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Original Article

Development of instant noodles from high-iron rice and iron-fortified rice flour

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Abstract

Instant high-iron noodles, prepared from wheat flour and high iron brown rice flour, were developed. Three varieties of rice flour, Suphan Buri 90 (SB), Homnin 313 (HW) and Homnin 1000 (HP), containing amylose content of 30.40, 19.10 and 15.74% (w/w) and iron content of 1.24, 2.04 and 2.22 (mg/100 g) respectively, were used to replace wheat flour for instant fried noodle production. To determine the physicochemical properties and acceptability of instant fried noodles, different percentages (30, 40, 50%) (w/w) of each rice flour sample were used. The instant fried noodles were fortified with ferrous sulphate at levels of 0, 32, 64% iron of RDI per serving. Increasing amount of iron content in the mixtures decreased the L* value, b* value and increased a* value for the color of the instant fried noodle with brown rice flour. The texture characteristic of the noodles with 30, 40, 50% replacement with each variety of brown rice flour were significantly different from those of wheat noodle. Tensile force of the noodles decreased from 11.57±1.30 g to 6.38±1.45 g (SB), 8.36±0.96 g to 5.71±0.57 g (HP) and 10.09±1.20 g to 5.46±1.31 g (HW) as the rice flour content increased from 30 to 50%. The sensory acceptability of the noodles made from each variety of 30% brown rice flour fortified with 32% iron of RDI had higher preference scores for elasticity, firmness, color and overall acceptability, than those with 64% iron of RDI. Instant fried noodles with HW and HP brown rice flour were subjected to consumer test using 100 rural primary school children. The frequency percent of the acceptability scores of the noodle with HP and HW were 88 and 84% respectively. Shelf life study revealed that the developed products were still acceptable up to 4 months. These products were claimed to be high iron noodle.

Keywords: instant fried noodle, iron, brown rice flour

1. Introduction

Iron deficiency is considered to be the common nutritional deficiency worldwide and affects approximately 20% of the world population (Martinez-Navarrete *et al.,* 2002). Women and young children are especially at risk. Iron deficiency effects include lower growth rate and impaired cognitive scores in children and poor pregnancy outcome and lower working capacity in adults. (Walker, 1998). The fortification of foods is often regarded as the most cost-effective, long-term approach to reducing the prevalence of iron deficiency (Hurrel, 1997).

A combination of an iron fortificant compound and food vehicle must be selected which is safe, acceptable to and consumed by the target population. It does not affect the organoleptic qualities and shelf-life of food vehicles, and provides iron in a stable, highly bioavailability form (Martinez-Navarrete *et al.,* 2002).

Food vehicles and iron compounds have to be matched in order to optimize iron bioavailability and to avoid rancidity in food, thereby spoiling its taste and odour.

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Cereal flour and products are currently the most frequently used for iron fortification. However, tthese products present two main disadvantages for iron fortification; they contain high levels of phytic acid (potential inhibitor of iron absorption) and they are extremely sensitive to lipid oxidation (Martinez-Navarrete *et al.*, 2002).

Rice can serve as a suitable vehicle for iron fortification as it constitutes a significant source of calories worldwide and especially in developing countries (Kapanidis *et al.*, 1996). Thailand is one of the domesticated rice areas in Southeast Asia and is also well known for the production of high quality rice. High iron rice was a specialty hybridized variety from the Rice Gene Discovery Unit in Thailand. Recommended daily intakes (RDI) of dietary iron for healthy Thai people is 15 mg per day (Food and drug Administration, 2002). The objective of this study was to develop instant fried noodles from high iron rice flour and rice flour fortified with ferrous sulphate at levels of 0, 32, 64% iron of RDI and furthermore to evaluate the physical, chemical and sensory properties of the products.

2. Materials and Methods

2.1 Preparation of raw materials and properties

Wheat flour (Erawan brand) was purchased from Siam Flour Mill Ltd, Bangkok, Thailand. Two specialty hybridized varieties were donated by the Rice Gene Discovery Unit, National Center for Genetic Engineering and Biotechnology, Kasetsart University, Kamphaeng Saen, which had high iron content and different color. One is white colored seed of Homnin 313 (HW) and another one is purple colored seed of Homnin 1000 (HP). The third brown rice variety is white colored seed of Suphan Buri 90 which is normal breeding available in the market. This variety was purchased from Rice Research Center Institute, Department of Agriculture, Bangkok, Thailand. All brown rice samples were prepared by dry milling using pin mill (Alpine, Augbury, Germany) with particle size of approximately 100-150 μm. Iron in the form of dry ferrous sulphate was donated by the Asia Drug Chemicals Ltd. The flours were analyzed for moisture, protein, fat, ash and dietary fiber contents according to AOAC (2000).

