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Effect of microwave and air drying of parboiled rice on stabilization of rice bran oil

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RESUMEN

Efecto del secado en microondas y al aire de arroz precocido sobre la estabilización de aceite de salvado de arroz.

Dos variedades de arroz, Giza 175 (grano corto) y Giza 181 (grano largo) se precocieron mediante la puesta en remojo de los granos a temperatura ambiente durante 20 horas y cocimiento al vapor durante 15 minutos, luego se secaron a temperatura ambiente o por microondas. Los resultados indicaron que el secado al aire y en microondas aumentó significativamente la extracción del aceite en ambas variedades de salvado de arroz. El precocido seguido del secado al aire o en microondas produjo un cambio pequeño en el contenido en proteína, fibra y ceniza y redujo el desarrollo de ácidos grasos libres (F.F.A.) en el aceite de salvado. Las muestras secadas en microondas tuvieron un menor contenido en F.F.A. que las muestras correspondientes al secado en aire. Aceites de salvado de arroz almacenado en frío presentaron menor F.F.A. que los almacenados a temperatura ambiente. La relación entre ácidos grasos insaturados totales y los saturados totales (Tu/Ts) disminuyó después del secado al aire y en microondas. Los resultados también mostraron que el secado al aire aumentó la relación de los hidrocarburos totales y esteroles totales (Tu/Ts) en ambas variedades mientras que en microondas la disminuyó.

PALABRAS-CLAVE: Aceite de salvado de arroz — Arroz precocido — Secado al aire (efecto del) — Secado en microondas (efecto del).

SUMMARY

Effect of microwave and air drying of parboiled rice on stabilization of rice bran oil.

Two rice varieties, Giza 175 (short grain) and Giza 181 (long grain) were parboiled by soaking the grains at room temperature for 20 hours and steaming for 15 min then dried either at room temperature or by microwave. The results indicated that air and microwave drying significantly increased oil extraction in both rice bran varieties. Parboiling followed by air or microwave drying produced a slight change on protein, fiber and ash content of rice bran and reduced the development of free fatty acids (F.F.A.) in oil bran. Microwave samples have less F.F.A. content than the corresponding samples air dried. Oils from the cold stored rice bran presented lower F.F.A. than the corresponding oil bran stored at room temperature. The ratio between total unsaturated fatty acids and total saturated ones (Tu/Ts) decreased after air and microwave drying. Results also show that air drying increased the ratio of total hydrocarbons and total sterols (Tu/Ts) in both varieties while microwave decreased it.

KEY-WORDS: Air drying (effect of) — Microwave drying (effect of) — Parboiled rice — Rice bran oil.

1. INTRODUCTION

Rice is one of the major cereal crops of Egypt. Rice bran is a by-product rice milling that has proved to be quite remunerative since it is a source of edible oil. The total rice production in Egypt is approximately 24 million tons per year. It gives about 20 thousand tons rice bran which contains about 2000 tons of oil.

Oil processing activity is not controlled. However, the rate of free fatty acid formation in rice bran is very high, up to 5-10% in a day and about 70% in a month under high humidity (Desikachar, 1977). Chemicals and fumigants were relatively ineffective in inactivating the lipase of rice bran, and only heat application was a suitable safety method.

Parboiling with steaming for 5-10 min inactivates lipase but not during the soaking step (Viraktamath and Desikachar, 1971). Steaming freshly harvested raw rice for 5-10 min also inactivates lipase. Lipase is inactivated completely by autoclaving rice bran for 3-20 min or by parboiling (Kratzer and Payne, 1977). The location of the lipase in the peripheral testa cross layer of the rice grain may explain the more efficient heat inactivation of rough rice as compared to that of rice bran, which has a fluffy nature (Viraktamath and Desikachar, 1971).

Velupillai *et al.* (1989) processed parboiling by soaking rough rice then subjecting it to sufficient microwave energy to partially gelatinize the starch component and increase the water content, draining and finally subjecting the rice to further microwave energy to effect total gelatinization and lower the water content.

Ajayi and Agun (1989) studied the effect of parboiling on some quality parameters of rice included grain breakage, swelling capacity and test water absorption ratio. For a 16-h steeped paddy, results showed favourable parboiling conditions with an acceptable product at 65-75°C soaking temperature and steaming times between 90 and 110 min.

Palipane and Swarnasiri (1985) observed that oil content of parboiled rice bran was higher on an average by 26% than raw rice bran. However, parboiling had no significant effect on the protein, fiber and ash content of bran.

Padua and Juliano (1974) explained the higher oil content of bran from parboiled rice as due to the hard endosperm with greater resistance to milling resulting in a bran fraction with lower endosperm contamination.

