	1.97
Moisture content (P)	2.65	2.54
V x P	N.S	N.S

B- Gel consistency (mm)

Zero time	92.73	91.13	94.40	92.75	96.20	90.60	94.67	93.82
3 Month	92.20	90.29	94.00	92.16	94.00	89.63	93.57	92.40
6 Month	91.00	88.73	92.07	90.60	91.33	86.10	85.13	87.52
9 Month	87.97	83.91	88.67	86.85	88.67	82.82	87.23	86.24
12 Month	85.47	77.69	84.86	82.67	84.87	79.83	83.93	82.88
Mean	89.87	86.35	90.80	89.01	91.01	85.80	88.91	88.57

L.S.D at 5% level for		
Varieties (V)	1.65	2.39
Moisture content (P)	2.13	3.09
V x P	N.S	N.S

C- Amylose content (%)

Zero time	18.84	18.51	21.00	19.45	18.43	18.43	21.07	19.31
3 Month	18.54	18.58	21.03	19.38	18.60	18.79	21.52	19.64
6 Month	18.75	18.87	22.07	19.89	18.93	19.56	22.31	20.27
9 Month	20.11	20.07	23.64	21.27	21.34	21.07	24.17	22.19
12 Month	21.28	22.04	24.90	22.74	21.83	23.23	25.65	23.57
Mean	19.50	19.61	22.53	20.55	19.83	20.22	22.94	21.00

L.S.D at 5% level for		
Varieties (V)	0.97	0.41
Moisture content (P)	1.25	0.54
V x P	N.S	N.S

D- Cooking time (min)

Zero time	22.13	22.33	24.33	22.93	22.67	21.66	24.66	23.00
3 Month	22.63	22.67	24.90	23.40	23.00	22.67	24.67	23.44
6 Month	23.10	23.00	25.07	23.72	23.33	23.33	26.00	24.22
9 Month	25.43	25.67	26.73	25.94	25.67	25.00	27.00	25.88
12 Month	26.50	28.33	28.83	27.89	26.66	28.67	27.33	27.55
Mean	23.96	24.40	25.97	24.78	24.27	24.27	25.93	24.82

L.S.D at 5% level for		
Varieties (V)	0.81	0.54
Moisture content (P)	1.06	0.70
V x	N.S	1.22

These differences are expected as these cultivars differed genetically. In addition, the comparisons between the mean values of the three varieties in accordance to the cooking and eating quality characters were illustrated in table (3). From this table, it is worthy to note that the highest mean values for all characters were calculated for the rice variety E. Yasmine except kernel elongation in 2013 and gel consistency (%) in 2014 season. Meanwhile, no apparent significant differences were estimated between the mean values of the two varieties Sakha 102 and Giza 179 for most characters in the two seasons of investigation, while they were significantly different from that of the third variety E.yasmine.

This was expected as the two cultivars are short grain Japonica type, however the third one (E.Yasmine) is long grain Indica type. Mettamanda (2006) and El-Hissewy *et al.* (2002) reported that storability of rice varied between varieties according to their genetic construction.

Furthermore, the analysis of variance demonstrated that the differences between different storage periods were significant for all cooking and eating quality characters under investigation in the two seasons of study. In details, the mean values of studied characters, as affected by various storage periods, presented in table (3) revealed that no significant differences were observed between zero time, 3 and 6 months storage

periods for all characters in both seasons except for gel consistency and cooking time in 2014 season. A tendency toward increasing mean values was identified for kernel elongation (%), amylose content (%) and cooking time as storage period was prolonged and maximized after 12 months. Meanwhile gel consistency became harder and significantly decreased from 92.70 mm. to 82.68 mm. in 2014 season and from 93.82 mm. to 82.88 mm. in 2015 season in comparison between the mean values of this character at zero time and 12 month storage period. These findings led to the conclusion that paddy rice could be stored for 6 months without any changes in its cooking and eating quality characters. Similar results were reported by Wang and Hsieh (1988), El-Kady and El-Hissewy (1994), Yang et al. (1995), Holcomb *et al.* (1997), Perdon *et al.* (1997) and Francois *et al.* (1999), meanwhile Macedo (1999) found that the reduction of grain quality began at the eight month for one cultivar and at the tenth month for another cultivar. El-Hissewy *et al.* (2002) Nessrin Bassuony (2009) and Aboukhadra et al.(2013) reported that no significant differences between 6 and 9 months .were determined regarding cooking and eating quality characters.

