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ORIGINAL ARTICLES

Preparation, composition and microbiological and rheological properties of functional processed cheese supplemented with rice bran.

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ABSTRACT

The utilization of the underutilized rice bran (RB) in the development of a functional processed cheese product containing fiber and bioactive phytochemicals found in RB was investigated. Rice bran was found to contain 841.33 mg total phenols/100 g and the following phenols were identified, catachin, chlorogenic acid, caffeic acid, vanillic acid, qumaric acid, ferulic acid, cinnamic acid and chyrisin. The effect of adding 2, 4 and 6 % RB on the chemical composition, microbiological, texture profile, colour attributes, oxidative stability of cheese fat, meltability, oiling off and sensory properties of processed cheese spreads (PCS) were determined. Generally, addition of 4 and 6% rice bran slightly and significantly changed most the studied characters. Thus the colour became more darker, oiling off and hardness increased while the meltability decreased. On the other hand, no significant differences were found between processed cheese containing 2% RB and control. The Addition of RB would add several bioactive compounds such as bioactive phenolic compound and fiber improving the nutritive value and health impact of the product. It is recommended to add 2% RB in PCS formulation as a novel product with better nutritive than the classic product. In the mean time it would give a feasible way for the utilization of rice bran and to decrease the cost of processed production.

***Key words*:** Processed cheese spread, Rice bran, Cheese composition, Textural profile analysis. Microbiological quality, Sensory properties, Polyphenols, Fiber.

Introduction

Measurable quantities of by-products arise from food processing. These by-products are either wasted or underutilized even most of these by-products contain several valuable nutrients. Utilization of food processing by-products represents a challenge to food industries which would increase the economy of the processed commodities or decrease the cost for disposal of these by-products.

In Egypt, 5.6 million tons of rice were milled in 2010-2011 (Ahram online, 2012) which result in about 0.56 million tons of rice bran. Rice bran in Egypt is used completely in animal feeding. The partial use of rice bran in human consumption would enhance the profitability of rice milling industry.

Rice bran is one of the underutilized by-products of rice milling. Rice bran represents the polish of the outer layer and the germ of the rice grain which represent about 10% of the rice grain weight. Rice bran is rich in proteins (12-14%), lipids (16-22%), dietary fiber (21%) minerals particularly iron, magnesium and potassium, and vitamins and antioxidants(Kahlon, 2009). Due to the nutritional value, and low cost of rice bran (Douaud, 2007), several studies have been done to evaluate its use in foods. Therefore, rice bran has been used in breakfast cereals and in granola tablets, snacks, and extruded food and also as a binder to replace soy protein isolates in food containing chicken meat (Crowley & Halliday, 2008), as a supplement for the production of high fiber bread (Abdul-Hamid & Luan, 2000), and in soft drinks and as supplementary component in the food industry (Kahlon, 2009). In addition to its nutritive value several therapeutic effects have been attributed to rice bran including lowering cholesterol blood (Kahlon, 2009) and potential cancer prevention (Foster *et al.,* 2013).

In order to use rice bran in human foods two problems should be considered i.e. the rapid oil deterioration and the low microbiological quality. The presence of potent lipase system in the bran results in rapid hydrolysis of rice bran oil, increased oil acidity and development of rancid flavour. Also, rice hulls are found in crude rice bran as contaminants. The contaminating hulls usually have high population of microorganisms specially fungi whose spores are heat resistant. Heat treatment was found necessary to stabilize rice bran from enzymatic and microbial deterioration (Oliveira *et al.,* 2012). Thermoplastic extrusion or heating at 80ºC for 20 min were found sufficient to stabilize rice bran for 90 days (Oliveira *et al.,* 2012).

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To extend the use of rice bran in human consumption it was thought desirable to explore the use of rice bran in processed cheese. Processed cheese is subjected to heat treatment during its manufacture. It is hypothised that the heat treatment received during the manufacture of processed cheese would inactivate the lipase activity of added rice bran and improve its microbiological quality. In the mean time addition of rice bran would diversify the functionalities and nutritional properties of processed cheese through the added new constituents such as fiber.

The present paper describes the utilization of rice bran in processed cheeses and the effect of this additive on the chemical, microbiological and rheological properties of the obtained processed cheese.