Shaheen *et al.* (1975) studied the effect of parboiling on the rate of lipid hydrolysis during longterm storage and they found that parboiling of rice reduced the development

of free fatty acids (F.F.A.) in the bran oil. The value of the parboiling process in reducing the rate of F.F.A. development is somewhat offset by the loss in resistance to oxidation, as was evident from an increase in the peroxide value for the parboiled samples .

Juliano (1977) found that the rice bran oil contained $C_{16:0}$ (12 - 28%), $C_{18:0}$ (1-4%), $C_{18:1}$ (40-50%), $C_{18:2}$ (16-38%) and $C_{18:3}$ (1-6%) while C_{12}, C_{14} and $C_{16:1}$ were found as a traces.

Yoon (1987) found that contents of polyunsaturated fatty acid of rice bran oil, e.g. linoleic acid were reduced more by heating than those of monounsaturated fatty acid e.g. oleic acid. Iodine value correlated very well with linoleic acid content.

Nasirullah, *et al.* (1989) studied the effect of acid, heat and cold stabilization on the quality characteristics of rice bran oil. They found that the major fatty acids obtained from the stabilized rice bran were myristic (1.2 - 3.3), palmitic (18 - 20.3), stearic (0.5 - 1.2), oleic (34 - 43.9), linoleic (31.0 - 35.7), linolenic (2.2 - 3.7) and arachidic (0.5 - 2.28 %).

Saunders (1990) found that bran contains 16-22% oil and this value was higher in parboiled bran (25 - 32%). Three major fatty acids, palmitic, oleic and linoleic, make up more than 90% of the total fatty acids. Crude bran oil extracted with hexane contains 4% unsaponifiable lipids which consist of sterols (ß - sitosterol, campesterol, and stigmasterol) 43% , triterpene alcohols 28%, 4-methyl sterol 10% and less polar compounds (squalene and other hydrocarbons and aliphatic alcohols) 19%, unsaponifiable material was higher in rice bran oil than in other vegetable oils. A considerable portion of the alcohol in this fraction (oryzanols) are esterified with ferulic acid. Tocopherols and ferulic acid esters are potent antioxidant, conferring good stability to the oil.

Anon (1991) found that rice bran oil contain high levels of phytosterol, tocopherols and 8 - oryzanol. These naturally occuring components impart a high resistance to thermal oxidation and deterioration.

The aim of the present investigation is to study the influence of microwave and air drying of parboiled rice on the stabilization of rice bran oil.

2. MATERIALS AND METHODS

Parboiling and Milling of Rice Samples

Two rough rice varieties, one short grain (Giza 175), and one long grain (Giza 181) were parboiled by soaking the grain at room temperature (25°C ± 2) for 20 hours. Water was drained and rice spread in small wire-mesh trays; then steamed for 15 min under a pressure of 1.5 kg /cm² and temperature 120°C. The steamed rice was dried by using two method: (a) Drying at room temperature (25°C ± 2) to a proper moisture content, generally ranging from 12 - 14% as Shaheen *et al* (1975). (b) Drying in microwave drayer for 3 min. The microwave oven Model RFS 510 SE (U.S.A.) was used. The oven was operated at full power 2250 W, 2450 MHz. A control for each variety was carried out without treating (soaking or heating). The samples were then milled in a Universal Laboratory mill to separate bran makes up approximately (6 - 7%) of rough rice weight including polish . Moisture, protein (Nx6.25), oil, crude fiber and ash content in the rice bran were determined according to A.O.A.C. (1980).

Two methods for bran storage were used :

(a) Bran samples were stored in air-tight glass container at room temperature (25°C ± 2) and samples were weekly withdrawn according to the method described by Shaheen *et al* (1975).

(b) Cold storage of the rice bran was achieved by keeping the bran in polyethylene bags at 0°C in freezer. The bags were removed from the freezer every month and allowad to attain room temperature before analysis according to the method mentioned by Nasirullah *et al.* (1989).

Free fatty acid determination

The free fatty acid (F.F.A.) content of the extracted oil was used as an index of bran and oil deterioration and was determined weekly over a 3-month period according to the method of A.O. A.C. (1980).

Lipid extraction from rice bran

The lipid material was extracted from rice bran with n-hexane as described by Choudhury and Juliano (1980).

Separation of fatty acids and unsaponifiable matter

The lipid material was saponified, their unsaponifiable matter was extracted with ether and the fatty acids were collected after acidification. The free fatty acids were methylated with diazomethane following the method by Vogel (1975).

