J. Agric. Sci. Mansoura Univ., 32 (4): 2673 - 2689, 2007

EFFECT OF SOME STORAGE CONDITIONS ON THE PHYSICAL AND TECHNOLOGICAL PROPRIETIES OF RAW, PARBOILED AND QUICK COOKING RICE

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ABSTRACT

Two varieties of Egyptian rice (*Oryza sativa* L.) namely Sakha 101 (Japonica) and Giza 182 (Indica) were employed in this study. Rice grains were stored for 9 months in three types of bags (polyethylene, polyethylene plus carton and polystyrene cup) at room temperature. The work to be described here was performed to figure out the best materials raw, parboiled and for packaging quick cooking rice grains in order to keep the physical and technological properties of the aforementioned rice. The results of this study can be summarized as follows: the physical properties of brown and white rice were varied from one variety to another. The water uptake and sedimentation values of brown, white and quick cooking of both raw and parboiled rice at 77ºC and 82ºC were varied according to of the tested rice varieties. In general, quick cooking white rice of Sakha 101 variety had the highest values of water uptake at both 77ºC and 82ºC as compared with those found in the other samples. On contrary, sedimentation value at 77ºC and 82ºC was decreased as affected by the previous mentioned conditions. Furthermore, the quick cooking white rice of the two tested varieties (Sakha 101 and Giza 182) had the highest values of alkali spreading values compared to the other rice samples. Generally, alkali-spreading values decreased after subjecting the two mentioned rice varieties to parboiling process. In addition, the alkali spreading values remain, without significant changes as a results of using different packaging materials or storage period. Quick cooking parboiled brown rice of Giza 182 variety had the lowest gel consistency in comparing to the other rice samples. However, parboiling and storage for 9 months at 25 $\pm$ 2ºC led to decrease in the viscosity of rice flour. Dealing with data presented in this study it can be concluded that storage of rice grains in polyethylene plus carton at room temperature was superior compared to those of polyethylene ad polystyrene cup in terms of maintaining storage stability, which in turn play an active role for improving the export of Egyptian rice over-seas, hence, increase the national income and finally develop the Egyptian economy.

INTRODUCTION

Rice is considered one of the most important cereal crop in the Afro-Asian continents. Whereas, it constitutes the essential food of over half (54 percent) of the worlds population. In addition, this crop is very important not only for local consumption, but also for exportation (El-Abd, 1999). In Egypt, rice is considered a stable food after wheat and the second export crop after cotton. Tungtrakul and Hasegawa (1998) used low density polyethylene (PE), nylon (Ny), polyvinylidene chloride coated nylon (KNy) and aluminum laminated (Al) for packaging and storing of rice at 10, 20 and 30ºC. When gas permeability is concerned, Al film gave the lowest permeability

especially, with respect of aroma retention. But Al not allow to moisture and oxygen transfer. Moreover, moisture generated by respiration and onset of anaerobic respiration led to undesirable odor to develop. Therefore, Al cannot be practically used. Out of the other three films, it was found that O_2 permeability of PE is 242 times greater than KNy and 76 times greater than Ny. KNy scored the highest when tested for flavor by sensory panels after 6 months of storage. A major deterrent that face the maximum utilization of brown rice is its short shelf life which reach only 3-6 months because of the rancid off flavors and off-odors that improved very quickly in this rice as its oil rapidly deteriorates (Chrastil, 1994). Quick-cooking rice requires significantly less cooking time than raw milled rice, (15 to 20 minutes). Various methods are employed to fissure raw rice or to dry cooked rice to produce a porous structure. Dry-heat methods include heating milled and brown rice at 77 to 82^{o}C for 10 to 30 minutes or at 272^{o}C for 17.5 seconds to fissure the grain (Juliano and Sakurai, 1985). Parboiling is a hydrothermal process in which the crystalline form of starch changed into an amorphous one due to the irreversible swelling and fusion of starch (Abou-Gharbia *et al.*, 1990). The major determinations of storage risk are moisture, temperature, and type of storage bags and time of store. Hong *et al.* (1994) stated that, milled rice grains, which packed in polyethylene bags with vacuum of CO_2 or air and stored at different temperatures, did not changed significantly during 12 months of storage. In addition, properties of cooked rice were improved when stored at 5-10^{o}C than at ambient temperature. Storage decreases cohesiveness, increases the volume of cooked rice and results in firmer texture (Chrastil, 1994). The present work was carried out to study the effect of some packaging materials (polyethylene, polyethylene plus carton and polystyrene cup and storage time at room temperature 25 $\pm$ 2^{o}C on the physical and technological properties of raw, parboiled and quick cooking rice varieties [Sakha 101 (Japonica) and Giza 182 (Indica)].

MATERIALS AND METHODS

Materials:

1. Two varieties of Egyptian rice (*Oryza sativa* L.) namely Sakha 101 (short grain japonica) and Giza 182 (long grain Indica) were employed in this study. They were selected paddy or white type of rice of higher grain production per feddan. Rice samples were obtained from the Rice Research and Training Center (RRTC) that located in Sakha at the Governorate of Kafr El-Sheikh, Egypt. Upon collecting rice samples, they were transferred to the Laboratory of Food Science and Technology Department, Faculty of Agriculture Kafr El-Sheikh, University, Egypt.
2. Three different types of packaging materials were used for packaging rice samples (brown, milled, parboiled brown, parboiled milled, quick cooking brown, quick cooking milled, quick cooking parboiled brown and quick cooking parboiled milled rice grains of the two tested (Sakha 101 and Giza 182) varieties). These types of packaging materials were polyethylene, polyethylene plus carton and polystyrene cup. The packaged rice samples

were stored at room temperature (that varied from 28 ± 2 to 20 ± 2 during summer and winter time, respectively) for nine months. Representative samples were withdrawn at regular intervals (once a month) for further technological and analytical processing.

Methods:

1. **Preparation of parboiled paddy rice:**
   Parboiled rice were prepared following the procedure of Singh *et al.* (1999), modified by boiling the samples at 100°C for 20 minutes, then steamed under pressure (1.5 kg/cm^2) at 121°C for 15 minutes. Parboiled rice was dried in an air oven at 55°C until constant weight was reached.
2. **Preparation of quick cooked rice:**
   Quick cooking process was carried out through three major steps: (soaking, cooking and drying) as described by Damir (1991).
3. **Physical and technological properties of rice samples:**
   Water uptake and sedimentation values at 77°C and 82°C were determined following procedures of Simpson *et al.* (1965). Furthermore, alkali spreading value was performed using the method described by Bhatttacharya and Sowbhagya (1980). Gel consistency was performed as described by Cagampang *et al.* (1973), where Kernel Elongation percentage of rice grain was measured using the method of Tomar (1985). On the other hand, pasting viscosity of rice flour was carried out using Brabender amylograph as described by A.A.C.C. (1995) procedures.

Statistical analysis:

Data of physical and technological properties were subjected to analysis of variance and the means were further tested using the least significant difference test (LSD) as outlined by Stell and Torrie (1980).

RESULTS AND DISCUSSIONS

Physical and technological properties of different treated varieties of brown and white rice were carried out to figures out the natural and qualities of the rice grain samples (Sakah 101 and Giza 182).