2.2 Instant fried noodle making

The experimental samples were prepared according to the basic formulation (Moss *et al*., 1987). Instant fried noodles were made from the prepared flour by mixing with 40% water absorption and 1.5% amounts of salt and 0.5% alkaline solution to have a uniform, smooth, and nonsticky dough. The flours were formed into dough sheets of 3 mm thickness and rested for 30 min before further size reduction and cutting. The final cutting roll gap was adjusted to 1.0 mm and the noodle sheet was cut through a cutter and waver. The noodles were steamed in a steamer and placed into a wire basket fitted with a lid and the basket was dipped in hot palm olein at 150-160°C for 1 min and cooled to room temperature before packing in a bag of metalized polyethylene. The sample size for one bag was 50 g.

2.3 Experimental design

Wheat flour in noodle formulation was substituted with each type of brown rice flour. A 3×3 full factorial design was used. Three levels of brown rice flour, Homnin 313 : wheat flour ratio (30 : 70, 40 : 60, 50 : 50) and three levels of iron content (0, 32, 64% RDI) of total dry mix weight. A total of nine instant fried noodles products were made, each was prepared in duplicate.

2.4 Pasting properties

Each brown rice flour and wheat flour in noodle formulation was substituted with each type of brown rice flour at 30, 40 and 50% of its dry weight were separately analyzed in duplicate for pasting properties using a Rapid Visco Analyser (RVA) model 3 D (Newport Scientific Pty Ltd., Warriewood NSW 2102, Australia). A suspension of 3.0 g flour (dry basis) in 25 g. of distilled water was heated from 50 to 95°C at the rate of 12°C/min with constant stirring at 160 rpm and held at 95°C for 2.5 min (break down), then cooled to 50°C at a rate of 13°C/min (set back) and held for 2 min. The total cycle was 12.5 min. Pasting temperature was recorded as the temperature at which an increase in viscosity was first observed. The values reported included pasting temperature (°C), peak viscosity (RVU), final viscosity (RVU), trough (lowest viscosity, RVU), break down (the difference between peak viscosity and trough, RVU), set back from peak (the difference between final viscosity and peak viscosity, RVU) and set back from trough (the difference between final viscosity and trough, RVU).

2.5 Amylose determination

The apparent amylose content (%) was determined according to the method of Juliano (1971).

2.6 Mineral determination

The noodle samples were analyzed duplication for total iron, calcium and sodium contents according to AOAC (2000) by using Inductively Couple Plasma - Atomic Emission Spectrophotometer (ICP - AES), PerkinElmer Instruments LLt, Model Optima 2000 DV, Shelton, USA. The iron content of noodles was calculated in % RDI.

2.7 Color measurement

The color of the experimental flour and noodle were measured using CIELAB 1976 L*, a*, b* C* and H* color scale. The measurements were done in triplicate at three random locations on the surface of each sample using spectrophotometer (Spectraflash 600 plus, Datacolor International, USA). The CIE color values were recorded as L* = lightness (0 = black, 100 = white), a* (-a* = greenness, +a* = redness) and b* (-b* = blueness, +b* = yellowness) C* = chromaticity, H* = hue (angle, 0-360).

2.8 Texture measurement

The textural qualities of the cooked noodles, in tensile strength, break distance (extensibility), firmness and stickiness were measured on a Texture Analyser model TA - XT_{2i}, Stable Micro System Ltd., (Vienna Court , Lammas Road , Godalming, Surrey GU7 1YL England) using a Spaghetti Tensile grips (A / SPR) pre-test speed 3.0 mm/s, test speed 3.00 mm/s and post-test speed 5.00 mm/s. The noodles were tested individually and the result of each sample was expressed as an average of ten measurements.