Determination of fatty acids and unsaponifiable matter

Fatty acids and unsaponifiable matter were determined using a Sigma 3 B gas chromatograph. The separation conditions were exactly as reported by Farag *et al.* (1985). Results were expressed as area percentage of the chromatograms.

3. RESULTS AND DISCUSSION

The effect of air and microwave drying after parboiling of rice on the chemical composition of rice bran is shown in Table I. The analysis of variance showed that air and microwave drying significantly* increased oil extraction in both rice bran varieties while microwave drying showed non significant increase in oil extraction than air drying .

* The least significant difference (L.S.D.) at the 5% level was calculated. Difference between the mean constituent value was compared with the L.S.D. value (0.76 for Giza 175 variety and 0.27 for Giza 181 variety) according to Snedecor & Cochran (1967).

Parboiling with both air and microwave drying gave slight change on protein, crude fiber and ash content of rice bran for the two varieties.

Table I
Effect of drying conditions on the chemical composition of rice bran (on dry basis)

		Protein %	Oil %	Fibers %	Ash %
Giza 175	Control	13.12	19.85	10.05	11.67
	Air drying	13.79	23.00	10.11	13.04
	Microwave drying	13.47	23.54	9.35	12.99
Giza 181	Control	13.11	18.10	8.68	12.77
	Air drying	13.33	20.87	8.32	11.60
	Microwave drying	12.97	20.94	8.84	10.15

The results obtained in this work are generally parallel to those obtained by Siriwardane (1969) who observed that the oil content of parboiled rice bran is 39% higher than that of raw rice bran, even though no differences were observed in the content of ash and protein. The high oil content in parboiled bran is probably due to effective removal of oil rich bran layers from the hardened parboiled rice grain during milling , unlike in raw rice where portions of the soft endosperm, rich in starch, also get milled out into the bran. Beneditode and Barber (1977) found that differences in composition between raw and parboiled brans depend upon the degree of milling and parboiling conditions. Palipane and Swarnasiri (1985) determined the levels of protein, fat, crude fiber, starch and ash in bran obtained from raw and parboiled rice bran from three types of mills and observed that parboiling had no significant effect on the protein, fiber and ash content of rice bran.

Table II shows the effect of drying conditions of parboiled rice and storage of rice bran on free fatty acids (F.F.A.) content of oil bran.

Table II
Effect of drying conditions and storage on F.F.A. content of rice bran oil

Parboiling treatment	**Duration of storage (weeks) at room temperature**									
	1	2	3	4	5	6	7	8	9	10
Giza 175										
Control	5.96	16.81	23.40	25.26	30.02	32.05	34.50	36.20	38.59	75.53
Air drying	3.05	5.08	6.00	6.51	6.87	8.12	8.54	9.12	11.25	13.47
Microwave drying	1.92	2.45	3.30	3.75	4.10	4.13	4.29	4.42	7.19	10.01
Giza 181										
Control	7.61	17.17	24.50	26.56	30.60	31.89	33.15	34.22	35.12	62.84
Air drying	3.03	4.39	4.91	5.02	5.49	5.49	7.28	7.44	7.50	10.26
Microwave drying	2.14	2.73	3.67	4.13	4.76	5.06	5.20	5.40	6.51	7.76

	Duration of storage (months) at Zero °C			
	1	2	3	4
Giza 175				
Control	5.85	9.23	14.52	18.11
Air drying	2.81	3.27	5.98	6.93
Microwave drying	1.68	2.47	2.97	3.86
Giza 181				
Control	7.35	10.95	16.63	22.37
Air drying	2.53	3.09	4.00	4.74
Microwave drying	2.59	2.95	3.20	3.85

The F.F.A. content of bran control (without parboiling) increased from 5.96 to 75.53% in Giza 175 variety after 10 weeks stored at room temperature. The corresponding increase in oil bran was from 3.05 to 13.47% and from 3.3 to 10.01% by air and microwave drying, respectively.

In case of oil bran isolated from Giza 181 variety, the control showed an increase in F.F.A. from 7.6 to 62.04% while air and microwave drying showed an increase from 3.03 to 10.26 and from 2.14 to 7.76% respectively.

It is worth to note that the untreated samples resulted in highest F.F.A. which was about 5.6 and 7.55 times as high as that of air and microwave drying processes respectively. In Giza 175, while it was 6.12 and 8.1 times as high as that of air and microwave drying processes respectively for Giza 181.