Water uptake value at 77°C and 82°C:

The values of water uptake for different rice samples at 77°C and 82°C are presented in Tables (1, 2, 3 and 4). It should be noted from these tables that, water uptake values at 77°C and 82°C were higher in white rice samples than those of brown rice one. This may be related to the removal of protein, lipids and minerals from brown rice samples, thus the decrease in water uptake that occurred at 82°C was relatively higher than that of 77°C, regardless to the rice varieties. Dharmaputra (1997) found that, water uptake could be easily bound by carbohydrate compared to lipid or protein. Apparent also from the same tables that, water uptake whether at 77°C or 82°C was decreased as a function of parboiling process for all rice samples. Furthermore, quick cooking white rice of Sakha 101 had relatively the highest water uptake value at 77°C and 82°C among all of the tested rice samples. In this relations, Lee *et al.* (1995) reported that, cooking time reflects the water

absorption. Furthermore, faster rate of water uptake indicts a shorter cooking time. However, water uptake increased during storage for all cooked rice samples. On the other hand, quick cooking of white rice (Sakha 101 variety) exhibited the highest water uptake at 82°C when stored in polyethylene plus carton for 9 months (520 ml HOH/100 g samples). The obtained results are in line with those reported by (Farag *et al*., 1996 and Perdon *et al*., 1997).

El-Kady and El-Hissewy (1999) reported that amylose dispersion that decrease on storage, is responsible for greater absorption and retention of water, hence resulting in the expansion value of rice grain.

Table (1): Changes in water uptake of raw, quick cooking parboiled and quick cooking parboiled brown rice of Sakha 101 variety at 77 and 82°C during storage for 9 months at room temperature.

Treatments	Storage period (month)	Water uptake at 77°C (ml HOH/100 g rice)			Water uptake at 82°C (ml HOH/100 g rice)		
		PE	PE + C	PSC	PE	PE + C	PSC
Raw rice		** *	** *	** *	** *	** *	** *
	0	230 o	230 o	230 o	282 o	282 o	282 o
	1	252 n	259 L	256 m	314 n	323 L	317 m
	2	267 k	277 i	272 j	336 k	352 i	341 j
	3	279 h	293 f	286 g	355 h	376 f	362 g
	6	307 c	318 a	306 c	380 e	408 a	391 c
	9	295 e	312 b	300 d	376 f	403 b	385 d
Quick cooking rice	0	252 n	252 n	252 n	310 o	310 o	310 o
	1	277 m	286 k	280 L	339 n	348 L	342 m
	2	295 j	311 h	300 i	361 k	377 i	366 j
	3	310 h	331 e	317 g	380 h	401 e	384 g
	6	331 e	358 a	341 c	395 f	433 a	416 c
	9	327 f	353 b	336 d	401 e	428 b	410 d
Parboiled rice	0	223 n	223 n	223 n	256 L	256 L	256 L
	1	238 m	244 k	241 L	279 k	285 k	282 k
	2	252 j	262 h	257 i	295 j	306 h	301 i
	3	264 g	278 e	271 f	311 g	325 e	318 f
	6	280 e	302 a	290 c	331 d	352 a	340 c
	9	278 e	293 b	287 d	328 de	346 b	337 c
Quick cooking parboiled rice	0	232 m	232 m	232 m	277 n	277 n	277 n
	1	255 L	264 k	258 L	304 m	313 k	307 L
	2	271 j	287 h	276 i	324 j	340 h	329 i
	3	284 h	305 de	291 g	341 h	362 ef	348 g
	6	303 e	330 a	313 c	364 e	392 a	375 c
	9	299 f	326 b	308 d	360 f	387 b	369 d

PE: Polyethylene PE + C: Polyethylene plus carton PSC: polystyrene cup.
**** Each value was an average of three determinations.**
***** Values followed by the same letter in column are not significantly different at P < 0.05**

Table (2): Changes in water uptake of raw, quick cooking parboiled and quick cooking parboiled white rice of Sakha 101 variety at 77 and 82°C during storage for 9 months at room temperature.

Treatments	Storage period (month)	Water uptake at 77°C (ml HOH/100 g rice)			Water uptake at 82°C (ml HOH/100 g rice)		
		PE	PE + C	PSC	PE	PE + C	PSC
		** *	** *	** *	** *	** *	** *
Raw rice	0	262 o	262 o	262 o	317 p	317 p	317 p
	1	288 n	294 L	291 m	347 o	353 m	350 n
	2	307 k	317 i	312 g	369 L	380 g	375 k
	3	324 h	338 f	331 g	390 i	405 j	398 h
	6	346 e	367 c	355 d	416 f	438 d	426 e
	9	366 c	391 a	376 b	439 c	465 a	451 b
Quick cooking rice	0	287 b	287 b	287 b	348 o	348 o	348 o
	1	318 o	327 m	321 n	383 n	392 L	386 m
	2	340 L	356 j	345 k	409 k	425 i	414 j
	3	359 i	380 g	366 h	432 h	453 f	439 g
	6	384 f	411 c	394 e	416 j	489 c	472 e
	9	405 d	438 a	417 b	486 d	520 a	499 b
Parboiled rice	0	254 o	254 o	254 o	294 o	294 o	294 o
	1	280 n	286 L	383 m	324 n	330 L	327 m
	2	299 k	309 i	304 j	346 k	357 i	352 j
	3	316 h	330 f	323 g	367 h	382 f	375 g
	6	338 e	359 c	347 d	393 e	415 c	403 d
	9	358 c	383 a	368 e	416 c	442 a	428 d
Quick cooking parboiled rice	0	265 p	265 p	265 p	316 p	316 p	316 p
	1	296 o	305m	299 n	351 o	360 m	354 n
	2	318 L	334 j	323 k	377 L	393 j	382 lk
	3	337 i	358 g	344 h	400 i	421 g	407 h
	6	362 f	389 c	372 e	429 f	457 c	440 e
	9	383 d	416 a	395 b	454 d	488 a	467 b

PE: Polyethylene PE + C: Polyethylene plus carton PSC: polystyrene cup.
**** Each value was an average of three determinations.**
***Values followed by the same letter in column are not significantly different at P < 0.05**

Table (3): Changes in water uptake of raw, quick cooking parboiled and quick cooking parboiled brown rice of Giza 182 variety at 77 and 82°C during storage for 9 months at room temperature.

Treatments	Storage period (month)	Water uptake at 77°C (ml HOH/100 g rice)			Water uptake at 82°C (ml HOH/100 g rice)		
		PE	PE + C	PSC	PE	PE + C	PSC
		** *	** *	** *	** *	** *	** *
Raw rice	0	202 p	202 p	202 p	244 b	244 b	244 b
	1	220 o	227 m	224 n	296 k	285 n	271 o
	2	236 L	246 j	241 k	287 m	298 j	293 L
	3	249 i	263 g	256 h	304 i	319 j	312 h
	6	267 e	288 a	276 c	326 e	348 a	336 c
	9	265 f	283 b	273 d	323 f	342 b	333 d
Quick cooking rice	0	217 n	217 n	217 n	265 o	265 o	265 o
	1	240 m	249 k	243 L	294 n	303 L	297 m
	2	258 j	274 h	263 i	316 k	332 i	321 j
	3	273 h	294 e	280 g	335 h	356 f	342 g
	6	294 e	321 a	304 c	360 e	388 a	371 c
	9	290 f	317 b	297 d	356 f	382 b	365 d
Parboiled rice	0	190 n	190 n	190 n	220 p	220 p	220 p
	1	208 k	215 m	212 L	243 o	249 m	246 n
	2	221 j	232 h	227 i	259 L	270 j	265 k
	3	232 h	247 ef	240 g	274 i	289 g	282 h
	6	248 e	270 a	258 c	294 e	316 a	304 c
	9	246 f	265 b	255 d	291 f	310 b	301 d
Quick cooking parboiled rice	0	199 o	199 o	199 o	239 o	239 o	239 o
	1	222 n	231 L	225 m	266 n	275 L	269 m
	2	238 k	254 h	243 j	286 k	302 i	291 j
	3	251 i	272 e	258 g	303 i	324 f	310 h
	6	270 e	297 a	280 c	326 e	354 a	337 c
	9	266 f	293 b	275 d	322 g	351 b	331 d

PE: Polyethylene PE + C: Polyethylene plus carton PSC: polystyrene cup.
**** Each value was an average of three determinations.**
***Values followed by the same letter in column are not significantly different at P < 0.05**

Table (4): Changes in water uptake of raw, quick cooking parboiled and quick cooking parboiled white rice of Giza 182 variety at 77 and 82°C during storage for 9 months at room temperature.

