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Substitution of Wheat Flour with Rice Flour and Rice Bran in Flake Products: Effects on Chemical, Physical and Antioxidant Properties

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Abstract: Rice flour and rice bran were used to substitute wheat flour in flake product in order to increase the nutrition value to consumers and add value to rice grain. Mixture design was applied to generate the various formulae under the constraint of wheat flour (WF) 40-70%, rice flour (RF) 0-57% and rice bran (RB) 0-30%. Consequently, the Scheffe regression was used to optimize the formulation. As a result, 10 formulae were studied and determined for physical, chemical and sensory properties. Proportion of 70% WF: 15% RF: 15% RB showed the highest sensory scores of all formulae and was not significantly different ($p<0.05$) compared with the commercial flake product. The results showed that all flakes substituted with, rice flour and rice bran had higher ash, protein, lipid and fiber contents than control (100% wheat flour). A greater values of antioxidant activities as measured by DPPH radical scavenging and, ferric reducing/antioxidant power (FRAP) than those of control was observed. This study has demonstrated that rice flour and rice bran could be used for wheat substituting, especially rice bran could be considered as a good functional ingredient for value adding of food products.

Key words: Flake・Antioxidant・Fatty acids・Fiber・DPPH・FRAP

INTRODUCTION

Rice is a staple food for more than half of world population. The major rice growing countries are Thailand, China, India, Indonesia, Bangladesh, Burma, Vietnam, Japan and the Philippines [1]. Although Thailand is one of the biggest rice exporters and growers, the utilization of rice is narrow compared with that of other cereals such as wheat in other parts of the world. Rice flour is considerably lower protein content compared with wheat flour and does not contain gluten, a viscoelastic protein helping in forming dough structure. Gluten in wheat is well-known as a unique protein containing gliadin and glutenin proteins which provides viscoelasticity for bakery products. This, in turns, is disadvantageous for wheat flour beacuse there is an evident that gluten can cause allergy namely, Celiac Sprue Disease to some people [2]. To avoid such problem, other cereal such as rice should be a good alternative source to replace wheat flour. Rice bran, as a rice by product has been claimed a good source of protein, fat and antioxidants, but is currently under-utilized, in spite of its high potential as a raw material for the preparation of functional foods or nutraceuticals. Rice bran is the outer layer of brown rice kernel which is removed while milling brown rice to white. The bran is primarily comprised pericarp, aleurone and subaleurone layers of kernel and typically includes the embryo or germ and small amount of starchy endosperm [3]. Rice bran powder is high protein, fiber and bioactive compounds [4], offers benefits like lowering of blood cholesterol [5-6] and decreases the incidence of artherosclerosis disease [7] and had laxative effect [4].

In Thailand, the popularity of bakery products including bread, cake and breakfast cereal are increasing due to western influence [8]. Fortification of rice flour and bran is evident across a number of markets, having found application in bread [1], fried dough [5]. However, there has been little work reported on using rice flour and rice bran for making flake products. Rice flakes are the main

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ingredients of many rice cereal products such as breakfast cereal. Using rice flour and rice bran in products such as flakes is a way of value adding to this grain. In addition, substituting wheat flour with rice flour provides a product that may be more suitable for individual suffering from Celiac Sprue Disease [2]. Previous research has shown that rice bran is beneficial for human health. It contains high protein significant amounts of antioxidants such as tocopherols, tocotrienol, gamma-oryzanol [9-11]. Therefore, substitution of rice flour and rice bran in flake products will increase the nutrition value and also provide health benefits to consumers.

The objectives of this study were to produce flake product by using rice flour and rice bran to substitute wheat flour and to compare qualities of the flakes including physical, chemical and sensory properties as well as antioxidant activities. This attempt was made to produce better and nutritious rice products and value adding to rice flour and especially rice bran, which is likely to be ignored and considered as waste product. In addition, substituting wheat flour with rice flour provides a product that may be more suitable for individual suffering from gluten allergy.

MATERIALS AND METHODS

Materials: Rice flour and wheat flour were purchased from local market (Maha sarakham, Thailand). Rice bran powder was prepared by milling rice grain (Khao Dawk Mali 105 variety) and grinding mill followed by sieving to separate grain from bran. Rice bran was ground and then passed through to 80 mesh sieves. These processes were done in a laboratory of Food Technology and Nutrition Department, Mahasarakham University.

The Flakes Processing: Mixture design was applied to generate the various formulae under the constraint of wheat flour 40-70%, rice flour 0-57% and rice bran 0-30%. Consequently, the Scheffe regression was used to optimize the formulation. As a result, 10 formulae were studied and determined for physical, chemical and sensory properties.

