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Effect of Pre-Thermal Treatments on Chemical Characteristics, Bioactive Compounds and Microstructure of Rice Bran.

Rania E. El-Gammal
Food Industries Department, Faculty of Agriculture, Mansoura University, 35516, Egypt

ABSTRACT

This work was carried out to determine the stability of commercially available rice bran samples subjected to different heat treatments using oven heating, microwave and steaming by autoclave. All rice bran samples were subjected to chemical and microstructure evaluation. Obtained results for chemical constituents indicated that moisture content was varied from 10.54 to 8.65 %. All protein content in stabilized rice bran samples did not exceed 18%, stabilized rice bran in oven had the highest ash content recording 4.8% in compare with the other samples. Microstructure analysis performed by scanning electron microscope SEM revealed that all stabilized rice bran samples have smooth, closed-celled structures. Results of bioactive compounds showed that total phenolic content of stabilized rice bran in oven exhibited the least content of total phenolics being 13.52 mg GAE/100g sample, while total flavonoids content (TFC) gradually decreased in all stabilized rice bran in compare with control. Results of HPLC detected the most abundant phenolic acids in all stabilized rice bran were Ferulic acid followed by Cinnamic acid. Also, gross chemical composition and fatty acid profile of oil extracted from different stabilized rice bran samples were determined. Results of acid value and free fatty acid (FFA%) content of untreated rice bran oil gradually increased from 0.15 to 0.31mg KOH /g and from 0.3 to 0.6%, respectively, while the changes in oxidation and rancidity parameters were decreased in all oil samples in compare with control one . also. Oryzanol content were decreased in all stabilized bran samples. Obtained results showed that total saturated fatty acids were ranged from 28.17 to 32.00 % in all oil samples, palmitic acid $C_{16:0}$ recorded the highest amount of total saturated fatty acids, the epidemic unsaturated fatty acid in all oil samples being oleic acid $C_{18:0}$,also adequate amount of essential fatty acids, linoleic acid $C_{18:2}$ ranged from 25.02 to 27.05 %.The minor amounts of linolenic $C_{18:3}$ not exceeded 0.08% in all rice bran oil sample in compare with 1.35 % in control sample. So, from the above mentioned data it could be concluded that thermal treatments caused an appreciable changes in total saturated and unsaturated fatty acids. Steaming using autoclave and irradiation by microwave appeared to be the most effective in stabilizing the rice bran for improving the stability of oil towards oxidation. Microwave and autoclaving treatment represented a practical tool for rice bran heat stabilization and reaps more advantage of oil compounds considered as a beneficial to human health.

Keywords: Rice bran, Thermal stability, Fatty acids profile, Phenolic and Flavonoid compounds.

INTRODUCTION

Rice (*Oryza sativa*) one of the most important cereal crops in the world, rice bran is a by-product from a rice milling . Rice bran obtained from the outer layer of rice produced during the polishing process of brown rice and contained 6–8% of the whole grain. It contains also valuable protein, fat, vitamins ,minerals and dietary fiber. In addition of bioactive phytochemicals compounds namely flavonoids, phenolic acids contains 4.2% unsaponifiable matter, which contains three different kinds of natural antioxidants of tocopherols, tocotrienols and oryzanol used in nutrition, pharmacy and cosmetics. (Sharma *et al* ., 2015 and Mariod *et al* .,2014).

Rice bran is rich in fatty acids and have an intensive lipase activity caused by the presence of lipoxygenases as endogenous enzymes due to immediate deterioration .Commercial use of rice bran required enzymatic inhibition suddenly after bran separation to avoid fatty acid hydrolysis and liberation , extend its shelf life and allow its safe marketing for human consumption (Paucar-Menacho *et al*., 2007).

Stabilization methods of rice bran could inhibit rancidity and prolong shelf life, selection of appropriate methods that are also able to preserve its nutrient compositions and become more challenging .Many treatments have been proposed to stabilize the rice bran by inactivating lipase (Saunders, 1990).