Materials and Methods

1-Materials:

1-Ras cheese (37.67% fat, 68.83% total solids) with the characteristic flavour of fully ripened Ras cheese was obtained from Cairo market.

2- Soft cheese (11.67% fat, 32.00% total solids) and butter oil were obtained from the dairy department, Cairo university.

3- Joha S9 emulsifying salts (BK Giulini Chemie GmbH, Landenburg, Germany) was obtained from the local market.

4-Rice bran (RB) was obtained from private rice milling plant in Kafr El-Sheikh. Rice bran was sieved using 100 mesh sieve and the fine rice powder was used in further experiments.

5- Laboratory chemicals. All chemical used were Analytical or HPLC grades.

Preparation of processed cheese spread:

Processed cheese spreads were prepared to contain 0, 2, 4 and 6% rice bran. Formulations of the different treatments (4 treatments) are shown in Table 1. The amounts of the used ingredients were calculated in order to fulfill the legal standard specification of the full fat processed cheese spread (~ 50% fat/dry matter).

The rice bran was soaked in part of the water used in the formulation before its addition to the other ingredients. The ingredients were mixed, placed in the processing kettle (locally made) of 2.5 kg capacity, and then heated by direct steam up to 90°C with continuous mixing at 1400 rpm for 5 min. Heating was discontinued, the hot cheese melt was packaged in wide-open screw capped glass bottles (100 ml capacity), and stored at 5°C until analysed. Three replicates were made from each treatment and analysed each in duplicate.

Table 1: Formulations of processed cheese spreads containing different contents of rice bran (RB).

Ingredients (g)	Control	2% RB	4% RB	6% RB
Ras cheese	320.8	288.6	256.4	224.4
Soft cheese	492.0	442.7	393.6	344.4
Rice bran	0.0	20.0	40.0	60.0
Emulsifying salt	30.0	30.0	30.0	30.0
Butter oil	52.0	69.6	86.8	105.2
Water	120.2	149.1	193.2	236.0
Total	1015.0	1000.0	1000.0	1000.0

2-Methods of analysis:

2-1. Chemical analysis and pH:

Rice bran was analysed for moisture, fat, crude protein (N x 5.95), ash and fiber according to AOAC methods (AOAC, 1995). Total carbohydrate was calculated by difference of fat, protein and ash contents from the total solids of rice bran. The total phenolic content of rice bran was determined according to the spectrophotometric method of Sultana *et al.* (2007). The phenolic compounds of rice bran were extracted with methanol, and individual compounds were separated and quantitatively determined by the HPLC method of De Leonardis *et al.*(2005) using HP 1100 (Agilent Technologies, Palo Alto, CA, USA) equipped with ZORBAX Eclipse XDB C18 column (15 cm x 4.6 mm I.D., 5µm) and diode array detector at 325 nm wavelength. Aliquot (20 µl) of the methanolic extract of rice bran were injected in the column and eluted with a gradient of methanol (phase A) and 2% acetic acid (phase B). Separated phenolic compounds were identified by comparison with the retention times of the standard compounds and quantitatively determined by the integrated chemostation chromatographic software interfaced to a personal computer.

Processed cheese spreads were analysed for moisture and fat contents according to (AOAC 1995) methods, for total nitrogen (TN) and soluble nitrogen (SN) contents by Kjeldahl method (IDF, 1993), and for total free amino acids (Folkertsma & Fox, 1992) and total volatile fatty acids according to Kosikowski (1986). The pH

was measured in a slurry prepared by macerated 20 g of cheese in 20 ml of distilled water using Hanna pH meter equipped with glass electrode (Hanna Co., Italy). For the oxidative stability of cheese fat, thiobarbeturic acid (TBA) value of the cheese fat was measured according to the (AOAC 1995) method. The acid value of cheese fat was determined according to (AOAC 1995) methods.

2.2. Microbiological analysis:

The total viable bacterial count (TC) was enumerated on tryptone glucose extract agar medium (TGEM). The proteolytic bacterial count was determined according to Dilliello (1982), and lipolytic bacterial count as described by Mahmoud (1988) using nutrient agar medium to which olive oil was added and plates were incubated at 30ºC for 2-3 days and then flooded with 20% cupper sulphate solution to detect lipolytic colonies. The mold and yeast count were enumerated of potato dextrose agar (APHA, 1985) and plates were incubated at 25 ± 2 º C for 4-5 days.