Flakes were produced with a rice bran powder, rice flour and wheat flour calculated on flour basis according to a mixture design with three components. Rice bran was milled into rice bran powder and passed through an 80 mesh. The rice bran powder was wet mixed with rice flour, wheat flour, palm oil, raising agent and water using standard including five main steps, namely, mixing, gelatinization, particle forming, flaking rolls and toasting was used for all formulations.

Extraction Procedure in the Flakes: The extracts prepared of antioxidant compounds from the rice flake were made by methanol for 5 min. The ratio between sample and extraction medium was 1:25. The mixtures were filtered through a filter paper (Whatman No. 1) [12] and used for analyzing antioxidant activity *in vitro*. All analyses were performed in three replicates.

The lipids were extracted according to the method of Bligh and Dyer[13]. Approximately 5 g of well-ground samples was extracted with 50.0 mL of chloroform-methanol (2:1, v/v) containing 10 mg/L of butylated hydroxytoluene and 0.1 mg/mL of nanodecanoic acid (C19:0, Sigma) as an internal standard. Then, the samples were stored in a fume hood overnight. Each sample was filtered and transferred into a separate funnel and added with 15 mL of 0.9% sodium chloride. The samples were shaken well to allow the phases to separate; the lower phase was then evaporated and transferred into a 10-mL volumetric flask.

Proximate Composition: The samples were analyzed for proximate composition (moisture, protein, fat, carbohydrate, ash and fiber) by the standard procedures of Association of Analytical Chemists (AOAC) [14]. However, protein values were subsequently obtained by using a factor of 6.25 for rice flake, 5.70 for wheat flour, 5.95 for rice flour and 6.31 for rice bran powder. Carbohydrate content (i.e. Nitrogen Free Extracts) of the sample was determined by subtracting the sum of the weights of moisture, protein, fat, ash and fiber from the total dry matter [15].

Physical Measurements: Color in sample were determined by a Minolta CR-300 Chroma Meter (Minolta, Japan) in L^*, a^*, b^* color scale. The texture was measured by adjusting the portion of the compression plunger until it barely touched the surface of the bread at the centre of the sample. Texture profile analysis of rice flake was performed at room temperature by using a TA-XT2 Texture Analyzer (Ltd in Godalming, Surrey UK) with 5-kg load cell. The plunger was then lowered at a constant speed until it compressed the sample to a predetermined degree (percentage of compression). The resulting peak force was measured in Newton.

Sensory Evaluation: Sensory evaluations of rice flake were conducted by 30 panelists, consisting of Department of Food technology and nutrition students, using a nine-point hedonic scale for five attributes (color, odor, taste, texture and overall acceptability) where nine is like extremely and one dislike extremely. Three coded samples were served and water was provided for rinsing between samples. Commercial flake product (10% rice flour and 5% rice bran added flake) was used to compared with our product for sensory test.

Antioxidant Activity: DPPH radical scavenging activity: The hydrogen atom or electron donation ability of the corresponding extracts and some pure compounds was measured from the bleaching of purple colored methanol solution of DPPH [16]. The antioxidant activity of the extracts, on the basis of the scavenging activity of the stable 1,1-diphenyl-2-picrylhydrazyl (DPPH) free radical, was determined by the method described by Braca *et al*. [17]. Aqueous extract (0.1 ml) was added to 3 ml of a 0.004% MeOH solution of DPPH. Absorbance at 517 nm was determined after 30 min and the percent inhibition activity was calculated as [(Ao-Ae)/Ao]x100 (Ao= Absorbance without extract; Ae = absorbance with extract).

Ferric Reducing/antioxidant Power (FRAP) Assay: FRAP assay was based on the reduction of Fe3+-TPTZ to a bluecoloured Fe2+-TPTZ [18]. The FRAP assay was adapted from Moyer *et al*, Hummer, Finn, Frei and Wrolstad [19]. The antioxidant potential of the extract sample from citrus peel was determined against a standard curve of ferrous sulphate (FeII, 0, 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0 mM) in Milli-Q water or methanol with 0.1% (v/v) HCl. The FRAP reagent was freshly prepared by mixing 100 ml of acetate buffer (300 mM, pH 3.6), 10 ml TPTZ solution (10 mM TPTZ in 40 mM/HCl), 10 ml $FeCl_3$ ●6H2O (20 nM) in a ratio of 10:1:1 and 12 ml distilled water, at 37° C. To perform the assay, 1.8 ml of FRAP reagent, 180 ll Milli-Q water and 60 µl sample, standard or blank were then added to the same test tubes and incubated at 37° C for 4 min; absorbance was measured at 593 nm, using FRAP working solution as blank. The reading of relative absorbance should be within the range 0-2.0; otherwise, the sample should be diluted. In the FRAP assay, the antioxidant potential of sample was determined from a standard curve plotted using the $FeSO_4$-7H2O linear regression equation to calculate the FRAP values of the sample.