Treatments	Storage period (month)	Water uptake at 77°C (ml HOH/100 g rice)			Water uptake at 82°C (ml HOH/100 g rice)		
		PE	PE + C	PSC	PE	PE + C	PSC
		** *	** *	** *	** *	** *	** *
Raw rice	0	227 o	227 o	227 o	274 o	274 o	274 o
	1	252 n	258 L	255 m	303 n	309 L	306 m
	2	271 k	281 i	276 j	325 k	336 i	331 j
	3	288 h	302 f	295 g	346 h	361 f	354 g
	6	310 e	331 c	319 d	372 e	394 c	382 d
	9	330 c	355 a	340 b	395 c	417 a	407 d
Quick cooking rice	0	245 b	245 b	245 b	301 k	301 k	301 k
	1	274 o	283 m	277 n	334 j	342 h-j	337 ij
	2	296 L	312 j	301 k	360 f-i	375 fg	365 f-h
	3	315 i	336 g	322 h	383 ef	403 de	390 f
	6	340 f	367 c	350 e	412 d	439 bc	423 cd
	9	361 d	394 a	373 b	437 bc	470 a	450 ab
Parboiled rice	0	222 o	222 o	222 o	272 n	272 n	272 n
	1	247 n	253 L	250 m	301 L	292 m	304 k
	2	266 k	276 i	271 j	323 i	319 j	329 h
	3	283 h	297 f	290 g	344 j	344 j	352 f
	6	305 e	326 c	314 d	370 e	377 d	380 c
	9	325 c	350 L	335 ab	393 b	404 a	405 a
Quick cooking parboiled rice	0	223 p	223 p	223 p	269 p	269 p	269 p
	1	252 o	261 m	255 n	302 o	311 m	305 n
	2	274 L	290 j	279 k	328 L	344 j	333 k
	3	293 i	314 g	300 h	351 i	372 g	358 h
	6	318 f	345 c	328 e	380 f	408 c	391 e
	9	339 d	372 a	351 b	405 d	439 a	418 b

PE: Polyethylene PE + C: Polyethylene plus carton PSC: polystyrene cup.
**** Each value was an average of three determinations.**
***** Values followed by the same letter in column are not significantly different at P < 0.05**

Sedimentation value at 77°C and 82°C:

Sedimentation values are interrelated with water uptake. The sedimentation test is a measure of the insoluble solids lost in the treating solution (cooking solution) at a specified temperature. The results in Tables (5, 6, 7 and 8) indicated that, sedimentation values at 77°C and 82°C were higher in white rice samples than those of brown rice. Furthermore, sedimentation values at 82°C were higher than those of 77°C for different rice treatments and varieties. Considerable reduction was recorded upon subjecting the different rice varieties to parboiling process, the reduction in sedimentation values that occurred at 82°C was higher than that at 77°C. However, Gariboldi (1974) found that, raw rice samples had more dissolved solids than that of the parboiled ones. Moreover, parboiled brown rice of Giza 182 had the lowest sedimentation value among all of the tested rice treatments (7.3 ml sed./100 g rice). sedimentation values decreased during storage for all of the cooked rice samples. These results may be due to the amount of amylose which was soluble in boiling water and decreased during storage of rice. These results probably reflect the increase in water insolubility of rice starch and protein during aging as reported by (Zhout *et al.*, 2002). Results indicate that the highest percentages of means for sedimentation values were recorded for control samples (zero time). Generally, the reduction of sedimentation value of rice samples was relatively higher when storage was carried out in polyethylene than those of polystyrene cup and polyethylene plus carton. The obtained values are found to be in the range of that reported by Biliaderis *et al*. (1993) and Ohtsubo *et al*. (1993).

Table (5): Changes in sedimentation value of raw, quick cooking parboiled and quick cooking parboiled brown rice of Sakha 101 variety at 77 and 82ºC during storage for 9 months at room temperature.

Treatments	Storage period (month)	Sedimentation value at 77ºC (ml sed./100 g rice)			Sedimentation value at 82ºC (ml sed./100 g rice)		
		PE	PE + C	PSC	PE	PE + C	PSC
		** *	** *	** *	** *	** *	** *
Raw rice	0	14.5 a	14.5 a	14.5 a	17.9 a	17.9 a	17.9 a
	1	14.2 ab	14.3 ab	14.2 ab	17.6 ab	17.7 ab	17.5 ab
	2	13.5 bc	13.8 ab	13.6 ab	16.7 cd	17.0 bc	16.9 bc
	3	12.5 d	12.7 cd	12.6 cd	15.5 ef	16.0 de	15.8 ef
	6	11.9 d-f	12.4 d	12.1 de	14.5 gh	15.4 ef	15.1 fg
	9	11.0 f	11.7 d-f	11.3 ef	13.6 i	14.6 gh	14.2 hi
Quick cooking rice	0	15.6 a	15.6 a	15.6 a	19.1 a	19.1 a	19.12 a
	1	15.2 a	15.3 a	15.2 a	18.8 ab	18.8 ab	18.7 b
	2	14.4 ab	14.7 ab	14.5 ab	17.8 c	18.1 c	18.0 c
	3	13.3 bc	13.7 bc	13.4 bc	16.5 ef	17.0 d	16.8 de
	6	12.6 cd	13.1 cd	12.8 cd	15.4 h	16.3 fg	16.0 g
	9	11.6 d	12.3 d	11.9 d	14.4 j	15.4 h	15.0 i
Parboiled rice	0	9.8 a	9.8 a	9.8 a	11.3 a	11.3 a	11.3 a
	1	9.6 ab	9.7 ab	9.6 ab	11.1 ab	11.1 ab	11.0 a-c
	2	9.0 a-c	9.3 a-c	9.1 a-c	10.3 d	10.6 cd	10.5 d
	3	8.1 b-d	8.5 b-d	8.2 b-d	9.2 fg	9.7 e	9.5 ef
	6	7.6 cd	8.1 cd	7.8 cd	8.3 i	9.2 fg	8.9 gh
	9	6.8 d	7.5 d	7.1 a	7.4 j	8.5 hi	8.1 i
Quick cooking parboiled rice	0	10.5 a	10.5 a	10.5 a	12.5 a	12.5 a	12.5 a
	1	10.2 a	10.3 a	10.2 a	12.2 a	12.2 a	12.1 a
	2	9.5 ab	9.8 ab	9.6 ab	11.3 b	11.6 b	11.5 b
	3	8.5 bc	8.9 bc	8.6 bc	10.1 de	10.6 c	10.4 cd
	6	7.9 c	8.4 c	8.1 c	9.1 f	10.0 de	9.7 e
	9	7.0 c	7.7 c	7.3 c	8.2 g	9.2 f	8.8 f

PE: Polyethylene PE + C: Polyethylene plus carton PSC: polystyrene cup.