Rice bran oil (RBO) extracted from the inner shell of rice, and it is a rich source of commercially-important and have uniquely properties in containing bioactive phytochemicals used in nutrition, pharmacy and cosmetics. Rice bran oil contains 4.2% unsaponifiable matter, which contains three different kinds of natural antioxidants of tocopherols, tocotrienols and oryzanol (Perretti *et al.,* 2003). RBO contains a significantly high amount of ɤ- oryzanol. This substance composed a several kinds of bioactive phenolic acids namely ferulic acid esters , triterpene alcohols and sterols which has a similar effect of tocopherols (Anwar *et al*., 2005 and Usha and Premi, 2011)

So, the objective of this work was study comparing the effect of different thermal pre-treatments using heat from oven , microwave and autoclave as stabilization methods on the chemical , microstructure properties and bioactive compounds of rice bran and their effect on oil properties .

MATERIALS AND METHODS

Materials:

Rice bran: Fresh samples of rice bran (*Oryzastiva L.*) were obtained from local mill, EL-Mansoura city, Dakhaleia Governorate, Egypt.

All chemicals and reagents were purchased from El-Gomhouria Pharmaceutical Company, El-Mansoura City, El-Dakhaleia Governorate, Egypt.

Methods:

Stability process of rice bran: 1800 gram of rice bran were divided into three portions and sieved using particle size mesh less than 80,all rice bran samples were thermally stabilized to deactivate lipase activity with different three methods as follows:

- **Heat :** Rice bran was stabilized using electric oven at 90°C for an hour (Pan,*et al*., 2005).
- **Microwave:** Rice bran was stabilized using microwave oven at 550W output power for 3 min. at 120°C according to the method described by Ramezanzadeh,*et al*. (2000).

- **Steaming:** Rice bran was steamed using autoclave at 110°C for 5 min. as described by Saiwan *et al.*(2010).

Chemical indices of rice bran:

Moisture, crude fat and ash were determined according to the method described in AOAC (2005). crude protein was determined using micro-kjelahel method as described by AOAC (2000). Carbohydrate content was determined by the differences according to the following equation: [100 - (moisture% + ash% + fat% + crude protein%)].

Total dietary fiber were determined according to AOAC (2005).

Microstructure of rice bran samples:

Stabilized rice bran samples and control one were observed in JEOL(JSM 6510LV) scanning electron microscope (Tokyo-Japan) with a 25 - KV acceleration voltage. The samples were sputtered with gold before examination, micrographs at 1000 magnification were presented.

HPLC analysis of Phenolic compounds:

Phenolic compounds was performed with a high pressure liquid chromatography HPLC according to the method described by Waskmundzka *et al*. (2007).

Determination of total phenolic compounds and total flavonoids:

Folin-Ciocalteu method was used to estimate total phenolic compounds (as gallic acid equivalent) using standardized spectrophotometric method according to *Ivanova et al. (2010)*. Flavonoids were estimated by the method of AOAC (2000).

Evaluation of antioxidant activity rice bran:

DPPH radical scavenging activity was determined according to Mau, *et al*. (2004).The absorbance was then measured at 517 nm. using Spekol 11, Carl Zeiss Jena, German. The percent of DPPH discoloration of the samples was calculated according to the following equation:

Antiradical Activity% =Absorbance of control-absorbance of sample/ absorbance of control

Extraction of rice bran oil:

Extraction of rice bran oil was carried out using the Soxhlet method according to AOAC(1999).

Chemical indices of rice bran oil:

Acid (AV), Peroxide (PV) and Iodine(IV) values were determined as described in AOAC (2000).

p -Anisidine value (***p*** -AV) was determined according to the method in AOAC (1999). The p-Anisidine value (p-AV) is calculated by the following formula:

$$p\text{-AV} = 25 \times (1.2As - Ab) / m$$

The absorbance was then measured at 350 nm. Using Spekol 11, (Carl Zeiss Jena, Germany).

Where, As= absorbance of the fat solution after reaction with the p-Anisidine reagent.Ab = absorbance of the oil solution. m = weight of the oil sample.