2.9 Chemical properties of instant fried noodle

Instant fried noodles were analyzed for moisture, protein, fat, ash and dietary fiber contents using the standard methods of AOAC (2000).

2.10 TBA value (Thiobarbituric Acid Value)

TBA value of the samples was analyzed by the method of Pearson (1976). The increase in the amount of red color formed in the reaction between 2-thiobarbituric acid (TBA) and oxidized lipids as oxidative rancidity advances has been applied to a wide variety of fatty acid. TBA value was expressed as mg malonaldehyde per kg sample.

2.11 Sensory acceptability

The cooked samples were evaluated by 18 panelists, using balanced incomplete block design (t = 9, k = 4, r = 8, b = 18, r = 3). A 9-point hedonic scale (1 = dislike extremely, 9 = like extremely) was used to evaluate acceptability of product attributes (color, flavor, elasticity, smoothness, firmness, brightness and overall acceptance). For the consumer acceptance of instant fried noodles, the samples were evaluated by 100 persons (schoolchildren aged between 6 and 14 years). They were asked to evaluate acceptability of the best sample from the experiments.

2.12 Statistical analysis

The physical and sensory data were analyzed using ANOVA and mean procedure of SAS (SAS 1989). Duncan's Multiple Range Test was applied to determine the significant differences among the means at 95% confident levels.

Table 1. Physicochemical properties of raw materials.

Flour (brown rice)	Moisture %	% dry basis								
		Protein	Fat	Ash	Dietary fiber	Amylose content	Iron content mg / 100 g	L*	a*	b*
Suphan Buri 90 (SB)	10.34^{b}±0.23	9.99^{c}±0.03	3.80^{a}±0.02	1.47^{b}±0.04	3.95^{b}±0.01	30.40^{a}±0.1	1.24^{b}±0.01	89.09^{b}±0.01	0.59^{c}±0.01	10.14^{a}±0.01
Homnin 313 (HW)	11.61^{a} ±0.03	11.05^{b}±0.09	3.92^{a}±0.05	1.57^{b}±0.02	3.98^{b}±0.01	19.10^{b}±0.15	2.04^{a}±0.01	86.72^{b}±0.01	1.06^{b}±0.01	10.43^{a}±0.01
Homnin 1000 (HP)	12.21^{a}±0.11	11.65^{b}±0.06	3.79^{a}±0.07	1.72^{a}±0.01	4.63^{a}±0.01	15.74^{c}±0.02	2.22^{a}±0.01	59.91^{c}±0.01	2.47^{a}±0.01	1.64^{c}±0.02
Wheat flour (W) (Erawan brand)	11.55^{a}±0.12	14.80^{a}±0.05	1.12^{b}±0.06	0.52^{c}±0.01	0.20^{c}±0.01	16.14^{c}±0.01	0.84^{c}±0.02	94.93^{a}±0.01	0.35^{c}±0.01	7.68^{b}±0.02

The same superscripts in the same column indicate non-significant differences ($P>0.05$) by ANOVA and DMRT.

3. Results and Discussion

3.1 Properties of raw materials

Chemical composition of raw materials is shown in Table 1. The protein content of various brown rice flour (9.99-11.65%) was significantly different from wheat flour (14.80%). Dietary fiber content of brown rice flour and wheat flour was 3.95-4.63% and 0.20%, respectively. The amylose content of Suphan Buri 90 (SB) (30.40%) was greater than those of high iron brown rice flour (15.74-19.10%). The iron content of brown rice flour Homnin 313 (HW) and Homnin 1000 (HP) were two-fold greater than that of regular breeding brown rice flour (SB). Rani and Bhattacharya (1995) reported that high amylose rice starch granules were strong and rigid, and therefore, resisted swelling and disintegration. On the other hand, low amylose rice starch granules were weak and fragile, so tended to swell and disintegrated.

Color of brown rice flour and wheat flour was significantly different. The color of the wheat flour was lighter than that of the brown rice flour (Table 1). The brown rice flour (SB, HW) had more yellowness than wheat flour. HP brown rice flour had a purple color with more redness and less yellowness.