Fatty Acid Analysis: Fatty acid methyl esters (FAMEs) of the total lipid extract were prepared by transesterfication in H_2SO_4 (0.9 mol/L in methanol). Before injection into the gas chromatograph, the FAMEs were filtered by Sep-pak silica column (Alltech Associates, Inc., Deerfield, IL). Samples (1 mL) were analyzed quantitatively using a Shimadzu model GC-2014 system (Shimadzu, Tokyo, Japan) fitted with flame ionization detection eluted with H_2 at 30 ± 1 mL/min, with a split ratio of 1:17. A fused silica capillary column (30 m x 0.25 mm, 25 µm film thickness; DB-Wax, USA) was used. The injector and detector were maintained at 250 °C. Nitrogen was used as a carrier gas and temperature programming was from 150°C (hold 5 min) to 230°C at 15°C/min, then to 170 °C (hold 10 min) at 10°C/min, then to 200°C (hold 3 min) at 5°C/min and then to 230°C (hold 2 min) at 15°C/min. Fatty acids were identified by comparison with standard mixtures of FAME and quantitative data were calculated using peak areas compared with the added internal standard:nanodecanoic acid (C 19:0) [20].

Statistical Analyses: Statistical analyses were conducted using SPSS (Statistical Program for Social Sciences, SPSS Corporation, Chicago, IL) version 12.0 for Windows. Data were presented as mean ± SD in all tables analyzed by general analysis of variance.

RESULTS AND DISCUSSION

Proximate Composition: The chemical composition of raw material preparations used in this study is presented in Table 1. Rice bran powder contained significantly higher contents of protein, fat, ash and fiber than did wheat flour and rice flour. Carbohydrate was the predominant chemical components in rice flour containing slightly but significantly ($p<0.05$) higher amylose content than that in wheat flour. The chemical composition of the flakes is shown in Table 2. As illustrated, protein, fat, ash and fiber of the flakes were increased with increasing proportion of rice bran powder. While, an increase of carbohydrate content was resulted from addition of RF (Table 2). Previous studies reported that rice bran is a rich source of fiber and considerably high protein and fat content [1]. An increase of fiber content in rice flour and rice bran-incorporated flakes may contribute to health benefits. It has been reported that intake more fiber resulted in increasing faecal bulk and lowering of plasma cholesterol [21].

Physical Property: Physical characteristic of rice flake shows in Table 3 represent color and texture parameters. For all color parameters, the extent of color change in rice flake was dependent on the proportion of rice flour, wheat flour and rice bran powder. Overall, a steady showed that $L*$ value of rice flake fortified with rice bran decreased with rice bran powder increased, while $a*$ and $b*$ value increased with rice bran powder increased. Darkness of the flakes was directly related to increased rice bran powder. This supports the report from previous study

Table 1: Chemical composition of raw material (%)

Components	Wheat flour	Rice flour	Rice bran powder
Moisture	13.67±0.20 ^{a}	11.77±0.06 ^{b}	12.34±0.24 ^{b}
Protein	11.00±0.00 ^{b}	6.83±0.11 ^{c}	13.17±0.12 ^{a}
Fat	1.25±0.00 ^{b}	0.21±0.00 ^{c}	20.36±0.01 ^{a}
Carbohydrate	69.04±0.21 ^{b}	80.35±0.16 ^{a}	32.37±0.26 ^{c}
Ash	0.53±0.01 ^{b}	0.22±0.01 ^{c}	11.12±0.01 ^{a}
Fiber	4.51±0.00 ^{b}	0.61±0.01 ^{c}	11.39±0.00 ^{a}
Amylose	33.50±0.06 ^{b}	35.36±0.06 ^{a}	3.63±0.06 ^{c}

Values are expressed as means ± standard deviation (n = 3).