Thiobarbituric acid value (TBA) was determined according to Pearson (1986)and was expressed as mg malonaldhyde/kg oil with the following equation:

$$TBA = 7.8 \times OD$$

Oxidative stability of rice bran oil:

Rancimat method was used to evaluate oxidative stability of rice bran oil according to AOAC (2005). Induction time refers to the time (hrs) at the break point of extrapolated of curve by Rancimat apparatus. The stability of oil was determined by Rancimat method using Rancimat Metrohm 679 and the induction period (IP) was conducted with Rancimat at 100°C.

Oryzanol content:

Oryzanol content of rice bran oil was determined by a spectrophotometric method (Gopal, *et al*., 2005)by dissolving 0.01 ml of the sample in 10 ml of hexane and reading the absorbance at 314 nm in a 1-cm cell (SPECTROUV-VISAUTO,UV-2602). The oryzanol content was calculated by using the formula: (A/W) × (100/358.9).

Where A is the absorbance of the sample, W is the weight of the sample in gram/100 ml, 358.9 is specific extinction coefficient for oryzanol.

Fatty acids composition of rice bran oil:

Fatty acids methyl esters (FAMS) of rice bran oil samples were performed according to the procedure of Radwan (1978).

Statistical analysis:

obtained results statically analyzed using analysis (ANOVA), while comparisons using Least Significant Difference test (LSD) at P.< 0.05 level of significance using SPSS (2008) version 17 program for windows

RESULTS AND DISCUSSION

Chemical indices of different stabilized rice bran samples:

Proximate chemical composition is one of the most important nutritional values for food to be considered as raw material for food products. Gross chemical composition of rice bran and stabilized samples is illustrated in Table (1). Obtained results indicated that moisture content varied from 8.65 to 10.54%, All protein content in stabilized rice bran samples did not exceed 18.00%.

Table 1. Gross Chemical constitutes of different stabilized rice bran samples.

Rice bran samples	Chemical constitutes					
	Moisture	Crude Protein	Ash	Carbohydrates	Crude fat	Dietary fibers
Control	10.54±0.01	16.81±0.03	4.2±0.01	47.34	21.11±0.1	26.72
Sample A	8.65±0.3	17.31±0.04	4.8±0.01	49.20	20.04±0.1	25.89
Sample B	9.01±0.01	17.65±0.02	4.3±0.02	47.48	21.56±0.2	26.67
Sample C	9.50±0.2	17.98±0.01	4.5±0.08	46.39	21.63±0.01	26.65

Sample A = stabilized rice bran in oven. Sample B= stabilized rice bran in microwave.
Sample C =stabilized rice bran in autoclave. Each value is the mean of three replicates ± SD

It was visually observed that rice bran samples with the lowest moisture content had loose and soft particles, while these samples with high moisture content had more agglutinated particles. Stabilized rice bran in oven had the highest ash content (4.8%) followed by stabilized rice bran in autoclave (4.5%), while stabilized rice bran in microwave had the lowest ash content being 4.3%.

Tabulated results also, indicated no significant changes in the crude fat content ranged from 20.04 to 21.11%, where the lowest one were detected in stabilized rice bran using oven (20.04%) and followed by the stabilized rice bran obtained from microwave (Table1). Total carbohydrates content ranged from 46.39 to 49.20% in stabilized rice bran in autoclave and in oven, respectively. The highest dietary fiber content (26.72%) was observed in bran obtained from oven, while all stabilized rice bran have nearly the same amount of dietary fiber.

These results were almost in agree with Singh and Sogi (2016), who stated that the changes in moisture content could be due to rice millers and also the effect of environmental and genetic factors. While, lower moisture content could be observed of microwave and autoclaving rice bran stabilized samples being (9.01 and 9.50%, respectively) in compared with control This could be due to the microwave and autoclaving process techniques itself During heating in microwave, water molecules have a turning rotation and absorb microwave energy, resulted in an increase in temperature and that way may reduction in moisture content (Nordin,*et al*.,2014).Also, it may be due to the different thermal processing treatments basics.

Effect of stability methods on the microstructure of rice bran samples :

Effect of stability methods on the microstructure of rice bran was presented in Figure (1). Microstructure analysis performed by scanning electron microscope SEM revealed that rice bran samples have different porous and open-celled structures for the three different pretreatments process of stabilization. In Figure(1),which is the micrograph of control sample showed that smooth large intact and aggregates were observed.Starch granules seemed to be emerged in gluten protein matrix and no detected holes could be observed. While, Microstructure showed disrupted of protein matrix on addition of bran stabilized in oven, highest temperature, damage and breaking in continuous symmetrical structure, surface were smooth, gathered of granules surface, small amounts of gaps could be observed.