Cold storage at 0°C showed that F.F.A. of control samples increased from 5.85 to 18.11% in Giza 175 variety within 4 months and from 7.35 to 22.37% for Giza 181. The corresponding oil from parboiled rice increased from 2.81 to 6.93 and from 2.53 to 4.74 for air drying and from 1.68 to 3.86 and from 2.59 to 3.85% for microwave drying for Giza 175, Giza 181 varieties respectively. It is evident from these results that parboiling of rice reduced the development of F.F.A. in bran oil and consequently, the deterioration of bran quality. F.F.A. content of microwaved samples was less than that of air dried samples.

From the above mentioned data, it could be stated that parboiling of rice followed by air or microwave drying reduce the F.F.A. of the extracted oil. Moreover, the storage under cooling condition resulted in reduction of F.F.A. by about 2 times less than storage at room temperature.

These results are in agreement with those of Shaheen *et al.* (1975) who found that parboiling of rice reduced the development of free fatty acids in the bran oil although the bran of parboiled rice can be stored as long as 10 months with only minor deterioration. The bran of untreated rice cannot be stored for more than 1 month without serious deterioration of oil and bran quality. Also Nasirullah and Najaraja (1989) found that the free fatty acid content of the oil obtained from the untreated rice bran or control increased from 4.8 to 20.3% within a 7 day period, the corresponding oils from rice bran which was stabilized by acid and heat and cold showed an increase only from 4.8 to 4.8 , 5.0 and 6.2 respectively.

Godber *et al.* (1993) found that both parboiling and extrusion stabilization reduced levels of free fatty acids compared to raw rice bran . Oxidative degradation was initially higher in parboiled rice bran, and increased during storage (32 weeks) to a greater degree in parboiled vs. extruded rice bran. Tao *et al.* (1994) found that the thermal efficiency of microwave heat stabilization of bran is greater than that of either dry or wet (steam) heating . Free fatty acid content increased from 4.0 to 4.9% in long grain rice bran and from 4.6 to 6.2% in medium grain rice bran during 4 weeks storage. Increases in untreated bran ranged from 4.0 to 68.3% and 4.6 to 56.8% for long and medium grain rice bran.

Table III shows the effect of air and microwave drying after parboiling on fatty acid composition of rice bran oil. It was observed that oleic and palmitic acid were the major constituent fatty acids while stearic and palmitoleic were minor constituents. It was also observed that palmitoleic, oleic and linoleic acid decreased in the two varieties after air and microwave drying. The decrease of palmitoleic was 2.02, 1%; oleic 1.33, 14.1%; linoleic 1.7, 0.74 % for Giza 175 and 3.15, 2.87% of palmitoleic; 26.57, 20.72% of oleic; 1.53, 1.51% of linoleic for Giza 181 after air and microwave drying respectively.

On the contrary palmitic acid increased by 3% and 3.62% by air and microwave drying respectively for Giza 175 compared with its control and increased by 3.2 and 1.44% for Giza 181 rice variety compared with its control.

Also, stearic acid increased by 1.74, 12.21% for Giza 175 and 18.85, 24.27% for Giza 181 after air and microwave drying compared with its control.

Table III

The effect of air and microwave drying of the relative percentage of fatty acid composition of rice bran oil

Fatty acid	Control		Air drying		Microwave drying	
	G.175	G.181	G.175	G.181	G.175	G.181
Palmitic	35.38	28.63	38.38	31.23	39.00	29.47
Palmitoleic	3.12	4.94	1.10	1.79	2.12	2.07
Stearic	1.46	6.32	3.20	25.17	13.67	30.59
Oleic	48.34	47.75	47.01	31.18	34.24	27.03
Linoleic	11.70	12.37	10.00	10.84	10.97	10.86
Tu/Ts*	**1.71**	**1.86**	**1.40**	**0.51**	**0.9**	**0.67**

*Tu/Ts refers to the ratio between the total unsaturated fatty acids to the saturated ones.

The ratio between the total unsaturated fatty acids and total saturated ones (Tu/Ts) decreased after air and microwave drying when compared with the untreated samples in the two varieties. This may be due to thermoxidative alteration during parboiling or microwave, and probably due to a reduction in the amount of natural antioxidants in rice bran after treating.

In general, palmitic, oleic and linoleic constitute the three major fatty acids. Our results are in agreement with those reported by Saunders (1990) who found that palmitic, oleic and linoleic acids make up more than 90% of the total fatty acids in rice bran oil. Also, Sakla *et al.* (1988) who found that linoleic and oleic acids were the most affected acids after 4 min of microwave treatment for soybean seeds. The relative percentage of linoleic acid decreased from 54.6 to 51.8 while that of oleic acid decreased from 24.1 to 19.0%.