**** Each value was an average of three determinations.**

*** Values followed by the same letter in column are not significantly different at P < 0.05**

Table (6): Changes in sedimentation value of raw, quick cooking parboiled and quick cooking parboiled white rice of Sakha 101 variety at 77 and 82ºC during storage for 9 months at room temperature.

Treatments	Storage period (month)	Sedimentation value at 77ºC (ml sed./100 g rice)			Sedimentation value at 82ºC (ml sed./100 g rice)		
		PE	PE + C	PSC	PE	PE + C	PSC
		** *	** *	** *	** *	** *	** *
Raw rice	0	16. 5a	16.5 a	16.5 a	19.2 a	19.2 a	19.2 a
	1	16.0 a	16.2 a	16.1 a	18.5 bc	18.8 b	17.6 d
	2	15.4 ab	15.6 ab	15.4 ab	17.5 d	18.2 c	16.8 e
	3	14.1 bc	14.6 bc	14.3 b	16.25 f	17.0 e	14.5 h
	6	13.0 cd	13.9 cd	12.4 cd	15.3 g	16.0 f	13.3 j
	9	11. 8d	13.1 d	12.3 d	14.0 i	14.8 h	12.9 k
Quick cooking rice	0	17.2 a	17.2 a	17.2 a	20.1 a	20.1 a	20.1 a
	1	16.4 a	17.0 a	16.9 a	19.5 ab	19.7 ab	19.6 ab
	2	16.1 ab	16.3 ab	16.1 ab	18.6 b-d	19.2 a-c	18.9 a-d
	3	14.7 bc	15.2 bc	14.9 bc	17.3 e-g	18.1 c-e	17. 7d-f
	6	13.6 cd	14.4 cd	13.8 cd	16.5 fg	17.2 e-g	16.6 fg
	9	12.3 d	13.5 d	12.8 a	15.2 h	16.1 gh	15.4 i
Parboiled rice	0	10.8 a	10.8 a	10.8 a	12.4 a	12.4 a	12.4 a
	1	10.4 a	10.6 a	10.5 a	11.8 b	12.0 ab	11.9 ab
	2	9.9 ab	10.1 ab	9.9 ab	10.9 b-d	11.5 bc	11.2 cd
	3	8.8 cd	9.2 bc	8.9 bc	9.7 g	10.4 ef	10.0 fg
	6	7.9 de	8.6 cd	8.1 de	8.7 h	9.5 g	8.9 h
	9	6.8 f	7.8 d-f	7.1 ef	7.5 i	8.4 h	7.6 i
Quick cooking parboiled rice	0	12.3 a	12.3 a	12.3 a	14.8 a	14.8 a	14.8 a
	1	11.8 ab	12.0 ab	11.9 ab	14.1 b	14.3 b	14.2 b
	2	11.2 b-d	11.4 a-c	11.2 b-d	13.1 e	13.7 c	13.4 d
	3	9.9 e	10.4 c-e	10.1 de	11.8 h	12.5 f	12.1 g
	6	8.5 f-h	9.7 ef	9.2 e-g	10.7 j	11.5 i	10.9 j
	9	7.7 h	9.2 e-g	8.1 gh	9.4 L	10.3 k	9.5 L

PE: Polyethylene PE + C: Polyethylene plus carton PSC: polystyrene cup.

**** Each value was an average of three determinations.**

*** Values followed by the same letter in column are not significantly different at P < 0.05**

Table (7): Changes in sedimentation value of raw, quick cooking parboiled and quick cooking parboiled brown rice of Giza 182 variety at 77 and 82ºC during storage for 9 months at room temperature.

	Storage period (month)	Sedimentation value at 77ºC (ml sed./100 g rice)			Sedimentation value at 82ºC (ml sed./100 g rice)		
		PE	PE + C	PSC	PE	PE + C	PSC
		** *	** *	** *	** *	** *	** *
Raw rice	0	11.5 a	11.5 a	11.5 a	14.2 a	14.2 a	14.2 a
	1	11.2 a	11.3 a	11.2 a	13.9 ab	13.9 ab	13.8 b
	2	10.5 ab	10.8 ab	10.4 ab	13.0 d	13.3 c	13.2 cd
	3	9.5 bc	9.9 bc	9.6 bc	11.8 f	12.3 e	12.1 e
	6	8.9 cd	9.4 cd	9.1 cd	10.8 h	11.7 f	11.4 g
	9	8.0 d	8.7 d	8.3 d	9.9 j	10.9 h	10.5 i
Quick cooking rice	0	12.3 a	12.3 a	12.3 a	15.5 a	15.5 a	15.5 a
	1	11.9 b	12.0 ab	11.9 b	15.1 ab	15.1 ab	15.0 b
	2	11.1 c	11.4 c	11.2 c	14.1 c	14. 4c	14.3 c
	3	10.0 e	10.4 d	10.1 de	12.8 ef	13.3 d	13.1 de
	6	9.3 gh	9.8 ef	9.5 fg	11.7 h	12.6 fg	12.3 g
	9	8.3 gh	9.0 h	8.6 fg	10.7 i	11.7 h	11.3 h
Parboiled rice	0	7.3 a	7.3 a	7.3 a	8.2 a	8.2 a	8.2 a
	1	7.1 a-c	7.2 ab	7.1 a-c	8.0 ab	8.0 ab	7.9 ab
	2	6.5 d	6.8 b-d	6.6 cd	7.2 c	7.4 bc	7.4 bc
	3	5.6 ef	6.0 e	5.7 ef	6.1 de	6.5 d	6.4 d
	6	5.1 g	5.6 ef	5.3 fg	5.2 fg	6.0 de	5.8 ef
	9	4.3 h	5.0 g	4.6 h	4.4 h	5.3 fg	4.9 gh
Quick cooking parboiled rice	0	7.8 a	7.8 a	7.8 a	9.0 a	9.0 a	9.0 a
	1	7.5 a-c	7.6 ab	7.5 a-c	8.7 ab	8.7 ab	8.6 ab
	2	6.8 de	7.1 b-d	6.9 cd	7.8 cd	8.1 bc	8.0 bc
	3	5.8 fg	6.2 ef	5.9 fg	6.6 ef	7.1 de	6.9 e
	6	5.2 g-i	5.7 fg	5.4 gh	5.6 g	6.5 ef	6.2 fg
	9	4.3 j	5.0 hi	4.6 ij	4.7 h	5.7 g	5.3 gh

PE: Polyethylene PE + C: Polyethylene plus carton PSC: polystyrene cup.
**** Each value was an average of three determinations.**
***Values followed by the same letter in column are not significantly different at P< 0.05**

Table (8): Changes in sedimentation value of raw, quick cooking parboiled and quick cooking parboiled white rice of Giza 182 variety at 77 and 82ºC during storage for 9 months at room temperature.