Micrographs for stabilized rice bran by microwave, granules lost their shapes and it looks flat,bran particle shape adhering the structure, but an opened structure can be observed, the network cavities were larger than the other graphs,protein matrix also showed disrupted structure and separated granules. Micrograph for stabilized rice bran by autoclaving showed a clear gatherings between molecules,no holes could be observed in the surface and marked reduction in the amount of gaps, network cover the granules, opened structure couldn't be observed, granules aggregates, symmetrical structure of starch granules and protein matrix.

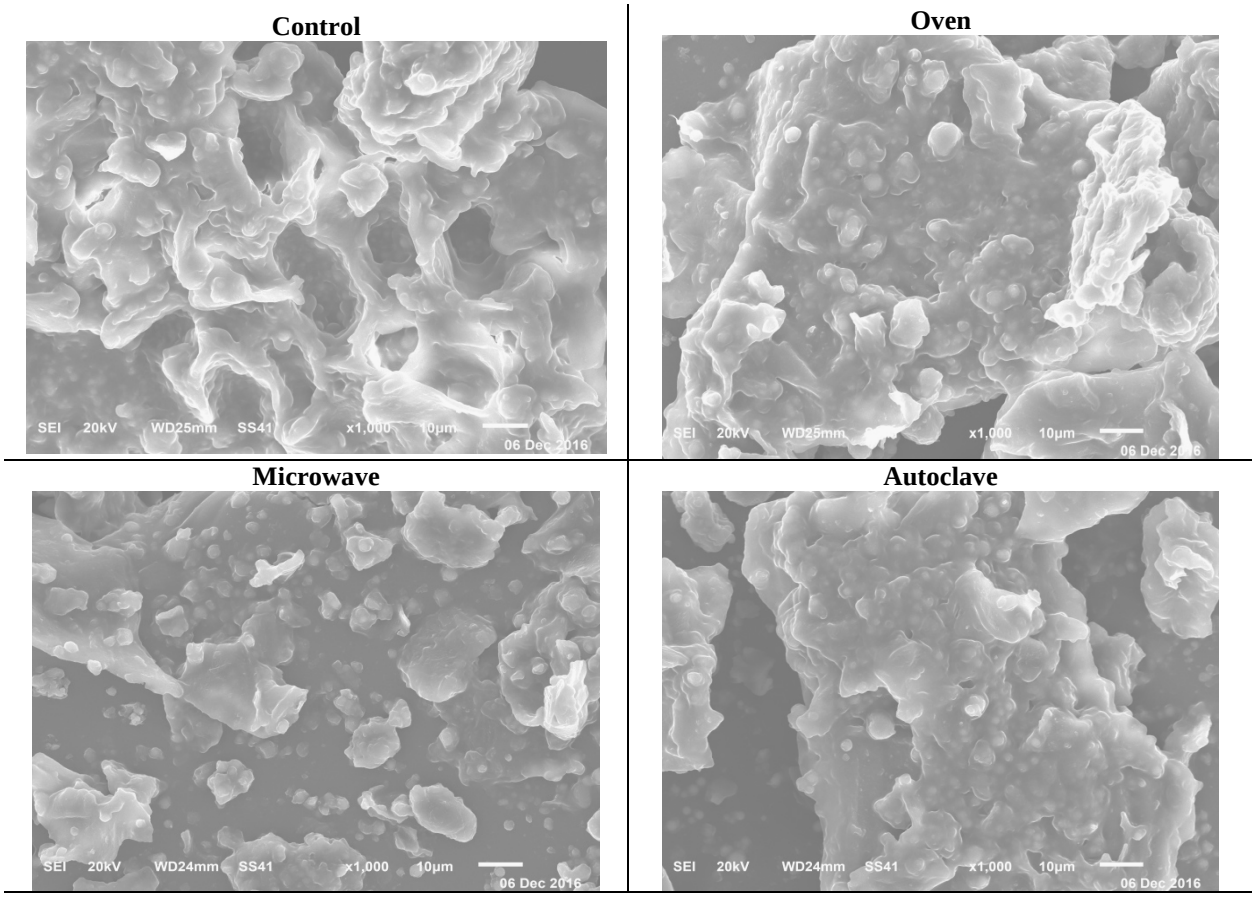

Figure 1. Effect of stability methods on the microstructure of rice bran.