Our results are supported by those of Krishnamurthy *et al.* (1985) who found that parboiling reduced iodine value which indicates the decrease of the degree of unsaturation.

Results in Table IV shows the unsaponifiable matter of rice bran oil (Giza 175 and Giza 181 varieties). It was observed that C_{28} constituted the highest percentage in the two varieties. C_{30} was the lowest constituent hydrocarbon in rice bran oil of Giza 175 while C_{18}, C_{21} and C_{26} were the minor components in Giza 181.

Results also show that air drying decreased C_{28} for the two varieties. The percentage of decreasing was 11.74 and 28.43% for Giza 175 and Giza 181, respectively. While microwave increased C_{28} in Giza 175 and decreased C_{28} in Giza 181. Air drying increased C_{30} from 0.12 to 2.42% in Giza 175 and from 1.22 to 4.09% in Giza 181, while microwave drying decreased C_{30} from 1.22 to 0.19 in Giza 181.

Results also show that air drying decreased stigmasterol and ß-sitosterol in the two varieties. While microwave increased campesterol from 0.12 to 2.11 in Giza 175 and from 0.34 to 0.43% in Giza 181, and stigmasterol from 2.30 to 6.32% in Giza 175 and from 2.03 to 4.09% in Giza 181, and ß-sitosterol from 5.52 to 14.75% in Giza 175 and from 5.14 to 9.54% in Giza 181.

Table IV
Effect of air and microwave drying on the relative percentage of unsaponifiable matter of rice bran oil

Unsaponifiable matter	Control		Air drying		Microwave drying	
	Giza 175	Giza 181	Giza 175	Giza 181	Giza 175	Giza 181
C 14	4.60	2.70	3.23	2.52	0.41	2.11
C 15	3.45	6.08	9.93	6.31	2.75	0.43
C 16	7.76	0.34	1.69	0.96	1.01	0.87
C 17	7.72	0.05	0.77	1.92	0.28	10.22
C 18	0.92	0.14	0.28	0.12	0.37	0.43
C 20	0.75	0.07	0.48	0.12	0.46	0.50
C 21	1.38	0.14	0.06	0.06	0.18	2.17
C 23	0.86	0.20	0.89	1.92	0.14	1.86
C 24	0.69	0.41	4.48	6.70	0.73	1.49
C 25	2.76	3.24	6.17	8.11	1.65	1.30
C 26	0.35	0.14	4.60	5.89	0.14	0.50
C 27	0.58	0.41	1.78	3.06	0.18	0.25
C 28	58.88	75.70	51.97	47.27	66.42	60.68
Squalene	0.58	0.90	0.48	1.02	0.73	1.42
C 30	0.12	1.22	2.42	4.09	0.23	0.19
C 32	0.35	0.54	4.28	7.39	1.10	1.49
Cholesterol	0.17	0.11	0.36	0.06	0.05	0.05
Campesterol	0.12	0.34	0.97	0.42	2.11	0.43
Stigmasterol	2.30	2.03	2.02	0.90	6.32	4.09
ß-sitosterol	5.52	5.14	2.91	2.28	14.75	9.54
Th /Ts	**11.3:1**	**12.1:1**	**14.94:1**	**26.63:1**	**3.3:1**	**6.1:1**

These results are in agreement with those of Fujino (1978) who mentioned that the most abundant constituent for sterol is ß-sitosterol.

Also, Saunders (1990) concluded that defatted rice bran did not significantly lower serum cholesterol and rice bran oil must contain minor components with strong hypocholesterolemic activity . Among compounds whose hypocholesterolemic activity oil components , ß-sitosterol is present in high concentration in rice bran oil compared to other oils. Tocotrienols are also present in high concentration. The unsaponifiable matter is well known to retard the oxidative rancidity.

It is worth to mention that the ratio between the total hydrocarbons to total sterols (Th/Ts) increased in both varieties after air drying the parboiled rice while microwave drying decreased it. Air drying may activate some chemical reactions, as hydrolysis of glycerides to glycerine and fatty acids, then this treatment mentioned activate oxidation of the unsaturated fatty acids separated from the hydrolysis and give organic acids of short chain. Also these fatty acids mentioned before may combine with sterols and form esters that may be compensated to energy, CO_2 and hydrocarbons.

No complete explanation can be offered to elucidate the discrepancies in the unsaponifiable composition due to the drying method.

It is concluded that oil deterioration can be prevented by stabilizing the bran (inactivating lipase) immediatly after milling , once the bran is stabilized it can be transported and stored for 30 - 60 days at ambient conditions without appreciable increase in F.F.A. content . Its high oxidative stability makes it preferred oil for frying and baking application.

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