2-3 Colour measurements:

The colour of the processed cheese spreads was measured using Hunter colorimeter Model D2s A-2 (Hunter Assoc. Lab.Inc. Va, USA) following the instruction of the manufacturer (Hunter colorimeter, 1976). The instrument was first standardized using a white tile (top of the scale) and a black tile (bottom of the scale). A specimen of the cheese (flat layer) was placed at the specimen port; the tri-stimulus values of the colour namely; L, a and b were measured where: L: value represents darkness from black (0) to white (100), a; value represents colour ranging from red (+) to green (-) and b value represents yellow (+) to blue (-).

2.4. Meltability and oiling off:

The cheese meltability was determined according to Savello *et al.* (1989) and oil separation was determined according to the method outlined by Thomas (1973).

2.5. Textural Profile Analysis:

Texture profile analysis (TPA) was performed on the whole cheese samples using the double compression test (TMS-Pro texture analyzer, Food Technology Co., USA). Samples were double compressed to 80% of their original height at a compression speed of 2 cm/min. The following parameters were evaluated by TPA according to the definitions given by the International Dairy Federation (IDF,1991): Hardness is the force required to attain a given deformation; fracturability is the force at which the material fractures; springiness or elasticity is the rate at which a deformed material goes back to its un-deformed condition after the deforming force is removed; and cohesiveness is defined as the quantity simulating the strength of the internal bonds making up the body of the product. The above textural parameters were determined using Texture Lab pro soft ware (Food Technology Co, USA). The value of the peak force of the 1st compression (bite) is the measure of hardness (in Newtons, N). The ratio between areas under peak force of the second bite to that of the first bite is the measure of cohesiveness (no dimension). The measure of springiness (no dimension) is the ratio of the distance taken to reach the force peak during the second bite to the distance elapsed to reach the peak force during the first bite.

2.6. Sensory analysis:

The sensory attributes (colour, aroma, taste, consistency, and oiling off) were assessed by a panel taste of 10 experienced members of the dairy department, National Research Centre, Cairo. Panelists were asked to judge each sensory attribute out of 10 point scale.

2.7. Statistical analysis:

Data were analysed statistically by ANOVA according to (Snedecor & Cochran 1980).

Results and Discussion

Chemical composition and phenolic compounds of rice bran:

The composition of the rice bran vary widely between varieties and environmental conditions (Amissah *et al.,* 2003; Butsat & Siriamorpun, 2010; Moongngram *et al.,* 2012). Therefore, The rice bran used in the present

study was analysed to explore its composition, and results are presented in (Table 2). The moisture content of RB in the present study was less than that reported (7.15-13.03%) by Amissah *et al.*(2003). The crude fat of RB falls in the range given for crude fat of rice bran. Amissah *et al.* (2003) reported a range of 13.43 to 19.85% in RB from nine rice varieties and Moongngram *et al.* (2012) reported a fat content of 17.32± 0.61% and 18.89 ± 0.51% in two varieties of non waxy rice respectively. The crude protein content (11.46%) of RB was in good agreement with that reported in the literature i.e. 12.93-13.66% Moongngram *et al.,* (2012). The carbohydrate content (53.90%)was higher and the fiber content (5.5%) was less than that reported in the literature (Amissah *et al.,* 2003; Moongngram *et al.,* 2012) which may be attributed to varietals' differences and the sieving of rice bran which may remove the coarse particles high in fiber content.

Table 2: Average composition of rice bran used in the present study.

Constituent	Concentration	Constituent	Concentration
Moisture	6.30%	Total carbohydrates	53.90%
Total solids	93.70%	Ash	6.68%
Fat	15.60%	Fiber	5.50%
Protein (N x 5.95)	11.46%	Total phenolic* compounds	841.33 mg /100g

* Values are expressed as gallic acid equivalent.

The phenolic compounds are important part of the bioactive components in rice bran. The total phenolic compounds in the used rice bran in the present study (841.33 mg/100 g) was higher than that reported in the literature. Moongngram *et al.* (2012) reported a total phenolic compounds ranging from 1.57 to 6.65 mg/g and Butsat & Siriamorpun (2010) who gave values ranging from 2.5-2.7 mg/g.