^{a,b} Values in the same row followed by different letters are significantly different ($p < 0.05$)

Table 2: Chemical composition of substitution of wheat flour with rice flour and rice bran in flake products (%)

Sample (WF: RF: RB)	Moisture	Protein	Fat	Carbohydrate	Ash	Fiber
43: 57: 0	10.00±0.24 ^{b}	8.62±0.09 ^{g}	4.05±0.02 ^{i}	69.73±0.21 ^{a}	5.02±0.07 ^{h}	2.59±0.00 ^{j}
70: 15: 15	6.94±0.09 ^{e}	11.06±0.03 ^{e}	8.11±0.02 ^{h}	63.43±0.07 ^{b}	7.79±0.06 ^{g}	3.66±0.01 ^{i}
50: 25: 25	10.86±0.04 ^{a}	10.74±0.11 ^{f}	9.84±0.18 ^{g}	57.04±0.12 ^{c}	7.72±0.02 ^{f}	3.81±0.01 ^{h}
55: 15: 30	7.49±0.12 ^{cde}	11.04±0.08 ^{e}	9.93±0.00 ^{g}	57.75±0.48 ^{c}	8.28±0.34 ^{e}	5.51±0.01 ^{g}
56: 7: 37	8.09±0.14 ^{c}	11.38±0.04 ^{d}	11.84±0.03 ^{f}	53.17±0.13 ^{d}	9.23±0.01 ^{d}	6.28±0.00 ^{f}
60: 0: 40	7.74±0.14 ^{cd}	11.64±0.08 ^{cd}	12.72±0.01 ^{e}	51.11±0.16 ^{e}	9.67±0.01 ^{d}	7.13±0.01 ^{e}
43: 7: 50	9.44±0.07 ^{b}	11.72±0.13 ^{bc}	14.51±0.16 ^{c}	46.52±0.30 ^{g}	10.34±0.04 ^{c}	7.46±0.00 ^{d}
50: 0:50	7.83±0.09 ^{cd}	11.92±0.02 ^{abc}	13.82±0.15 ^{d}	48.53±0.11 ^{f}	10.24±0.29 ^{c}	7.65±0.01 ^{c}
45: 0: 55	6.83±0.12 ^{e}	11.94±0.08 ^{ab}	15.50±0.43 ^{b}	46.34±0.12 ^{g}	11.31±0.04 ^{b}	8.01±0.01 ^{b}
40: 0: 60	7.32±0.49 ^{de}	12.15±0.02 ^{a}	17.16±0.02 ^{a}	42.91±0.55 ^{h}	11.92±0.05 ^{a}	8.54±0.01 ^{a}

Values are expressed as means ± standard deviation (n = 3).

WF (wheat flour), RF (rice flour): RB (rice bran powder)

^{a,b} Values in the same column followed by different letters are significantly different ($p < 0.05$).

Table 3: Physical characteristic of substitution of wheat flour with rice flour and rice bran in flake products

	Color			Texture	
Sample (WF: RF: RB)	*L**	*a**	*b**	hardness(Newton)	crispness(Peaks)
43: 57: 0	86.74±2.61 ^{a}	-1.30±0.08 ^{d}	14.03±1.25 ^{e}	115.66±1.49 ^{a}	5.33±0.58 ^{d}
70: 15: 15	78.74±0.56 ^{b}	1.80±0.01 ^{c}	23.81±0.11 ^{d}	83.15±0.90 ^{cd}	11.00±1.73 ^{abc}
50: 25: 25	76.48±0.54 ^{bc}	2.69±0.65 ^{c}	25.68±2.11 ^{cd}	93.91±1.32 ^{b}	12.00±1.73 ^{ab}
55: 15: 30	73.54±0.25 ^{bcd}	2.91±0.37 ^{bc}	26.10±2.22 ^{cd}	84.01±1.75 ^{c}	9.33±0.58 ^{bcd}
56: 7: 37	73.23±0.85 ^{bcd}	3.46±0.61 ^{bc}	26.84±0.95 ^{cd}	79.29±1.36 ^{de}	13.67±1.15 ^{a}
60: 0: 40	63.71±1.92 ^{ce}	7.99±0.85 ^{a}	35.97±0.82 ^{a}	84.16±1.01 ^{c}	11.33±1.53 ^{ab}
43: 7: 50	77.09±1.07 ^{cd}	3.53±0.42 ^{bc}	25.98±1.95 ^{cd}	80.97±0.95 ^{cde}	7.00±0.00 ^{cd}
50: 0:50	66.91±2.43 ^{de}	5.00±0.55 ^{b}	30.40±1.67 ^{bc}	79.24±0.88 ^{de}	8.67±0.58 ^{bcd}
45: 0: 55	67.68±3.79 ^{de}	8.05±0.87 ^{a}	35.40±0.41 ^{ab}	77.38±0.10 ^{e}	12.00±1.00 ^{ab}
40: 0: 60	57.02±1.32 ^{ef}	8.81±0.70 ^{a}	33.18±1.10 ^{ab}	79.84±0.87 ^{cde}	12.00±1.00 ^{ab}

Values are expressed as means ± standard deviation (n = 3)

WF (wheat flour), RF (rice flour): RB (rice bran powder)

^{a,b} Values in the same column followed by different letters are significantly different ($p < 0.05$).