This means that stabilization method resulted in great changes in the microstructure of rice bran . From microstructure examination , it could be concluded that thermal pretreatment in autoclave method more better

than the other ones which less structure changes were occurred .

Bioactive compounds of different stabilized rice bran samples :

- **Identification and fractionation of phenolic compounds in stabilized rice bran samples:**

Results of HPLC showed that about ten phenolic acids were identified in stabilized rice bran samples expect control sample, Sinapic acid and Ellagic acid were disappeared in oven one (Table 2). The most abundant phenolic acid found in all stabilized rice bran were Ferulic acid followed by Cinnamic acid, Ferulic and Cinnamic acid were 63.50 and 55.50% in control rice bran sample, respectively.While a considerable decrease could be observed in all stabilized rice bran sample in both phenolic acids namely Cinnamic and Ferulic, this decrease may be due to the different methods used in the stabilization of rice bran, which affect positively on the structure of phenolic acids(Zhou, *et al*., 2004 andMelissa and Marchesan 2011).

Table 2. Identification and fractionation of phenolic compounds in stabilized rice bran samples.

Phenolic compounds (mg/g)	Stabilized rice bran samples			
	Control	Oven	Microwave	Autoclave
Caffeic acid	1.04	0.78	0.86	0.99
Vanillic acid	0.75	0.23	0.55	0.62
Synirgnic acid	0.95	0.53	0.89	0.94
Sinapic acid	0.05	-	0.01	0.02
Cinnamic acid	55.50	42.31	52.04	53.26
Ferulic acid	63.50	55.33	60.11	62.89
Chlorogenic acid	0.68	0.23	0.52	0.41
p-coumaric acid	0.47	0.03	0.25	0.38
Ellagic acid	0.08	-	0.01	0.01
Protocatechuic acid	1.53	0.51	0.61	0.90

Minor constituents were also identified namely Caffeic, Chlorogenic, and Ellagic acids, each accounting was less than 1% of total phenolic acids in all stabilized rice bran samples .Besides all of this, it could be detected that there were decreasing amounts in total phenolic compounds in compared with control one, stabilized rice bran sample in oven reduced the (TPC) by 20% followed by microwave being 7.33% and by autoclave was 3.31%.Microwave and steaming treatments seem to have slightly changes in phenolic compounds in compared to heat by oven.

Table 3. Total phenolic compounds, total flavonoids and antioxidant activity% of different stabilized rice bran samples.

Rice bran samples	Total phenolic	Total flavonoids	Antioxidant Activity %
Control	25.69	4.68	70.11
Sample A	13.52	2.65	55.84
Sample B	22.36	3.98	65.32
Sample C	23.65	4.05	67.98

- **Antioxidant activity of stabilized rice bran samples :**

The DPPH assay determined free radical scavenging capacity as a measure of antioxidant capacity in samples. DPPH has a stable radical with a maximum absorbance at 517 nm, (Melissa and Marchesan 2011).A decrease in radical scavenging DPPH assay were clearly observed in all stabilized rice bran samples in compare with control sample. But the lowest decrease in antioxidant activity could be observed in rice bran stabilized in autoclave (67.98%) followed by the other rice bran samples. As mentioned in Table (3)

- **Total phenolic compounds (TPC) and total flavonoids (TFC) :**

Total phenolic compounds content was estimated by the Folin–Ciocalteu colorimetric method, using gallic acid as a standard phenolic compound. All values of total phenolics (TPC) in stabilized rice bran samples decreased in compared with control sample. Total phenolic content of stabilized rice bran in oven exhibited the least content being 13.52 mgGAE/100g sample. While the other stabilized rice bran sample B and C were nearly the same. These resultswere in accordance with those reported by Lloyd,*et al*. (2000), who stated that total phenolic compounds TPC values in stabilized rice bran ranged from 24.20 to 27.20 mg GAE/100 g sample.