Table 3: Phenolic compounds content (mg/100g) of rice bran.

Phenolic compound	Retention time (min)	Concentration (mg/100 g)
Catachin	6.80	294.12
Chlorogenic acid	15.83	0.91
Caffeic acid	17.00	17.35
Vanillic acid	18.00	113.20
Qumaric acid	21.40	6.89
Ferulic acid	23.50	183.04
Cinnamic acid	26.00	1.02
Chyrisin	31.00	3.14
Total	--	619.67

Eight phenolic compounds were identified in the methanolic extract of rice bran (Table 3). Three phenolic compounds were found as the major phenolic compound in RB. These were catachin, vanillic and ferulic acids. Chloragenic, caffeic, qumaric, cinnamic acids and chyrisin were present in much smaller amounts or traces. Butsat & Siriamorpun (2010) reported that ferulic, p-coumaric and vanillic acids were the main phenolic compounds in rice bran with p-hydroxybenzoic, protocatachic and chlorogenic acidc as minor constituents. On the other hand, Pourli *et al.,* (2010) identified up to 11 phenolic compounds in rice bran: caffic, ferulic, gallic, gentisic, p-coumaric, p-hydroxybenzoic, sinapic, syringic, vanillic acids and vanillin with protocatchic and vanillic acids are the major components. The observed differences in the type and concentration of individual phenolic compounds between the different studies may be attributed to differences in the method of extraction and rice variety.

Chemical Composition and pH of processed cheese spread:

Addition of rice bran (RB) in the processed cheese mix increased slightly the moisture and decreased the total solids contents of the product except with 6% RB where TS increased slightly (Table 4). However, these changes were found not significant (P> 0.05). The TS contents of processed cheese spreads (PCS) from control and treatments meet the Egyptian standards specification for full fat PCS (ESO, 2005). The fat content of PCS increased with the increase in the added RB in the mix and the differences between the control and treatments were highly significant (P< 0.001). This can be attributed to the oil content in RB (Table 1). However, calculating the fat content on dry basis revealed unsignificant (P> 0.05) differences in fat/DM between the control and treatments due to differences in the TS contents of PCS (Table 4). The fat contents of control and treated PCS fall in the legal range of full fat PCS (ESO, 2005). The total protein content of PCS decreased gradually with addition of RB and differences were found significant (P< 0.05). Rice bran contained less protein content than the cheese. Replacement of cheese base in the formulation with RB is expected to decrease the protein content of the product. However, the protein contents of the spreads in the present study were in agreement with values reported for market processed cheeses (Mahfouz *et al.,* 1986; Khader *et al.,* 1997). The control PCS had less soluble N (Table 3) than PCS containing RB and differences between them were significant (P< 0.01). Proteins of RB were reported to be globulins and albumins (Jiamyangyuen *et al.,* 2005) which would be extracted with the soluble N. This may explain the high soluble N in PCS containing RB. The

SN/TN ratio in PCS increased with increase in the RB in PCS (P<0.01). The ash content decreased slightly with the increase of the added RB in PCS but the differences were insignificant.

Table 4: Chemical composition and pH of processed cheese spreads containing different percentages of rice bran (RB) Mean ± standard deviation.

	Control	2% RB	4% RB	6% RB
Total Solids %	48.77 ± 3.52	48.22 ± 4.55	48.31 ± 2.57	50.33 ± 4.11
Fat %	22.50 ± 0.50^{c}	24.67 ± 0.49^{b}	25.37 ± 0.32^{ab}	26.40 ± 0.40^{a}
Fat/DM %	46.30 ± 3.57	50.81 ± 4.46	52.59 ± 2.20	52.65 ± 3.54
Total Protein %	13.90 ± 0.09^{a}	13.59 ± 0.06^{b}	12.59 ± 0.13^{c}	11.77 ± 0.09^{d}
Soluble N %	0.90 ± 0.02^{a}	0.88 ± 0.006^{ab}	0.92 ± 0.01^{ac}	0.93 ± 0.02^{ac}
SN/TN	41.47 ± 0.47^{b}	41.53 ± 0.15^{b}	46.43 ± 0.12^{a}	50.43 ± 0.42^{a}
Ash %	6.07 ± 0.07	5.71 ± 0.58	5.60 ± 0.42	5.45 ± 0.36
Acidity%	1.27 ± 0.03^{a}	1.18 ± 0.09^{a}	1.03 ± 0.13^{ab}	0.93 ± 0.09^{b}
pH	5.83 ± 0.04	5.59 ± 0.07	6.02 ± 0.06	6.12 ± 0.02
TVFA*	20.33 ± 0.58^{d}	23.33 ± 0.58^{c}	26.00 ± 0.00^{b}	28.83 ± 1.04^{a}
FAA*	0.22 ±0.02^{c}	0.30 ± 0.02^{b}	0.33 ± 0.1^{ab}	0.38 ± 0.02^{a}