Table 4: Sensory score of substitution of wheat flour with rice flour and rice bran in flake products (nine-point hedonicscale)

	Sensory score				
Sample (WF: RF: RB)	Color	Odor	Taste	Texture	Overall acceptability
Commercial product	6.33 ± 1.39[bc]	6.10 ± 1.27[a bc]	7.13 ± 1.38[a]	7.07 ± 1.14[a]	7.21 ± 1.22[a]
43: 57: 0	5.93 ± 1.27[c]	5.84 ± 1.02[c]	5.79 ± 1.41[c]	5.79 ± 1.37[b]	5.77 ± 1.22[b]
70: 15: 15	7.12 ± 0.88[a]	6.58 ± 1.16[ab]	6.92 ± 0.86[ab]	6.94 ± 0.84[a]	7.10 ± 0.86[a]
50: 25: 25	7.02 ± 0.98[ab]	5.91 ± 1.05[c]	6.09 ± 1.14[c]	6.16 ± 1.08[b]	6.30 ± 1.00[b]
55: 15: 30	6.01± 1.07[c]	5.93 ± 0.87[bc]	5.91 ± 0.93[c]	5.99 ± 1.00[b]	5.97 ± 0.83[b]
56: 7: 37	5.96 ± 1.05[c]	6.67 ± 1.06[a]	6.24 ± 0.94[bc]	5.99 ± 1.19[b]	6.33 ± 0.94[b]
60: 0: 40	5.93 ± 1.03[c]	6.09 ± 0.86[abc]	6.11 ± 0.84[c]	6.06 ± 0.85[b]	5.94 ± 0.99[b]
43: 7: 50	6.01 ± 1.16[c]	6.13 ± 0.97[abc]	5.79 ± 1.28[c]	5.76 ± 1.18[b]	5.91 ± 1.10[b]
50: 0:50	6.39 ± 0.92[bc]	6.68 ± 1.05[a]	6.16 ± 1.11[c]	6.04 ± 1.31[b]	6.28 ± 1.08[b]
45: 0: 55	5.74 ± 1.12[c]	6.04 ± 0.90[a bc]	5.70 ± 1.09[c]	5.71 ± 1.10[b]	5.87 ± 1.04[b]
40: 0: 60	6.86 ± 1.20[ab]	6.06 ± 0.93[abc]	6.02 ± 0.98[c]	6.10 ± 1.09[b]	6.08 ± 1.16[b]

Values are expressed as means ± standard deviation (n = 30).

WF (wheat flour), RF (rice flour): RB (rice bran powder)

[a,b] Values in the same column followed by different letters are significantly different ($p < 0.05$).

that addition of rice bran fiber caused darkness of bread crumb, resulting from fiber [1]. In data represents influence of rice bran powder on the texture of the flakes. Replacement of rice bran powder with increasing significantly decreased the hardness values from 115.66 to 79.84 N. The crispness values were not significantly different in different samples.

Sensory Evaluation: Table 4 shows sensory score for color, odor, taste, texture and overall acceptability of rice flake. Odor, taste, texture and overall acceptability were not found to be significantly different compared with commercial product when proportion of rice flour, wheat flour and rice bran powder that 15: 70: 15 and showed the highest sensory scores over other formulas. The scores for all characteristic tests of rice flake were all at acceptable values. Sensory evaluations revealed the rice flake fortified with rice bran were overall acceptable (score 7 out of 9) and not significantly different compared to that of commercial one. Panelists also commented that the flakes were comparable to rice commercial flakes currently available in the market. This confirms that the rice bran powder preparations from rice bran have great potential in food applications, especially in development of functional foods including functional snack products.

Antioxidant Activity: DPPH is a free radical compound and has been widely used to test the free radical-scavenging ability of various samples [22-24]. It is a stable free radical with a characteristic absorption at 517 nm, was used to study the radical-scavenging effects of extracts. As antioxidants donate protons to this radical, the absorption decreases. To evaluate the scavenging effects of methanol extract of rice flake, DPPH. inhibition was investigated. Antioxidant activities of rice flake fortified with rice bran compared with unfortified product are shown in Fig. 1. The percentage of DPPH radical scavenging activity significantly increased by 27.74 % for the flake substituted with rice bran compared to commercial product (100% wheat flour). In addition, the the flake substituted with rice bran had lower IC_{50} values than commercial product. FRAP assay measures the reducing potential of an antioxidant reacting with a ferric tripyridyltriazine (Fe3+-TPTZ) complex and producing a coloured ferrous tripyridyltriazine (Fe2+-TPTZ) [18, 25]. Generally, the reducing properties are associated with the presence of compounds which exert their action by breaking the free radical chain by donating a hydrogen atom [26-27]. According to Benzie and Strain [18], the reduction of Fe3+-TPTZ complex to blue-coloured Fe2+-TPTZ occurs at low pH. FRAP values of the extracts of fortified rice flake (11.94) were significantly higher than that of unfortified product (6.60 mM FeSO4/g sample).