Results in the same Table (3) showed that the total flavonoids (TFC) gradually decreased in all stabilized rice bran samples in compare of control sample, this decrease may be due the effect of high temperature used in the stabilization process.

Phenolic acids are substances containing a phenolic ring and an organic carboxylic acid function. The antioxidant property notably depends on the number and the position of hydroxyl groups on the phenolic ring (Chatha *et al*., 2006 and Yawadio , 2007).

Some chemical indices of stabilized rice bran oil samples:

Results in Table (4) illustrated some chemical indices used to evaluate the favorable stabilized methods in preventing hydrolysis and oxidation of rice bran oil.The Acid Value (AV) and free fatty acid FFA% formation were criteria to determine the lipase activity and evaluate hydrolysis and stability process of oil. The rate of free fatty acid formation in rice bran has been shown in Table (4). The initial acid value and FFA% content of control rice bran oil sample was around 0.15 and 0.30, respectively. These parameters were increased to 1.32 and 2.56 in extracted stabilized rice bran oil using oven and decrease in rice bran oil from the other thermal treatments. These results were almost in agree with Sung-Min *et al* .,(2014), who found that during thermal treatment of rice bran oil bran have the initial FFA value of around 0.25%.But obtained results are in differed with Choudhary,*et al*., (2013), who found that stabilization method by using cold-treated process have the ability to reduce FFA% and acid value below 1% and he suggested that this process is favorable for human consumption, as it caused on decreasing the amount of free fatty acid% and did not exceed 3 % in any food is consumable.

Also, results in the same table cleared that microwave stabilized rice bran oil have the lower content of FFA% and AV values as compared with the other stabilized oil using oven and control one. The least acid value and FFA% indicated that the lower rate of enzymatic hydrolysis in rice bran. Microwave heating inactivates the enzymes that cause rancidity such as

lipases and lipoxygenases through the internal heating of particleswithin the microwave cavity. The cavity makes the dipolar water molecules in the samples excited by the electromagnetic waves, resulting in enhancement kinetic energy along with the friction and produces an even distributed of heat through the samples.(Nanua, *et al*. 2009and Nordin, *et al*. 2014).

Table 4. Some chemical indices of stabilized rice bran oil samples.

Rice bran samples	Chemical indices							
	AV (mg KOH/g)	FFA %	PV (mlEqv./1000g)	TBA value (mg Mal/Kg)	*p*-AV	IV (g I/100g)	Oxidative stability (hours)	Oryzanol Content
Control	0.15±0.1	0.30±0.1	0.32±0.2	0.02±0.02	11.25±0.1	94.89±0.1	8.24	2.2±0.2
Sample A	1.32±0.1	2.56±0.01	3.51±0.2	1.65±0.1	15.25±0.3	92.65±0.2	11.35	1.8±0.1
Sample B	0.21±0. 1	0.42±0.01	1.98±0.2	0.05±0.3	11.13±0.2	94.61±0.2	10.98	1.3±0.1
Sample C	0.31±0.01	0.61±0.02	1.52±0.2	0.07±0.2	11.14±0.1	94.21±0.2	10.96	1.5±0.1

Sample A = stabilized rice bran in oven.:Sample B= stabilized rice bran in microwave.: Sample C =stabilized rice bran in autoclave. Each value is the mean of three replicates ± SD

Para anisidine value(*p*-AV) is a more meaningful test for the assessment of the oil's quality during thermal treatment more accurate than the peroxide value to determine the secondary oxidation products (Mariod *et al*., 2010).

Thiobarbituric acid value (TBA), may be a good chemical parameter for quality assurance and measuring the extent of the secondary oxidation of edible oils(Rubalya and Neelameagam, 2008).