	Storage period (month)	Sedimentation value at 77ºC (ml sed./100 g rice)			Sedimentation value at 82ºC (ml sed./100 g rice)		
		PE	PE + C	PSC	PE	PE + C	PSC
		** *	** *	** *	** *	** *	** *
Raw rice	0	14.9 a	14. 9a	14.9 a	17.4 a	17.4 a	17.4 a
	1	14.5 ab	14.6 ab	14.5 ab	16.7 b	16.9 ab	16.8 ab
	2	13.9 a-d	14.0 a-c	13.8 b-d	15.7 d	16.4 bc	16.0 cd
	3	12.7 ef	13.0 de	12.7 ef	14.4 fg	15.1 e	14.7 ef
	6	11.7 g	12.3 e-g	11.8 fg	13.5 h	14.1 g	13.5 h
	9	10.5 h	11.5 g	10.7 h	12.2 i	13.4 gh	12.1 i
Quick cooking rice	0	15.2 a	15.2 a	15.2 a	17.8 a	17.8 a	17.8 a
	1	14.8 a	15.0 a	14.9 a	17.2 bc	17.4 ab	17.5 ab
	2	14.3 ab	14.5 ab	14.3 ab	16.3 e	16.9 cd	16.8 d
	3	13.1 c-e	13.6 bc	13.3 cd	15.1 g	15.8 f	15.6 f
	6	12.2 ef	13.0 c-e	12.5 de	14.3 h	14.9 h	14.5 h
	9	11.1 g	12.3 ef	11.5 fg	13.1 j	13.8 i	13.2 j
Parboiled rice	0	9.2 a	9.2 a	9.2 a	10.6 a	10.6 a	10.6 a
	1	8.8 ab	9.0 ab	8.9 ab	10.0 bc	10.2 ab	10.1 bc
	2	8.3 bc	8.5 ab	8.3 bc	9.1 e	9.7 cd	9.4 de
	3	7.1 de	7.6 cd	7.3 de	7.9 g	8.6 f	8.1 g
	6	6.2 fg	7.0 d-f	6.5 ef	6.9 h	7.7 g	7.0 h
	9	5.1 h	6.2 fg	5.5 e-h	5.7 i	6.6 h	5.7 i
Quick cooking parboiled rice	0	10.2 a	10.2 a	10.2 a	12.3 a	12.3 a	12.3 a
	1	9.9 b	9.9 b	9.8 b	11.6 b	11.8 b	11.7 b
	2	9.1 c	9.3 c	9.1 c	10.6 d	11.2 c	10.9 cd
	3	7.8 ef	8.3 d	8.0 de	9.3 fg	10.0 e	9.6 f
	6	6.8 g	7.6 f	7.1 g	8.2 h	9.0 g	8.4 h
	9	5.6 i	6.7 g	6.0 h	6.9 j	7.8 i	7.0 j

PE: Polyethylene PE + C: Polyethylene plus carton PSC: polystyrene cup.
**** Each value was an average of three determinations.**
***** Values followed by the same letter in column are not significantly different at P < 0.05**

Alkali spreading value:

Alkali spreading value is used as an inverse indicator of gelatinization temperature of rice starch granules. The gelatinization temperature is the temperature at which the starch granule begins to swell irreversibly in hot water with a simultaneous loss of crystallite (Irshad, 2001). Results of the alkali spreading. Results given in Tables (9 and 10) showed that, alkali spreading value of brown rice of the two tested varieties had lower values in comparing with white rice ones.

Table (9): Changes in alkali spreading values of raw, quick cooking, parboiled and quick cooking parboiled brown and white rice of Sakha 101 variety during storage for 9 months at room temperature.

Treatments	Storage period (month)	Brown rice						White rice					
		PE		PE + C		PSC		PE		PE + C		PSC	
Raw rice	0	4.5**	N.S	4.5**	N.S	4.5**	N.S	6.0**	N.S	6.0**	N.S	6.0**	N.S
	1	4.5		4.5		4.5		6.0		6.0		6.0	
	2	4.5		4.5		4.5		6.0		6.0		6.0	
	3	4.5		4.5		4.5		6.0		6.0		6.0	
	6	4.0		4.0		3.5		5.5		5.5		5.5	
	9	3.5		3.5		3.5		5.0		5.0		5.0	
Quick cooking rice	0	6.0	N.S	6.0	N.S	6.0	N.S	7.0	N.S	7.0	N.S	7.0	N.S
	1	6.0		6.0		6.0		7.0		7.0		7.0	
	2	6.0		6.0		6.0		7.0		7.0		7.0	
	3	6.0		6.0		6.0		7.0		6.5		7.0	
	6	5.5		5.5		5.5		6.5		6.5		6.5	
	9	5.0		5.5		5.0		6.0		6.0		6.5	
Parboiled rice	0	3.5	N.S	3.5	N.S	3.5	N.S	5.0	N.S	5.0	N.S	5.0	N.S
	1	3.5		3.5		3.5		5.0		5.0		5.0	
	2	3.5		3.5		3.5		5.0		5.0		5.0	
	3	3.5		3.5		3.5		5.0		5.0		5.0	
	6	3.0		3.0		3.0		4.5		4.5		4.5	
	9	2.5		2.5		2.5		4.0		4.0		4.0	
Quick cooking parboiled rice	0	5.0	N.S	5.0	N.S	5.0	N.S	6.0	N.S	6.0	N.S	6.0	N.S
	1	5.0		5.0		5.0		6.0		6.0		6.0	
	2	5.0		5.0		5.0		6.0		6.0		6.0	
	3	5.0		4.5		4.5		6.0		6.0		6.0	
	6	4.5		4.5		4.5		5.5		5.5		5.5	
	9	4.0		4.0		4.0		5.0		5.0		5.0	

PE: Polyethylene PE + C: Polyethylene plus carton PSC: polystyrene cup.
**** Each value was an average of three determinations.**
N.S. Not significant

As for brown rice, it seems to be require a longer time to cook. Moreover, the alkali spreading values decreased after subjecting the two mentioned rice varieties to parboiling process. These results may be due to the variation in terms of processing conditions for the rice varieties as clarified by Takano (1980). The resistance of parboiled rice to disperse in the alkali test may be related to the hardness of the grain as a result of the retrogradation that take place in gelatinized starch. The quick cooking white rice of the two tested varieties (Sakah 101 and Giza 182) had the highest values for alkali spreading values compared to the other rice samples. The alkali test value remains without changes in the different packaging materials

and during the first three months of storage. The obtained results are in agreement with those reported by Mutters (2000) and Teo *et al*. (2000).

Table (10): Changes in alkali spreading values of raw, quick cooking, parboiled and quick cooking parboiled brown and white rice of Giza 182 rice variety during storage for 9 months at room temperature.

Treatments	Storage period (month)	Brown rice						White rice					
		PE		PE + C		PSC		PE		PE + C		PSC	
Raw rice		**		**		**		**		**		**	
	0	4.5	N.S	4.5	N.S	4.5	N.S	6.0	N.S	6.0	N.S	6.0	N.S
	1	4.5		4.5		4.5		6.0		6.0		6.0	
	2	4.5		4.5		4.5		6.0		6.0		6.0	
	3	4.5		4.5		4.5		6.0		6.0		6.0	
	6	4.0		4.0		4.0		5.5		5.5		5.5	
	9	3.5		3.5		3.5		5.5		5.5		5.5	
Quick cooking rice	0	5.5	N.S	5.5	N.S	5.5	N.S	7.0	N.S	7.0	N.S	7.0	N.S
	1	5.5		5.5		5.5		7.0		7.0		7.0	
	2	5.5		5.5		5.5		7.0		7.0		7.0	
	3	5.5		5.0		5.0		7.0		7.0		7.0	
	6	5.0		5.0		5.0		6.5		6.5		6.5	
	9	4.5		4.5		4.5		6.5		6.5		6.5	
Parboiled rice	0	3.5	N.S	3.5	N.S	3.5	N.S	4.5	N.S	4.5	N.S	4.5	N.S
	1	3.5		3.5		3.5		4.5		4.5		4.5	
	2	3.5		3.5		3.5		4.5		4.5		4.5	
	3	3.5		3.5		3.5		4.5		4.5		4.5	
	6	3.0		3.0		3.0		4.5		4.5		4.5	
	9	3.0		3.0		3.0		4.0		4.0		4.0	
Quick cooking parboiled rice	0	5.0	N.S	5.0	N.S	5.0	N.S	6.0	N.S	6.0	N.S	6.0	N.S
	1	5.0		5.0		5.0		6.0		6.0		6.0	
	2	5.0		5.0		5.0		6.0		6.0		6.0	
	3	5.0		5.0		5.0		6.0		6.0		6.0	
	6	4.5		4.5		4.5		5.5		5.5		5.5	
	9	4.5		4.5		4.5		5.5		5.5		5.5	