Rice bran contains a significant amount of natural phytochemicals such as oryzanols, tocopherols and tocotrienols that have been reported as the strongest antioxidants in rice bran [9-11]. The tocopherols and tocotrienols can be used as radical scavengers, terminating the propagation of radicals and generating unreactive phenoxyl radicals as well as hydroperoxide products [28]. In addition, rice bran contains a phenolic content higher than wheat bran. The phenolic compounds showed higher antioxidant activities, in contrast to tocopherol [29]. While, tocotrienols as a lipophilic

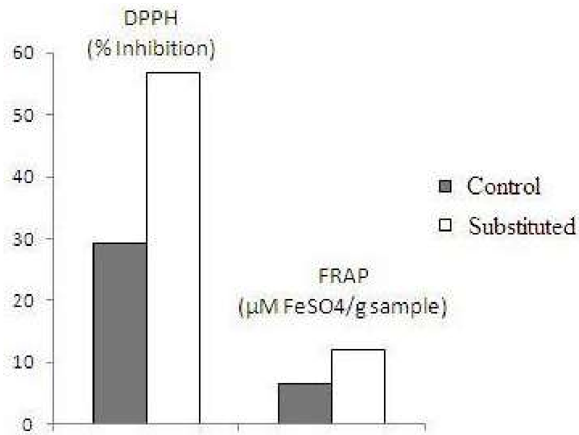

Fig. 1: Antioxidant activity of the flakes Substitution of wheat flour with rice flour and rice bran compared with control.

Table 5: Fatty acid composition in flake compared with control (% of total fatty acid)

	flake ($\bar{x}$ ± SD)	
Fatty acid	Control	Substituted
Saturated fatty acid		
C14:0	0.21±0.01[a]	0.08±0.00[b]
C15:0	0.45±0.00[b]	0.54±0.01[a]
C16:0	24.14±0.02[b]	24.93±0.02[a]
C18:0	2.61±0.18[a]	2.36±0.01[b]
C20:0	0.27±0.02[b]	0.29±0.00[b]
Total	27.68±0.23[b]	28.20±0.04[a]
Monounsaturated fatty acid		
C16:1	0.16±0.01[b]	0.19±0.00[a]
C17:1	0.08±0.00[a]	0.04±0.00[b]
C18:1	30.56±0.04[b]	32.47±0.01[a]
Total	30.80±0.05[b]	32.70±0.01[a]
Polyunsaturated fatty acid		
C18:2n-6	20.04±0.10[b]	23.71±0.11[a]
C18:3n-3	20.59±0.12[a]	14.37±0.05[b]
C18:3n-6	0.89±0.01[b]	1.02±0.01[a]
Total	41.52±0.23[a]	39.10±0.17[b]
Lipid content (%)	0.54±0.03[b]	1.91±0.11[a]

Values are expressed as means ± standard deviation (n = 3)
Control (100% wheat flour)
[a,b] Values in the same column followed by different letters are significantly different ($p < 0.05$).

antioxidant, have shown peculiar physiological potential including antitumor properties toward mammary cancer [30-31] reducing serum chloresterol effects [32] and anti-inflamation [33]. Previous studies have reported that intake of a tocotrienol-rich fraction of rice bran lowers serum total and LDL-cholesterol concentrations in hypercholesterolemic person [32,34]. Full-fat rice bran, when added to the prudent diets of moderately hyperlipidemic individuals, produced significant cholesterol reduction and improvement in the LDL-C: HDL-C ratio in most of these individual [35]. Other studies have demonstrated the gamma-oryzanol in stabilized rice bran decreases cholesterol absorption and inhibit aortic fatty streak formation in hamsters [36].