From obtained results, the values of peroxide, TBA and Para anisidine were in parallel. In all rice bran oil samples, rice bran oil in sample A exhibited the highest value in peroxide was 3.51 ml eqv/kg oil, TBA being 1.65 ml malonaldhyde / kg oil and 15.25 for *p*-anisidine value, while the lowest values being (1.98 and 1.52), (0.05 and 0.07) and (11.13 and 11.14) for peroxide, thiobarbituric and *p*-anisidine value in rice bran oil sample B and C, respectively.Data observed in Table(4) showed that all rice bran oil samples improved the oxidative stability against control one,the highest induction period was 11.35 hours more than elven months of storage. On the other hand, the other oil samples were approximately the same about ten months of storage. From tabulated results, pretreatments methods for rice bran were preferred in increasing the shelf life of oil than untreated one.

Results also in the same table showed that oryzanol content of the stabilized rice bran oil samples were approximately the same in all samples, while a decrease in oryzanol content was clearly observed in the case of microwave heating at the same condition.

Fatty acids profile of stabilized rice bran oil samples:

Fatty acids composition is an essential indicator of its nutritional value (Ulbricht and Southgate,1991), results of HPLC analysis of methyl esters of saturated (SFA) and unsaturated (USFA) individual fatty acids of rice bran oil samples were described in Table (5) and. Obtained results showed that total saturated fatty acids were ranged from 28.17 to 32.00% in all oil samples, while palmitic acid ($C_{16:0}$) recorded the highest amount of total saturated fatty acids in compare with other individual fatty acids being 26.47, 25.78 and 23.24% in rice bran oil using oven, microwave and autoclave, respectively .Data in the same table cleared that epidemic unsaturated fatty acid in all oil samples being oleic acid ($C_{18:0}$),revealed data showed also that rice bran oil represented adequate amount of essential fatty acids such as linoleic acid ($C_{18:2}$) namelyomega-6 was ranged from 25.02 to 27.05% and minor amounts of linolenic $C_{18:3}$ (omega-3 fatty acid) did not exceed0.08% in all rice bran oil sample in compare with 1.35 % in control one. These obtained results were almost in agree with those given by Choudhary *et al*., (2013), who stated that total saturated fatty acid gradually increase in all stabilized rice bran oil using convention heat methods.

Thermal treatments caused an appreciable changes in total saturated and unsaturated fatty acids content, an observed decrease in total unsaturated fatty acid followed with observed increase in total saturated fatty were seen. The decreasing rate of in USFA being 8.15,5.61 and 2.99% in oven, microwave and autoclave stabilized samples, respectively. Also, increasing rate of SFA were 23.45 , -13.91 and -8.68% for the same samples, respectively.

Table 5. Fatty acids profile of stabilized rice bran oil samples.

Fatty acids	Stabilized rice bran samples			
	Control	Oven	Microwave	Autoclave
$C_{14:0}$ (Myristic acid)	0.30	0.60	0.53	0.51
$C_{16:0}$ (Palmitic acid)	22.80	26.47	25.78	23.24
$C_{18:0}$ (Stearic acid)	1.92	3.11	2.91	2.80
$C_{20:0}$ (Arachadic acid)	0.90	1.82	0.98	1.72
Total saturated fatty acid (TSFA)	25.92	32.00	30.11	28.17
$C_{18:1}$(Oleic acid)	43.90	42.26	42.05	43.97
$C_{18:2}$(Linoleic acid) (ω-6)	28.73	25.02	27.03	27.05
$C_{18:3}$(Linolenic acid) (ω-3)	1.35	0.07	0.08	0.08
PUFA	30.08	25.73	27.83	27.85
TUSFA	74.04	67.98	69.88	71.82
Total fatty acids (TFA)	99.99	99.98	99.99	99.99

MUFA: Mono unsaturated fatty acids. PUFA: polyunsaturated fatty acids. TUSFA:Total unsaturated fatty acids.

So, It could be concluded from the above mentioned data that thermal treatment by heat in microwave oven and autoclave for rice bran have a negative effect on chemical constituents, but the same thermal treatment conserve the microstructure of the granules. Also, results indicated that microwave and autoclaving could be considered as stabilized pretreatment for rice bran oil showed considerable efficiency in inhibiting lipid oxidation of rice bran oil . It has been evidenced these pre-treatment procedure has been arrested the lipase action and enhanced quality of

rice bran and rice bran oil. Undesirable and anti-nutritional factor like lipase was inactivated and minimized on processing of rice bran using different thermal treatment.