No significant difference between means with the same super script,
***** TVFA, total volatile fatty acids ml 0.1 N NaOH/100 g cheese; FAA, Free amino acids mg/g cheese.

Wide variation in the ash content of processed cheese were reported ranging from up to 11.28 % for freshly prepared processed cheese (Abd El-Hamid *et al.,* 2002) to low as 4.70% (Kebary *et al.,* 1998) due to differences in the NaCl content, emulsifing salt percentage and the use of different ingredients in different studies. The ash contents of PCS in the present study fall in the reported ash content of PCS. The acidity of PCS decreased with the increase of the added RB in the product which may be attributed to the presence of alkaline salts in RB. The pH of PCS followed opposite trend to changes in acidity with the increase in the RB in the product. However, the differences in pH between control and treatments were not significant. However, the pH of control and treatments fall in the range reported for pH of PCS (Mahfouz *et al.,* 1986, Khader *et al.,* 1997).

The TVFA of PCS from different treatment increased significantly (P< 0.05) with the increase in RB the product, probably due to the presence of volatile acidity in RB. Also, PCS containing RB had slightly higher free amino acids than the control and differences were significant (P< 0.05).

Acid value and thiobarbeturic acid (TBA) of cheese fat:

The acid value of PCS fat increased significantly (P< 0.05) with the addition of 4% and 6% rice bran in comparison to the control, while the difference in acid value of control and 2% RB was insignificant (Table 5). Determination of TBA as an index of the oxidative stability of PCS fat revealed unsignificant differences between control and PCS containing RB (Table 5). The low TBA values of PCS from different treatment indicate acceptable oxidative stability of fat in PCS from control and all treatments. This may explain the results of the sensory evaluation of the products (Table 10) where addition of RB had no significant effect on the taste and aroma of the PCS.

Table 5: Acid value (as % oleic acid/cheese fat) and TBA (absorbance) of milk fat of processed cheese spreads containing different percentages of rice bran (RB) Mean ± standard deviation.

	Control	2% RB	4% RB	6% RB
Acid value	1.58 ± 0.30^{a}	2.13 ± 0.16^{ab}	2.47 ± 00^{b}	3.03 ± 0.16^{b}
TBA	0.05 ± 0.002	0.06 ± 0.02	0.07 ± 0.02	0.08 ± 0.02

*No significant difference between means with the same super script

Microbiological quality:

Inclusion of rice bran in different concentration in the processed cheese mix had no probable effect on the microbiological quality of the product (Table 6). Thus no significant differences were found in the total viable, lipolytic and mould and yeast counts between control and processed cheese spreads containing different percentages of rice bran. On the other hand, control processed cheese spread contained significantly (P<0.05) higher proteolytic count than spreads containing 2 and 6% RB. The total viable counts of control and RB containing PCS were higher than that reported (Mahfouz *et al.,* 1986) namely: 60-5000 cfu/g, and by Abd Alla *et al.,* (1996) namely : 42-87 x 10^{2} cfu/g in market processed cheese samples. The low lipolytic count in PCS containing RB in comparison to the control, suggested that RB had little effect of lipolytic count in PCS. The

presence of lipolytic bacteria in RB were isolated and identified as *Bacillus firmus* and *Micrococcus caseolyticus* (Zaki *et al.,* 1970).

Table 6: Microbiological quality of processed cheese spreads containing different percentages of rice bran (RB) Mean ± Standard deviation.