Table (3) further revealed that the interaction between varieties and storage period was not significant in general except in case of cooking time in 2014 season only. This result indicated that both factors independently affected the studied characters. The only interaction found in cooking time showed that prolonging storage period caused an increasing in cooking time for the three rice varieties. The maximum increase was defined for the variety Giza 179 (7 minutes) while, the lowest increase (2.66 min) was determined for the variety E.yasmine. Insignificant interaction between varieties and storage periods was reported by El-Hissewy *et al.*(2002) Nessrin Bassuony (2009) and Aboukhadra et al.(2013) .

Finally, it can be concluded that all cooking and eating quality characters of varieties were significantly affected by different storage periods as the

aforementioned results showed significant differences between varieties and between different storage periods in the two seasons of study. Meanwhile, the interaction between the two factors was not significant in general. The only exception was that of cooking time in 2014 only. No significant differences in most studied characters mean values were estimated up to 6 months storage period. Beyond that, storage period had a significant impact on virtually all measured characters. Kernel elongation (%), amylose content (%) and cooking time values were increased however gel consistency mean values were decreased.

CONCLUSIONS

The results declared that there were significant differences between varieties for all cooking and eating characters except cooking time where the differences between varieties were not significant in the two season of study. Further more, significant differences between grain moisture content levels were also apparent. On the other hand, the interaction between cultivars and moisture content levels was significant for kernel elongation (%), gel consistency and cooking time characters in 2014 season only. In general, it can be concluded that cooking and eating quality characters declined dramatically by increasing grain moisture content and the best results could be achieved by storing paddy rice with 14% moisture content.

Additionally, All cooking and eating quality characters were affected significantly by cultivars and different storage periods as the results showed significant differences between cultivars and between different storage periods in the two seasons of study. Meantime, the interaction between the two factors was not significant in general. The only exception was that of cooking time in 2015 only. No significant differences in most studied characters mean values were found up to 6 months storage period. After that, storage period had a significant impact on virtually all measured character. Kernel elongation (%), amylose

content (%) and cooking time values were increased, however gel consistency mean values were decreased.

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الملخص الغربى

تاثير بعض ظروف التخزين على بعض صفات الطبخ والأكل وجودة حبوب الارز

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اجريت هذة الدراسة بمركز تدريب تكنولوجيا الارز بالاسكندرية موسمى ٢٠١٣ ، ٢٠١٤ وذلك لدراسة تاثير بعض ظروف التخزين على بعض صفات الطبخ والاكل وجودة حبوب الأرز٠ استخدمت مجموعة متنوعة من الاصناف المحلية من الأرز المصرى سخا ١٠٢ ، جيزة ١٧٩ من الاصناف قصيرة الحبة، وياسمين المصرى من الاصناف العطرية طويلة الحبة لمناقشة تاثيركل من محتوى الرطوبة الأبتدائية (١٢، ١٤، ١٦ ، ١٨، ٢٠%) بعد فترة تخزين ١٢ شهرا على جودة صفات الطبخ والاكل ، وقد اظهرت النتائج فروق معنوية بين اصناف الارز الثلاثة المستخدمة فى الدراسة لجميع الصفات المدروسة باستثناء صفة وقت الطبخ.

كذلك تم دراسة تاثير فترات التخزين المختلفة (٣، ٦، ٩، ١٢ شهر) عند محتوى رطوبة التخزين الأبتدائية الأمثل (١٤%) فى مخزن مغلق جيد التهوية على جودة صفات الطبخ والاكل على الثلاث اصناف المصرية المستخدمة فى الدراسة، وتبين عدم وجود فروق معنوية كبيرة بين الاصناف تحت الدراسة حتى فترة تخزين ٦ أشهر على جميع الصفات المدروسة.

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