The results from RVA measurements are given in Table 2. The results revealed that the peak viscosity of HW, SB and HP brown rice flour were 447.17, 329.92 and 297.17 RVU, respectively. Flour with a lower peak viscosity has a lower thickening power than that with a higher peak viscosity. Therefore HP brown rice flour had a lower thickening power than SB and HW brown rice flour. The final viscosity of SB, HW and HP brown rice flours were 654.25, 400.75 and 261.00 RVU, respectively. The final viscosity of rice paste is related to the amylose content. Flour with a higher amylose content gives a higher final viscosity. Lai (2001) also reported that rice contained 28.8% amylose had higher final viscosity than that with 17.90%. The setback of SB, HW and HP brown rice flour were 450.92, 205.82 and 137.00 RVU, respectively. The result indicated that SB brown rice flour had greater retrogradation, resulting in more firmness of the cooked paste. Incorporation of rice flours in the formulation affected the rheological behavior on heating and cooking of the flour samples. Oda *et al*., (1980) found that starch pasting properties correlated well with noodle quality of salted noodles.

3.2 Physical properties of instant fried noodles.

3.2.1 Textural characteristics of instant fried noodles

It is generally accepted that the main criterion for assessing the overall quality of cooked pasta is based on the evaluation of texture (Smewing, 1997). In this experiment, rehydrated noodles were tested to measure tensile force and break distance. The results are shown in Table 3 and Figure 1. Tensile force and break distance of noodles with 30, 40, 50% replacement with each variety of brown rice flour were significantly different ($p<0.05$). The noodles with each variety of 30% brown rice flour and 0% RDI had tensile force (8.36±0.96 - 11.57±1.30 g) values higher than the other noodles, and they were different from those of control (16.85±1.32 g). The tensile force and break distance of the noodles decreased, as the rice flour content increased from 30 to 50% replacement as shown in Figure 1. As the amount of brown rice flour increased from 30 to 50% of total composite flour, break distance value decreased from 26.86±2.04 to 13.98±2.02 mm for SB, 23.84±2.36 to 15.46±1.97 mm for HW 313 and 20.40±2.71 to 12.09±4.22 mm for HP. Furthermore, the SB brown rice flour had higher amylose content than others. The hardness of cooked fried noodles gradually decreased as rice flour increased, and noodle with brown rice flour SB had greater hardness than others ($P<0.05$). Our observation was similar to the study of Baik, and Lee, (2003) who reported that amylose content of starch correlated positively with hardness of cooked white salted noodles.

3.2.2 Color characteristics of instant fried noodles

For the color measurement of dry instant fried noodles, the composite wheat-brown rice flour ratio significantly affected L*, a* and b* values ($P < 0.05$) (Table 4). The L* (lightness) and b* (yellowness) values of the instant fried noodles fortified with iron decreased, while a* (redness) value increased, as the amount of iron content increased ($P<0.05$). Therefore, the products became more reddish, darker, and less yellowish. For each level of composite brown

Table 2. Pasting properties of various brown rice flour and wheat flour.

Sample	RVU						
	Peak viscosity	Trough	Final viscosity	Break down	Set back from peak	Set back from trough	Pasting Temp (°C)
Suphan Buri 90 (SB)	329.92±1.11	203.58±2.02	654.25±2.51	126.33±1.94	324.33±1.95	450.92±1.54	72.25±0.04
Homnin 313 (HW)	447.17±3.23	194.92±3.40	400.75±4.22	252.25±2.20	-46.42±0.11	205.83±3.44	75.35±0.05
Homnin 1000 (HP)	297.17±1.50	124.00±2.21	261.00±2.20	173.17±4.20	-36.17±0.40	137.00±2.20	75.25±0.05
Wheat flour (W)	344.08±1.28	186.25±4.10	326.50±2.28	157.83±1.20	-17.58±0.51	140.25±2.00	68.15±0.08

Table 3. Textural characteristic of cooked noodle made from wheat-brown rice composite flour.