Groups	Control	2% RB	4% RB	6% RB
Total count (x 10^3)	81.0 ± 8.0	78.7 ± 23.5	61.7 ± 10.5	66.7 ± 16.2
Proteolytic count (x 10^2)	44.7 ± 7.4^a	21.3 ± 10.0^b	30.7 ± 4.9^a	19.3 ± 7.1^b
Lipolytic count (x 10^1)	41.5 ± 15.1	24.8 ± 18.7	28.3 ± 13.2	32.3 ± 18.7
Mould & yeast count (x 10^1)	40.8 ± 16.3	37.5 ± 8.9	48.3 ± 15.3	43.3 ± 7.4

* No significant difference between means with the same super script

Moulds and yeasts were reported to be absent in market processed cheese (Mahfouz *et al.,* 1986; Abd Alla *et al.,* 1996). The presence of Moulds and yeasts in control and RB containing PCS may be due to post contamination during the manual packaging of PCS. However, it was evident from the results that the RB had no probable effect of moulds and yeasts content of PCS.

Textural profile analysis (TPA):

Table 7: Textural profile analysis (TPA) of processed cheese spreads containing different percentages of rice bran (RB) Mean ± Standard deviation.

	Control	2% RB	4% RB	6% RB
Hardness (N)	3.1 ± 0.2^a	3.5 ± 0.3^{ab}	3.9 ± 0.4^{ab}	4.2 ± 0.4^b
Cohesiveness	0.44 ± 0.05	0.51 ± 0.17	0.42 ± 0.08	0.47 ± 0.15
Springness	0.43 ± 0.08	0.50 ± 0.14	0.43 ± 0.08	0.46 ± 0.06
Gumminess	1.36 ± 0.12	1.78 ± 0.42	1.62 ± 0.24	1.93 ± 0.45
Chewiness	0.59 ± 0.15	0.92 ± 0.45	0.70 ± 0.25	0.90 ± 0.37

*No significant difference between means with the same super script

Addition of RB increased significantly ($P< 0.05$) the hardness of PCS and this increase ran parallel to the percentage of RB added (Table 7). The presence of fiber and high carbohydrate content in RB may bind high percentage of the moisture in PCS increasing the hardness of the product. Montesinos-Herrero *et al.,* (2006) found that the addition of fiber in imitation cheese to increase the viscous modulus which explains the increased hardness of PCS containing RB found in the present study. However, other textural parameters of PCS were not significantly affected with the added RB.

Meltability and free oil:

Table 8: Meltability and free oil of processed cheese spreads containing different percentages of rice bran (RB) Mean ± standard deviation.

	Control	2% RB	4% RB	6% RB
Meltability mm	92.00 ± 3.0^a	87.33 ± 1.53^{ab}	84.67 ± 2.52^b	80.33 ± 3.06^b
Free oil	59.67 ± 1.53^a	64.00 ± 2.00^a	70.67 ± 2.08^b	72.67 ± 3.06^b

* No significant difference between means with the same super script

The addition of RB changed significantly ($P <0.05$) the meltability and free oil index of PCS (Table 8). Thus the meltability of PCS decreased with the increase of RB to 4% and 6%. This decrease can be attributed to the increased hardness of PCS containing RB. On the other hand, addition of 4% and 6% RB increased significantly the free oil in comparison to control while the addition of 2% RB had no significant effect on the oiling off of PCS. The presence of rice oil may be responsible for the observed increase in the free oil.

Colour attributes:

Instrumental measurements of colour is based on the determination of three parameters i.e., L (% whiteness), a and b. Table 9 shows decreases in whiteness with the increased percentage of added RB in PCS which can be attributed to the brownish colour of RB. However, the differences in L values between control and treatments were not significant. The L values of control PCS were in agreement with previous reports (Khader *et al.,* 1997). The a value of PCSs increased with the increase of RB in the product indicating that PCS acquired more reddish hue but the differences between treatments were not significant.

Table 9: Colour attributes of processed cheese spread containing different percentages of rice bran (RB) Mean ± standard deviation.

	Control	2% RB	4% RB	6% RB
L %	77.46 ± 1.20	71.30 ± 4.37	65.77 ± 8.78	65.00 ± 1.43
a	2.33 ± 0.60	2.56 ± 0.34	3.12 ± 0.62	3.48 ± 0.33
b	19.39 ± 1.22	18.63 ± 0.71	17.73 ± 0.83	17.73 ± 0.40

***** No significant difference between means with the same super script

Sensory properties:

Table 10: Sensory evaluation (out of 10 points for each character) of processed cheese spread containing different percentages of rice bran (RB) Mean ± standard deviation.