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تأثير المعاملات الحرارية الأولية على الخصائص الكيميائية والمركبات الحيوية والتركيب الداخلي لنخالة الأرز

رانيا إبراهيم الجمال

قسم الصناعات الغذائية – كلية الزراعة – جامعة المنصورة

اجريت هذه الدراسة بغرض دراسة تأثير عملية الثبات الحراري لعينات من نخالة الأرز التجارية والتي تعرضت للمعاملات الحرارية باستخدام (الحرارة- جهاز الميكروويف- المعاملة بالبخار باستخدام الاوتوكلاف) . تم دراسة التركيب الكيماوي والتركيب الداخلي للحبيبات . أعطت نتائج التحليل الكيماوي ان محتوي الرطوبة تراوح بين 8.65: 10.54% ، ولم تتجاوز نسبة البروتين لعينات نخالة الأرز المعامل حراريا عن 18% وأعطت عينات نخالة الأرز المعامل حراريا بالتسخين اعلي المعدلات في نسبة الرماد حيث وصلت الي 4.8 % مقارنة بالعينات الأخرى .وأظهرت نتائج التركيب الداخلي باستخدام الميكروسكوب الإلكتروني SEMأن جميع عينات نخالة الأرز ذات تركيب متماثل والحبيبات ذات سطح ناعم ومغلقة التركيب الحبيبي . اوضحت نتائج تحليل المركبات الحيوية لعينات نخالة الارز المعاملة حراريا ، ان العينات المعاملة حراريا بالتسخين احتوت علي اقل نسبة للمركبات الفينولية الكلية وهي 13.52 ملجم/ 100 حمض جاليك، وأيضا حدوث انخفاض ملحوظ في معدلات المركبات الفلافونيدية الكلية لجميع عينات نخالة الأرز المعاملة حراريا مقارنة بالعينة الكنترول . أيضا تم إجراء التحليل الكيماوي للأحماض الدهنية للزيت المستخلص من عينات نخالة الأرز وكانت هناك زيادة تدريجية في قيم رقم الحموضة والأحماض الدهنية الحرة % من 0.15 : 0.31 ملجم KOH / جم و 0.3 : 0.6 علي التوالي . بينما حدث انخفاض واضح لجميع ثوابت الأكسدة والتزنخ في كل عينات الزيت مقارنة بالعينة الكنترول . وأعطت قيم مركب الاوريزانول انخفاض ملحوظ مقارنة بالعينة الكنترول . اظهرت نتائج تحليل محتوي الأحماض الدهنية ان نسبة الأحماض الدهنية المشبعة تراوحت بين 28.17 : 32.00 % لجميع عينات الزيت . كما سجل حمض البالمتيك $C_{16:0}$ اعلي معدل في الاحماض الدهنية المشبعة . وكان حمض الاوليك $C_{18:1}$ هو الحمض الدهني الغير مشبع السائد لجميع عينات الزيت . ووجدت كميات محسوسة من الأحماض الدهنية الأساسية حيث تراوحت نسبة حمض اللينوليك $C_{18:2}$ مابين 25.02 : 27.05 % ولم تزيد كمية حمض اللينولينك عن 0.08 % في جميع عينات الزيت مقارنة ب1.35 % للعينة الكنترول . ولذا نخلص من النتائج المتحصل عليها ان المعاملة الحرارية لنخالة الأرز ادت الي حدوث تغيرات ملموسة في محتوي الأحماض الدهنية المشبعة والغير مشبعة وان المعاملة باستخدام الاوتوكلاف واستخدام الميكروويف أظهرت أكثر فاعلية في تحسين الثبات تجاه عملية الاكسدة والمحافظة علي المكونات المختلفة بالزيت . كما تعتبر وسيلة ناجحة للاستفادة لعملية الثبات الحراري لنخالة الارز والاستفادة من مكوناته .

الكلمات الدالة :- نخالة الارز – الثبات الحرارى - الاحماض الدهنية - المركبات الفينولية والفلافونيدية