Noodle	Tensile force (g)	Distance (mm)
Homnin 313 (white) HW		
0% RDI		
HW1 – 30%	10.09±1.20[a]	23.84±2.36[a]
HW2 – 40%	8.84±1.41[b]	18.68±2.84[b]
HW3 – 50%	5.46±1.31[c]	15.71±4.22[c]
32% RDI		
HW4 – 30%	10.03±0.81[a]	23.78±2.78[a]
HW5 – 40%	8.09±1.03[b]	17.45±1.63[b]
HW6 – 50%	5.62±0.34[c]	15.82±2.33[c]
64% RDI		
HW7 – 30%	10.12±1.12[a]	23.18±2.61[a]
HW8 – 40%	8.61±1.08[b]	17.76±2.01[b]
HW9 – 50%	6.09±0.69[c]	15.46±1.97[c]
Homnin 1000 (Purple) HP		
0% RDI		
HP1 – 30%	8.36±0.96[a]	20.40±2.71[a]
HP2 – 40%	7.61±0.77[b]	14.65±2.79[b]
HP3 – 50%	5.71±0.57[c]	12.09±4.22[c]
32% RDI		
HP4 – 30%	8.15±1.22[a]	20.09±3.03[a]
HP5 – 40%	7.85±1.03[b]	14.99±2.29[b]
HP6 – 50%	5.67±0.87[c]	13.39±2.80[c]
64% RDI		
HP7 – 30%	8.09±1.33[a]	20.29±2.21[a]
HP8 – 40%	7.61±0.52[b]	14.80±2.33[b]
HP9 – 50%	5.47±0.95[c]	12.99±2.10[c]
Suphan Buri 90 (SB)		
0% RDI		
SB1 – 30%	11.57±1.30[a]	26.01±0.99[a]
SB2 – 40%	10.55±1.61[a]	20.87±2.29[b]
SB3 – 50%	6.38±1.45[c]	14.45±2.41[c]
32% RDI		
SB4 – 30%	11.73±0.99[a]	26.86±2.04[a]
SB5 – 40%	10.48±1.15[b]	20.10±2.55[b]
SB6 – 50%	6.10±1.24[c]	14.11±2.01[c]
64% RDI		
SB7 – 30%	11.20±1.79[a]	26.48±2.30[a]
SB8 – 40%	10.20±1.28[b]	20.95±2.80[b]
SB9 – 50%	6.00±1.59[c]	13.98±2.02[c]
Wheat flour	16.85±1.32	69.40±10.81

The same superscripts in the same column indicate non-significant differences (P>0.05) by ANOVA and DMRT.

rice flour ratio, L* and a* values significantly decreased with increasing rice flour content. The iron fortified noodles were more reddish and darker than the control (without adding iron).

Correlation among textural characteristics, and color measurement were calculated (Table 5). Tensile strength was positively correlated with break distance (r = 0.866, P<0.01), (r = 0.528, P<0.01) lightness and negatively correlated with % rice flour (r = 0.898, P<0.05). The break distance value was positively correlated with L* value and negatively correlated with % rice flour. L* value was positively correlated with b* value.