Fatty Acid Composition: Lipid content and lipid acid composition were compared between substituted and non-substituted flakes as shown in Table 5. In general, polyunsaturated fatty acid (PUFA) was the most predominant fatty acid in both samples, followed by monounsaturated fatty acid (MUFA) and saturated fatty acid (SFA) (Table 5). Addition of 15% rice bran effected on increased in MUFA and SFA but decreased in PUFA. A slight but significant increase of 18:1 and 18:2n-6 in substituted RF and RB flakes was observed. A likely explanation is that 18:1 and 18:2n-6 which are found abundant in rice bran contributed to fatty acid composition of the flakes [5]. However, a decrease of PUFAs in substituted RF and RB flakes resulted from lower content in 18:3n-3 in RF and RB than in WF. Two essential fatty acids are ALA and LA. Which, must be supplied in the diet because our body cannot synthesize them. LA and ALA are the starting point for synthesis of variety of other unsaturated fatty acid [37]. Oleic acid has been reported to be responsible for the reduction in blood pressure [38].

CONCLUSION

This study has demonstrated that addition of rice bran was found to increase fiber and ash contents in flake products. More importantly, antioxidant activities of the flakes were significantly higher than control (no added rice bran). An increase of fiber and ash contents in RF and RB-incorporated flakes may contribute to health benefits, for example increasing faecal bulk and lowering of plasma cholesterol. Flakes product could be made from a significant proportion of RF and RB with an overall acceptable. This study has also demonstrated that rice bran could be considered as a good functional ingredient for adding value of food product.

REFERENCES

1. Hu, G., S. Huang, S. Cao and Z. Ma, 2009. Effect of enrichment with hemicelluloses from rice bran on chemical and functional properties of bread. Food Chem., 115: 839-842.

2. Steve Helms, N.D., 2005. Celiac Disease and Gluten-Associated Diseases. Alternative Med. Rev., 10: 172-192.
3. Tahira, R., Ata-ur-Rehman and M.A. Butt, 2007. Characterization of rice bran oil. J. Agric. Res., 45(3): 225-230.
4. Saunders, R.M., 1990. The properties of rice bran as a food stuff. CFW., 35: 632-636.
5. Chotimarkorn, C. and Silalai, 2007. Oxidative stability of fried dough from rice flour containing rice bran powder during storage. LWT, 41: 561-568.
6. Kahlon, T.S., F.I. Chow and R.N. Sayre, 1994. Cholesterol lowering properties of rice bran. CFW, 39: 99-103.
7. Saunders, R.M., 1985. Rice bran: composition and potential food uses. Food Rev Int., 1: 465-495.
8. Anon Dalodom, 1997. Rice and rice products research program. Kasetsart University, Bangkok, Thailand.
9. Godber, J.S. and B.O. Juliano, 2004. Rice lipids. In E.T. Champagne (Ed.), Rice: Chemistry and technology (3rd ed., pp: 163-190). Minnesota: American Association of Cereal Chemists Inc.
10. Godber, J.S. and J.H. Wells, 1994. Rice bran: As a viable source of high value chemicals. La Agr, 37(2): 13-17.
11. Orthoesfer, F.T. and J. Eastman, 2004. Rice bran and oil. In E.T. Champagne (Ed.), Rice: Chemistry and technology, (3rd ed., pp: 569-593). Minnesota: American Association of Cereal Chemists Inc.
12. Dasgupta, N. and B. De, 2004. Antioxidant activity of Piper betle L. leaf extract in vitro. Food Chem, 88: 219-224.
13. Bligh, E.G. and W.J. Dyer, 1959. A Rapid Method of Total Lipid Extraction and Purification. Canadian J. Biochem. Physiol., 37: 911-917.
14. AOAC, 1996. Official Method of Analysis. 16th (Ed.) Association of Official Analytical Chemists, Washington D.C.
15. Adeduntan, S.A., 2005. Nutritional and Antinutritional Characteristics of Some Insects Foragaing in Akure Forest Reserve Ondo State, Nigeria. J. Food Tech Af., 3(4): 563-567.
16. Gulluce, M., F. Sahin, M. Sokmen, H. Ozer, D. Daferera, A. Sokmen, *et al.,* 2007. Antimicrobial and antioxidant properties of the essential oils and methanol extract from Mentha longifolia L. ssp. longifolia. Food Chem, doi: 10. 1016/.j.foodchem. 2006.10.061.
17. Braca, A., Tommasi, D. Nunziatina, Bari, Lorenzo, Di, Pizza, Cosimo, Politi, Mateo, Morelli and Ivano, 2001. Antioxidant principles from Bauhinia terapotensis. J. Nat. Prod., 64: 892-895.
18. Benzie, I.F.F. and J.J. Strain, 1996. The ferric reducing ability of plasma as a measure of ''antioxidant power" the FRAP assay. Anal Biochem., 239: 70-76.
19. Moyer, R.A., K.E. Hummer, C.E. Finn, B. Frei and R.E. Wrolstad, 2002. Anthocyanins, phenolics and antioxidant capacity in diverse small fruits: Vaccinium, Rubus and Ribes. J. Agr. Food Chem., 50: 519.
20. Yang, L.F., S. Siriamornpun and D. LI, 2006. Polyunsaturated fatty acid content of edible insects in Thailand. J. Food Lipids, 13: 277-285.
21. Varo, P., R. Laine and P. Koivistoinen, 1983. Effect of heat treatment on dietary fibre: Interlaboratory study. J. Association Analysis Chem., 66(4): 933-938.
22. Hatano, T., M. Takagi, H. Ito and T. Yoshida, 1997. Phenolic constituents of liquorice. VII. A new calcone with a potent radical scavenging activity and accompanying phenols. Chem Pharmaceut Bull, 45: 1485-1492.
23. Sakanaka, S., Y. Tachibana and Y. Okada, 2005. Preparation and antioxidant properties of extracts of Japanese persimmon leaf tea (kakinoha-cha). Food Chem., 89: 569-575.
24. Shimoji, Y., Y. Tamura, Y. Nakamura, K. Nanda, S. Nishidai, Y. Nishikawa, *et al*., 2002. Isolation and identification of DPPH radical scavenging compounds in kurosu (Japanese unpolished rice vinegar). J. Agr. Food Chem., 50: 6501-6503.
25. Kubola, J. and S. Siriamornpun, 2008. Phenolic contents and antioxidant activities of bitter gourd (*Momordica charantia* L.) leaf, stem and fruit fraction extracts in vitro. Food Chem., 110: 81-890.
26. Duh, P.D., P.C. Du and G.C. Yen, 1999. Action of methanolic extract of Mung bean hulls as inhibitors of lipid peroxidation and non-lipid oxidative damage. Food Chem Toxicol., 37: 1055-1061.
27. Gordon, M.H., 1990. The mechanism of antioxidant action in-vitro. In B.J.F. Hudson (Ed.), Food antioxidants (pp: 1-18). London: Elsevier Appl. Science.
28. Kitts, D., 1997. An evaluation of the multiple effects of the antioxidant vitamins. Trends Food Sci Tech, 8(6): 198-203.
29. Chen, J. and C.T. Ho, 1997. Antioxidant activities of caffeic acid and its relates hydroxycinnamic acid compounds. J. Agr. Food Chem., 45: 2374-2378.