	Control	2% RB	4% RB	6% RB
Colour	9.41 ± 0.90^{a}	8.42 ± 1.31^{ab}	7.91 ± 0.70^{b}	7.42 ± 0.79^{b}
Aroma	9.58 ± 0.90	9.58 ± 0.67	9.75 ± 0.45	9.50 ± 0.80
Consistency	9.08 ± 0.90	8.9 ± 0.90	8.58 ± 1.08	8.75 ± 0.87
Oiling off	10.00 ± 0.00	10.00 ± 0.00	10.00 ± 0.00	10.00 ± 0.00
Taste	9.17 ± 0.94	9.17 ± 1.03	9.08 ± 0.90	9.08 ± 1.00
Total	46.8 ± 3.1	46.2 ± 2.3	44.8 ± 2.2	44.1 ± 3.0

* No significant difference between means with the same super script

Table 10 shows that the scores for colour attribute decreased significantly (< P 0.05) with the increased addition of RB in the PCS. However, differences in colour scores between control and PCS containing 2% RB were not significant. Sensory analyses of colour confirm the trend of colour changes, on addition of RB, measured by instrumental analysis, but it gives an overall judging for colour which may explain the significance of sensory values. Scores of other sensory attributes (aroma, consistency, oil separation and taste) were not significant. Consequently, the total sensory scores were not significantly different between treatments.

Conclusions:

Processed cheese spread containing up to 6% rice bran can be successfully made. The added RB had slight effects on the composition, microbiological quality, textural profile, meltability and oiling off, oxidative stability of cheese fat and sensory properties of the obtained PCS. The percentage of added RB affects the magnitude of these changes. It is recommended to add 2% RB in the PCS formulation as it had almost the same characteristics of control PCS. In addition to the health impacts of the bioactive constituent of RB on PCS, the addition of RB would reduce the cost of PCS production and increase the profit of the cheese manufacture.

References

Abd Alla, E.A.M., K. El-Shafei, G.A. Ibrahim and O.M. Sharaf, 1996. Changes in microflora and biogenic amines of some market processed cheeses during storage. Egypt. J.Dairy Sci., 24: 217-226.

Abdel-Hamid, L.B., O.A. Zammar and A. E. Hagrass, 2002. Utilization of ripened curd slurry in processed Cheddar cheese spread making. Egypt. J. Dairy Sci., 30: 283-296.

Abdul-Hamid, A. and Y.S. Luan, 2000. Functional properties of dietary fiber prepared from defatted rice bran. Food Chemistry, 68: 15-19.

Ahram online, 2012. English.ahram.org.eg/../Egypt-production of rice… Oct. 16 2012.

Amissah, J.G.N., W.O. Ellis, I. Oduro and J.T. Manful, 2003. Nutrient composition of bran from new rice varieties under study in Ghana. Food Control, 14: 21-24.

AOAC, 1995.Official Methods of Analysis. 16th ed. Association of Official Analytical Chemists. Inc. Arlington, Virginia,USA.

APHA, 1985. Standard Methods for the Examination of Dairy Products. American Public Health Association, Washington DC, USA.

Butsat, S. and S. Siriamorpun, 2010. Antioxidant capacities and phenolic compounds of the husk, bran and endosperm of Thai rice. Food Chem., 119: 606-613.

Crowley, L. and J. Halliday, 2008. Rice bran approved as meat enhancer. www.Food Navigator.com, 2008.

Dillielio, L.R. 1982. Methods in Food and Dairy Microbiology. AVI Pub Co. Westpart. CN, USA.

De Leonardis, A., V. Macciola and N. De Monenico, 2005. A first pilot study to produce a food antioxidant from sunflower seed shells (*Helianthus annus*). Eur. J. Lipid Sci. Technol., 107: 220-227.

Douaud, C., 2007. NutraCea taking rice bran to big food players. www.FoodNavigator.com, 2007.

ESO, Egyptian Standards Organization, 2005. Standard specifications of processed cheese and spreads with vegetable oils Part II processed cheese spread. Standard No 999-2

Folkertsma, B. and P.F. Fox, 1992. Use of the Cd-ninhydrin reagent to assess proteolysis in cheese during ripening. J. Dairy Research, 59: 217-224.