PE: Polyethylene PE + C: Polyethylene plus carton PSC: polystyrene cup.
**** Each value was an average of three determinations.**
N.S. Not significant

Gel consistency (mm):

Gel consistency of rice is classified as hard (26 to 40 mm); medium (41 to 60 mm) and soft (61 to 100 mm) as reported by Cagampang *et al.* (1973). Data presented in Tables (11 and 12) show that, gel consistency in brown rice decreased in comparing with white rice. Moreover, gel consistency content decreased after subjecting the brown and white rice to parboiling process. Quick cooking parboiled brown rice variety of Giza 182 had the lowest gel consistency content (76.5 mm) in comparing with the other rice samples. However, gel consistency decreased with prolonging storage period. Gel consistency shows a slight hardening effect, particularly for medium gel samples, during progressive aging for several months (Perez and Juliano, 1981). These results are in accordance with those found by (El-Kady and El-Hissewy, 1999; Wiset *et al.,* 2001 and Tan and Corke, 2002).

Table (11): Changes in gel consistency of raw, quick cooking, parboiled and quick cooking parboiled brown and white rice of Sakha 101 rice variety during storage for 9 months at room temperature.

Treatments	Storage period (month)	Brown rice			White rice		
		PE	PE + C	PSC	PE	PE + C	PSC
		** *	** *	** *	** *	** *	** *
Raw rice	0	90.5 a	90.5 a	90.5 a	95.5 a	95.5 a	95.5 a
	1	89.5 b	89.6 b	89.0 bc	94.3 b	94.0 b	93.0 d
	2	88.0 d	88.8 c	88.0 d	93.5 c	93.0 d	92.5 c
	3	87.3 e	88.0 d	87.4 de	92.0 f	91.5 g	91.0 h
	6	85.5 fg	85.8 f	85.0 g	90.2 i	90.0 i	89.1 j
	9	82.3 i	83.0 h	82.5 hi	88.5 k	88.3 k	86.2 L
Quick cooking rice	0	85.0 a	85.0 a	85.0 a	90.0 a	90.0 a	99.0 a
	1	84.0 b	84.1 b	84.3 b	88.5 c	89.5 ab	89.1 b
	2	82.3 cd	82.5 c	82.0 cd	87.3 d	88.2 c	88.0 c
	3	81.8 d	82.0 cd	81.7 d	86.5 e	87.3 d	87.5 d
	6	79.5 ef	79.8 e	79.1 f	85.0 g	85.8 f	86.0 f
	9	76.9 g	77.2 g	76.3 h	83.2 i	82.9 i	84.2 h
Parboiled rice	0	83.0 a	83.0 a	83.0 a	89.0 a	89.0 a	89.0 a
	1	81.9 b	82.0 b	81.5 c	88.0 b	87.2 c	88.0 b
	2	80.3 g	81.1 d	80.5 f	86.4 d	86.0 de	86.3 d
	3	78.7 i	80.8 e	80.0 h	85.5 e	84.9 f	84.8 f
	6	76.5 k	78.7 i	77.6 j	84.0 g	83.3 h	83.1 h
	9	73.7 n	76.0 L	75.1 m	81.7 j	82.5 i	81.2 j
Quick cooking parboiled rice	0	78.0 a	78.0 a	78.0 a	87.0 a	87.0 a	87.0 a
	1	76.7 b	76.8 b	76.2 c	85.8 bc	86.2 b	85.4 c
	2	74.8 e	757 d	74.8 e	84.7 d	84.9 d	84.0 e
	3	73.9 f	74.5 e	74.0 f	83.6 e	84.1 e	83.1 f
	6	71.7 h	72.1 g	71.3 i	82.0 h	82.5 g	81.5 i
	9	69.1 jk	69.3 j	68.8 k	79.8 jk	80.1 j	79.5 k

PE: Polyethylene PE + C: Polyethylene plus carton PSC: polystyrene cup.

**** Each value was an average of three determinations.**

*** Values followed by the same letter in column are not significantly different at P < 0.05**

Table (12): Changes in gel consistency of raw, quick cooking, parboiled and quick cooking parboiled brown and white rice of Giza 182 variety during storage for 9 months at room temperature.

Treatments	Storage period (month)	Brown rice			White rice		
		PE	PE + C	PSC	PE	PE + C	PSC
		** *	** *	** *	** *	** *	** *
Raw rice	0	86.0 a	86.0 a	86.0 a	92.0 a	92.0 a	92.0 a
	1	85.0 b	85.1 b	84.5 b	91.1 c	91.5 b	91.0 c
	2	83.5 c	84.3 b	83.5 c	90.2 d	90.0 d	90.0 d
	3	83.0 e	83.5 c	83.3 c	89.4 e	89.5 e	89.2 e
	6	81.6 d	80.5 e	80.0 e	87.3 g	88.0 f	87.0 g
	9	78.2 f	77.5 f	78.0 f	84.9 i	86.0 h	85.2 i
Quick cooking rice	0	80.0 a	80.0 a	80.0 a	86.0 a	86.0 a	86.0 a
	1	78.9 ab	79.0 ab	77.4 cd	84.8 bc	85.4 ab	85.0 bc
	2	77.3 cd	78.1 bc	77.3 cd	83.5 d-f	84.3 cd	83.9 de
	3	76.7 d	77.2 cd	76.7 d	82.9 fg	83.6 d-f	83.2 e-g
	6	74.5 e	74.8 e	74.2 e	81.5 i	82.0 hi	81.6 i
	9	71.6 f	72.1 f	71.5 f	79.0 j	79.3 j	79.4 j
Parboiled rice	0	81.0 a	81.0 a	81.0 a	88.0 a	88.0 a	88.0 a
	1	80.0 b	80.1 b	79.5 c	87.1 c	87.4 b	87.2 c
	2	78.5 e	79.0 d	78.5 e	86.2 de	86.3 d	86.0 e
	3	78.0 f	78.4 e	77.0 g	85.1 g	85.7 f	85.1 g
	6	76.5 h	77.0 g	75.5 i	83.6 i	84.1 h	83.3 j
	9	73.5 k	74.0 j	72.6 L	82.4 k	81.3 L	80.4 m
Quick cooking parboiled rice	0	76.5 a	76.5 a	76.5 a	79.0 a	79.0 a	79.0 a
	1	75.2 b	75.3 b	74.7 c	77.9 c	78.2 b	77.8 c
	2	74.4 d	74.2 e	73.4 f	76.8 d	76.9 d	76.4 e
	3	73.5 f	73.1 g	72.6 h	75.6 g	76.1 f	75.5 g
	6	71.5 i	71.1 j	71.5 i	74.1 i	74.5 h	74.0 i
	9	69.0 m	69.6 k	69.2 L	72.0 k	72.5 j	72.2 k

PE: Polyethylene PE + C: Polyethylene plus carton PSC: polystyrene cup.