30. Guthrie, N., A. Gapor, A.F. Chambers and K.K. Carroll, 1997. Inhiition of proliferation of estrogen receptor-negative MDA-MB-435 and-positive MCF-7 human breast cancer cells by palm oil tocotrienols and tamoxifen, alone and in combination. J. Nutr., 127(3): 544S-548S.
31. Nasaretnam, K., 2005. Palm tocotrienols and cancer. In D. Bagchi and H.G. Preuss (Eds.), Phytopharmaceuticals in cancer chemoprevention (pp: 481-490). London: CRC Press.
32. Qureshi, A.A., S.A. Sami, W.A. Salser and F.A. Khan, 2002. Dose dependent suppression of serum cholesterol by tocotrienol-rich fraction (TRF_{25}) of rice bran in hypercholesterolemic humans, Atherosclerosis, 161: 199-207.
33. Akihisa, T., K. Yasukawa, M. Yamaura, M. Ukiya, Y. Kimura, N. Shimizu, *et al.,* 2000. Triterpene alcohol and sterol ferulates from rice bran and their anti-inflammatory effects. J. Agr. Food Chem., 48: 2313-2319.
34. Qureshi, A.A., B.A. Bradlow, W.A. Salser and L.D. Brace, 1997. Novel tocotrienols of rice bran modulate cardiovascular disease risk parameters of hypercholesterolemic humans. J. Nutr. Biochem., 8: 290-298.
35. Gerhardt, A.L. and N.B. Gallo, 1998. Full-fat rice bran and oat bran similarly reduce hypercholesterolemia in humans. J. Nutr., 128: 865-869.
36. Rong, N., L.M. Ausman and R.J. Nicolosi, 1997. Oryzanol decreases cholesterol absorption and aortic fatty streaks in hamsters. Lipids, 32: 303-309.
37. de Lorgeril, M. and P. Salen, 2004. Alphalenoleic acid and coronary heart disease. Nutr Metabol Cardiovasc Dis., 14: 162-169.
38. Teres, S., G. Barcelo, M. Benet, R. Alarez, R. Bressani, J.E. Halver and P.V. Escriba, 2008. Oleic acid content is responsible for the reduction in blood pressure induced by olive oil. PNAS. 105(37): 13811-13816.