Foster, G.M., K. Raina, A. Kumar, S. Kumar, R. Agarwal, M.H. Chen, J.E. Bauer, A.M. McClung and E.P. Rayan, 2013. Rice varietal differences in bioactive bran components for inhibition of colorectal cancer cell growth. Food Chem., 141: 1545-1552.

Hunter Association Lab Inc. 1976. Hunter Colorimeter Introduction manual. Hunter Lab Inc. Fairfax,VA, USA.

IDF, 1991. Rheological and fracture properties of cheeses. Bulletin No. 268, International Dairy Federation, Brussels, Belgium.

IDF, 1993. Milk. Determination of nitrogen content by Kjeldahl method. Standard B20. International Dairy Federation, Belgium

Jiamyangyuen, S., V. Srijesdaruk and W.J. Harper, 2005. Extraction of rice bran protein concentrate and its application in bread. Songklanakarin J. Sci. Technol, 27: 55-64.

Kahlon, T.S. 2009. Rice bran: Production, composition, functionality and food applications, physiological benefits. In " Fiber Ingredients: Food Applications and Health Benefits" (Eds S.S. Cho and P.Samul), pp305-321, CRS Press, Taylor Francis Group, N.Y.

Kebary, K.M.K., A.M. Abeid and R.M. Badawi, 1998. Impact of fat replacers on properties of low fat processed cheese spread. Proc. 7th Egypt Conf. Dairy Sci. Techno., 383-401.

Khader, A., A. Hamed, A.F. Al-Khamy, G.A. El-Garawany and M.H. Abd El-Salam, 1997. Chemical composition and properties of market processed cheese. Egypt J. Dairy Sci., 25: 269-279.

Kosikowski, F.V., 1986. Cheese and Fermented Milk Products. 2nd Ed Published by the Author, Cornell Univ., Ithca, NY.

Mahfouz, M.B., H.F. El-Dein, S. El-Shibiny, H.F. Haggag and M.N. Magdoub, 1986. Chemical and microbiological quality of market processed cheese. Egypt. J. Dairy Sci., 14: 33-41.

Mahmoud, S.A.Z. 1988. Practical Applied Microbiology. Egyptian Anglo Library (in Arabic).

Moongngram, A., N. Daomukda and S. Khumpika, 2012. Chemical composition, phytochemicals, and antioxidant capacity of rice bran, rice bran layer, and rice germ. APCBEE Procedia, 2: 73-79.

Montesinos-Herrero, C., D.C. Cottell, E.D. O'Riordan and M. O'Sullivan, 2006. Partial replacement of fat by functional fibre in imitation cheese: Effects on rheology and microstructure. Int. Dairy J., 24: 910-919.

Oliveira, M.G.C., P.Z. Bassinello, V.L.L. Lobo and M.M. Rinaldi, 2012. Stability and microbiological quality of rice bran subjected to different heat treatments. Ciênc. Tecnol. Aliment., Campinas, 32: 725-732.

Pourali, O., F.S. Asghari and H.Yoshida, 2010. Production of phenolic compounds from rice bran biomass under subcritical water conditions. Chem. Eng. J., 160: 259-266.

Savello, P.A., C.A. Ernstrom and M. Kalab, 1989. Microstructure and meltability of model process cheese made with rennet and acid casein. J. Dairy Sci., 72: 1-12.

Snedecor, G.W. and W.G. Cochran, 1980. Statistical Methods. Sixth Ed.The Iowa State University Press, Ames, Iowa, USA.

Sultana, B., F. Anwar and R. Przybylski, 2007. Antioxidant activity of phenolic components present in barks of *Azadirachta indica*, *Terminalia arjuna*, *Acacia nilotica*, and *Eugenia jambolana* Lam. trees. Food Chem., 104: 1106-1114.

Thomas, M.A., 1973. The use of hard milk fat fraction in processed cheese. Aust.J.Dairy Technol., 28: 77-83.

Zaki, S.M., S. Taha, S. El-Henawy and H. Abdel Gawad, 1970. Lipolytic microorganisms in rice bran. Bull. N. 378 Faculty of Agric. Ain-Shams University.