**** Each value was an average of three determinations.**

*** Values followed by the same letter in column are not significantly different at P < 0.05**

Elongation (%):

Elongation percentage is defined as the ratio of length of cooked rice grain to the length of milled rice grain (El-Akary, 1992). The elongation percentages of cooked rice presented in Tables (13 and 14) show higher values for white rice than brown rice and short grain variety (Sakha 101) than that of long grain variety (Giza 182) for all treatments. This was expected because of the large amount of water that added to short grain samples. Moreover, the elongation percentage of quick cooking white rice of the Sakha 101 variety was the highest among all of the studied rice samples. Moreover, it was decreased upon subjecting rice to parboiling process. The decrement means were 73.9% and 69.4% for quick cooking white rice and quick cooking parboiled white rice of Sakha 101 variety, respectively. Hardness of rice seems to correlate negatively with its elongation percentage. Furthermore, elongation percentage increased by increasing the storage period. These results may be due to the changes in the branched fractions of starches that have great effect on elongation percentage (Chinnaswamy, 1993). These results are in accordance with those of Daniels *et al.* (1998) and Pearce *et al.* (2001).

Table (13): Changes in elongation percentages of raw, quick cooking, parboiled and quick cooking parboiled brown and white rice of Sakha 101 variety during storage for 9 months at room temperature.

Treatments	Storage period (month)	Brown rice			White rice		
		PE	PE + C	PSC	PE	PE + C	PSC
		** *	** *	** *	** *	** *	** *
Raw rice	0	69.1 h	69.1 h	69.1 h	72.1 h	72.1 h	72.1 h
	1	70.1 g	70.3 g	70.2 g	73.3 j	73.2 j	73.3 j
	2	71.4 f	71.8 f	71.6 f	74.7 f	74.9 f	74.7 f
	3	73.1 e	73.7 e	73.3 e	76.6 e	77.8 d	76.8 e
	6	76.4 d	77.4 c	76.8 cd	81.7 c	81.7 c	81.4 c
	9	79.9 b	81.4 a	80.5 b	85.5 b	86.5 a	85.8 b
Quick cooking rice	0	70.2 i	70.2 i	70.2 i	73.9 j	73.9 j	73.9 j
	1	71.3 h	71.4 h	71.4 h	75.1 i	75.1 i	75.1 i
	2	72.7 g	73.0 g	72.9 g	76.6 h	76.7 h	76.7 h
	3	74.4 f	74.9 f	74.7 f	78.6 g	78.9 f	78.7 fg
	6	77.5 e	78.9 d	78.3 d	83.3 e	83.9 d	83.5 e
	9	80.2 c	83.1 a	82.2 b	87.8 c	88.8 a	88.2 b
Parboiled rice	0	66.2 i	66.2 i	66.2 i	68.3 h	68.3 h	68.3 h
	1	67.1 h	69.3 h	67.2 h	69.3 g	69.5 g	69.4 g
	2	68.3 f	68.7 f	68.5 fg	70.6 f	60.9 f	70.4 f
	3	70.0 e	70.6 e	70.2 e	72.3 e	72.8 e	72.5 e
	6	73.1 d	74.1 c	73.5 cd	76.9 d	77.8 c	77.1 d
	9	76.0 b	77.9 a	76.5 b	81.0 b	82.1 a	81.4 b
Quick cooking parboiled rice	0	66.9 h	66.9 h	66.9 h	69.4 i	69.4 i	69.4 i
	1	67.9 g	68.1 g	68.0 g	70.6 h	70.5 h	70.6 h
	2	69.2 f	69.6 f	69.2 f	72.0 g	72.2 g	72.0 g
	3	70.9 e	71.5 e	71.0 e	73.9 f	74.2 f	74.0 f
	6	74.2 d	75.1 c	74.7 cd	78.1 e	79.0 d	78.5 de
	9	77.7 b	78.8 a	77.3 b	81.7 c	83.8 a	83.1 b

PE: Polyethylene PE + C: Polyethylene plus carton PSC: polystyrene cup.

**** Each value was an average of three determinations.**

*** Values followed by the same letter in column are not significantly different at P < 0.05Z**

Table (14): Changes in elongation percentages of raw, quick cooking, parboiled and quick cooking parboiled brown and white rice of Giza 182 variety during storage for 9 months at room temperature.

Treatments	Storage period (month)	Brown rice			White rice		
		PE	PE + C	PSC	PE	PE + C	PSC
		** *	** *	** *	** *	** *	** *
Raw rice	0	58.0 h	58.0 h	58.0 h	63.1 i	63.1 i	63.1 i
	1	59.0 h	59.2 h	59.0 h	64.3 h	64.3 h	64.2 h
	2	60.3 fgh	60.7 ab	59.9 gh	65.7 g	65.8 g	65.6 g
	3	62.0 efg	62.6 c-f	62.3 d-g	67.4 f	67.8 f	67.5 f
	6	64.4cde	65.1 bc	64.8 cd	71.2 e	72.1 d	71.6 e
	9	67.5 ab	68.7 a	69.0 a	75.3 c	76.6 a	76.0 b
Quick cooking rice	0	59.3 i	59.3 i	59.3 i	65.1 i	65.1 i	65.1 i
	1	60.4 g	60.5 h	60.3 h	66.2 h	66.3 h	66.3 h
	2	61.5 g	62.0 g	61.8 g	67.5 g	67.8 g	67.7 g
	3	63.3 f	63.9 f	63.5 f	69.2 f	69.8 e	69.5 ef
	6	65.9 e	66.8 d	67.3 a	73.6 d	74.5 c	74.0 cd
	9	69.2 c	70.6 b	69.9 bc	79.0 ab	79.2 a	78.6 b
Parboiled rice	0	54.0 g	54.0 g	54.0 g	57.2 g	57.2 g	57.2 g
	1	54.9 f	55.0 f	54.0 g	58.1 fg	58.4 fg	58.2 e-g
	2	56.1 e	56.3 e	56.0 e	59.3e-g	59.8 d-g	59.5 e-g
	3	57.7 d	58.0 d	57.8 d	61.0 d-g	61.5 c-g	61.2 c-g
	6	60.0 c	60.9 c	60.3 c	64.9 a-e	65.8 a-c	65.4 a-d
	9	63.0 b	64.1 a	63.5 ab	68.6 ab	70.0 a	69.5 a
Quick cooking parboiled rice	0	54.9 j	54.9 j	54.9 j	58.1 h	58.1 h	58.1 h
	1	55.8 i	56.0 i	55.8 i	59.1 g	59.3 g	59.2 g
	2	56.9 h	57.3 h	57.0 h	60.4 f	60.8 f	60.6 f
	3	58.5 g	59.0 f	58.7 g	62.1 e	62.7 e	62.3 e
	6	61.4 e	62.2 d	61.6 c	65.4 d	67.2 c	66.6 c
	9	64.6 c	66.0 a	64.9 b	70.3 b	71.4 a	71.0 ab

PE: Polyethylene PE + C: Polyethylene plus carton PSC: polystyrene cup.
**** Each value was an average of three determinations.**
***** Values followed by the same letter in column are not significantly different at P < 0.05Z**

Pasting characteristics of rice flour:

Pasting characteristics of the tested rice samples are presented in Table (15). The values of transmission point, temperature at maximum viscosity ^{o}C, viscosity at 95^{o}C, viscosity at 50^{o}C and set back viscosity increased after parboiling for rice variety (Giza 182) by about (69-81^{o}C and 79.5-82.5^{o}C); (94.5-94.5 and 91.5-94.5^{o}C); (555-630 and 320-530 B.U); (1000-1090 and 875-920 B.U) and (200-540 and 330-430 B.U); respectively. In addition, maximum viscosity decreased after parboiling the two rice varieties by about (800-550 and 545-490 B.U), respectively. The drop in starch paste viscosity was occurred as a function of cooking at 94^{o}C may clarify the degree of disintegration of gelatinization granules as reported by (Zhout *et al*., 2002). The viscosity of the cooked starch pastes cooked at 50^{o}C may clarify the degree of reassociation (retrogradation) of amylose (Singh et al., 1990). The difference in viscosity value that recorded between

hot paste and paste cooled at 50°C may be referred to the set back value as reported by (Singh *et al.,* 1990). From the amylograph curves for the flour of the tested rice variety (Giza 182), which stored from 0 to 9 moths, it should be observed that, there was a reduction in transmission point, maximum viscosity, temperature at maximum viscosity, and viscosity at 95°C and viscosity at 50°C. These changes may be occurred as a function of several factors such as contribution of a starch granule associated with protein or changes in cell wall compounds in addition to the changes in the rice starch itself (Yamamoto and Shirakawa, 1999). Finally and based on the aforementioned results it can be concluded that, storing of rice grains in polyethylene plus carton at room temperature is superior then those stored in polyethylene or polystyrene cup in terms of maintaining storage stability, which in-turn play an active role for improving the export of Egyptian rice over-seas, hence, increase the national income and finally develop the Egyptian economy.

Table (15): Changes in pasting characteristics of raw, quick cooking, parboiled and quick cooking parboiled brown and white rice of Giza 182 variety during storage for 9 months at room temperature.

Nnnnnnnnnnnn	Storage period (month)	T.P. °C	Maximum viscosity B.U	Temp. at maximum viscosity °C	Viscosity at 95°C B.U	Viscosity at 50°C B.U	Set back viscosity B.U.
Brown rice	0	69.0	800	94.5	555	1000	200
	9	61.5	435	88.5	315	730	295
Quick cooking brown rice	0	69.0	1790	93.0	1420	2085	295
	9	61.5	440	88.5	350	850	410
Parboiling brown rice	0	81.0	550	94.5	630	1090	540
	9	63.0	485	91.5	365	800	315
Quick cooking parboiling brown rice	0	66.0	640	94.5	900	1580	940
	9	63.0	460	90.0	360	615	155
White rice	0	79.5	545	91.5	320	875	330
	9	63.0	400	88.5	315	500	100
Quick cooking white rice	0	76.5	510	92.5	355	610	100
	9	58.5	490	88.5	370	830	340
Parboiling white rice	0	82.5	490	94.5	530	920	430
	9	60.0	445	87.0	350	545	100
Quick cooking parboiling white rice	0	82.5	560	94.5	590	1040	480
	9	60.0	400	87.0	310	500	100

T.P.: Transmission point °C **B.U.: Brabender unit**

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تـأثير بعـض ظـروف التخـزين علـى الخـواص الطبيعيـة والتكنولوجيـة لـلأرز الخـام والمغلى والمطبوخ طبخا سريعا

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أجرى هذا البحث لدراسة بعض الظروف التخزينيه على الأرز الخام والمغلى والمطبوخ طبخا سريعا مثل التخزين على فترات (كل ١ ، ٢ ، ٣ ، ٦ و ٩ شهرا) واستخدام مواد تعبئة مختلفة (البولى إيثيلين والبولى إيثيلين + كرتون والبولى إستيرين) لتعبئة الأرز الخام والمغلى والمطبوخ طبخا سريعا للمحافظة على صفات الأرز الطبيعية والتكنولوجية ، واستخدم فى هذا البحث صنفان من الأرز هما سخا ١٠١ (صنف يابانى) وجيزه ١٨٢ (صنف هندى) وهذان الصنفان يتم زراعتهما فى محافظة كفرالشيخ ، كما تم الحصول على العينات من مركز تدريب الأرز من محصول عام ٢٠٠١م ، وتم معاملة الصنفين بالغلى. كما تم إجراء الطهى السريع لكل من الأرز البنى والأبيض الخام والمغلى لكل من الصنفين ، وتم تخزين عينات الأرز على درجة حرارة الغرفة لمدة تسعة شهور.

وفيما يلى ملخص لنتائج هذه الدراسة:

وجدت اختلافات فى الخواص الطبيعية للأرز البنى والأبيض ، وترجع هذه الاختلافات تبعا للصنف المختبر. وقد أثرت عملية ضرب الأرز على الخواص الطبيعية له. ووجدت اختلافات فى قيم الماء الممتص والمواد الصلبة الغير ذائبة للأرز البنى والأبيض المطبوخ طبخا سريعا للأرز المغلى والغير مغلى على درجتى حرارة ٧٧°م ، ٨٢°م تبعا للصنف والمعاملة. وكانت قيمة الماء الممتص على درجة حرارة ٧٧°م ، ٨٢°م عالية فى الأرز الأبيض المطبوخ طبخا سريعا لصنف سخا ١٠١ عند مقارنتها بباقى العينات. كما وجد أن عملية الغلى تقلل من نسبة احتواء الماء عند درجتى حرارة ٧٧°م ، ٨٢°م وكذلك تقلل من المواد الصلبة الغير ذائبة على نفس درجتى الحرارة. إضافة لما سبق وجد أيضا أن عملية التخزين تزيد من نسبة الماء الممتص وتقلل من المواد الصلبة الغير ذائبة بالنسبه لكل العينات موضع الدراسة. اختلفت قيم انتشار القلوى لحبوب الأرز البنى والأبيض والمطبوخ طبخا سريعا المغلى والغير مغلى تبعا للصنف والمعاملة. كما وجد أن قيم انتشار القلوى قد انخفضت بعد عملية الغلى وتزيد بعد عملية الطهى السريع. وجد أيضا أن عملية التخزين والعبوات لا تؤثر معنويا على قيم انتشار القلوى. اختلفت قيم تماسك الجبلى لحبوب الأرز البنى والأبيض والمطبوخ طبخا سريعا للأرز المغلى والخام. فكانت فى الصنف جيزه ١٨٢ البنى المغلى أقل من باقى العينات ، كما وجد أن سيولة الجبلى قد انخفضت بعد عملية الغلى وكذلك أثناء فترات التخزين. اختلفت قيم استطالة الحبوب بعد الطهى فى عينات الأرز المختلفة. فكانت فى الأرز الأبيض المطبوخ فى الصنف سخا ١٠١ أعلى عن باقى العينات ، كما وجد أن عملية الغلى أدت إلى انخفاض استطالة الحبوب بعد الطهى كما تزيد استطالة الحبوب خلال فترات التخزين. وجد أن عملية الغلى أدت إلى انخفاض لزوجة مطحون الأرز عن الخام وكذلك التخزين يقلل من لزوجة مطحون الأرز (المغلى والخام).

وقد اتضح من هذه الدراسة أن تخزين حبوب الأرز فى عبوة (البولى إيثيلين + كرتون) تعد أفضل من التخزين فى عبوات البولى إيثيلين أو البولى إستيرين وذلك من ناحية ثبات صفات الحبوب الطبيعية والتكنولوجية للتخزين. بالإضافة إلى أن تخزين الأرز فى صورة أرز مغلى أو المطبوخ طبخا سريعا يكون أفضل من ناحية ثبات حبوب الأرز للتغيرات فى صفاتها الطبيعية والتكنولوجية.

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