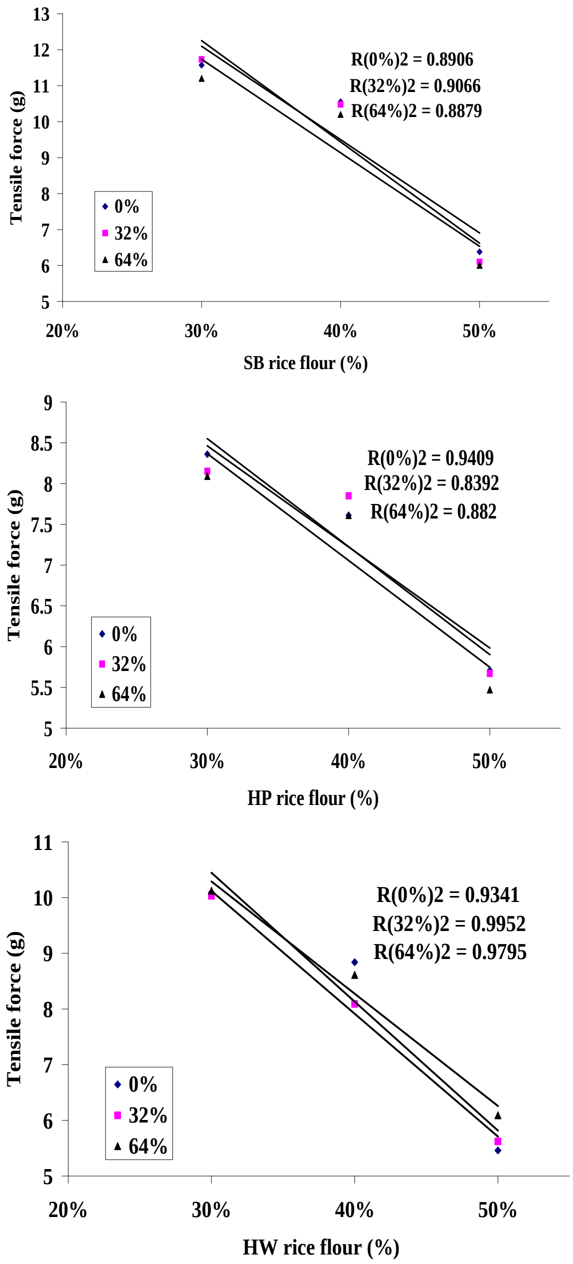

Figure 1. Textural characteristic of cooked noodle made from wheat-brown rice composite flour.

3.3 Sensory evaluation

The mean values of the hedonic ratings for sensory attributes of cooked instant fried noodles samples are shown in Table 6. The amount of each variety of brown rice flour

Table 4. Color measurement of high iron noodle from wheat-brown rice composite flour.

Noodle	Iron content % RDI	L*	a*	b*
Homnin 313 (white) flour				
HW1	0	$79.50^{a} \pm 0.01$	$1.01^{h} \pm 0.01$	$20.75^{c} \pm 0.01$
HW2	0	$76.92^{b} \pm 0.02$	$1.55^{g} \pm 0.01$	$21.37^{b} \pm 0.01$
HW3	0	$74.12^{c} \pm 0.02$	$2.36^{e} \pm 0.01$	$21.98^{a} \pm 0.01$
HW4	32	$73.40^{c} \pm 0.02$	$2.10^{f} \pm 0.03$	$20.29^{d} \pm 0.01$
HW5	32	$71.88^{d} \pm 0.04$	$2.31^{e} \pm 0.01$	$18.20^{h} \pm 0.01$
HW6	32	$70.68^{e} \pm 0.05$	$2.76^{d} \pm 0.01$	$18.56^{g} \pm 0.01$
HW7	64	$72.29^{d} \pm 0.02$	$2.97^{b} \pm 0.02$	$19.70^{e} \pm 0.01$
HW8	64	$71.00^{e} \pm 0.02$	$2.87^{c} \pm 0.02$	$19.11^{f} \pm 0.02$
HW9	64	$68.11^{f} \pm 0.01$	$3.34^{a} \pm 0.01$	$19.28^{f} \pm 0.01$
Homnin 1000 (purple) flour				
HP1	0	$48.06^{a} \pm 0.01$	$5.54^{a} \pm 0.01$	$8.48^{a} \pm 0.03$
HP2	0	$43.92^{c} \pm 0.01$	$4.52^{b} \pm 0.01$	$5.84^{b} \pm 0.01$
HP3	0	$40.43^{f} \pm 0.01$	$2.84^{c} \pm 0.02$	$3.20^{c} \pm 0.02$
HP4	32	$43.67^{c} \pm 0.01$	$0.94^{d} \pm 0.05$	$2.77^{d} \pm 0.04$
HP5	32	$41.38^{e} \pm 0.01$	$0.42^{e} \pm 0.01$	$1.78^{e} \pm 0.01$
HP6	32	$39.80^{g} \pm 0.02$	$0.12^{f} \pm 0.02$	$1.25^{f} \pm 0.01$
HP7	64	$44.07^{b} \pm 0.01$	$0.46^{e} \pm 0.01$	$3.22^{c} \pm 0.04$
HP8	64	$41.85^{d} \pm 0.04$	$0.01^{g} \pm 0.01$	$1.79^{e} \pm 0.01$
HP9	64	$38.58^{h} \pm 0.03$	$-0.41^{h} \pm 0.01$	$-0.08^{g} \pm 0.01$
Suphan Buri 90 (SB)				
SB1	0	$80.75^{a} \pm 0.04$	$0.38^{i} \pm 0.01$	$20.72^{c} \pm 0.02$
SB2	0	$78.63^{b} \pm 0.01$	$1.27^{h} \pm 0.02$	$22.15^{b} \pm 0.02$
SB3	0	$75.75^{d} \pm 0.2$	$2.26^{d} \pm 0.2$	$23.35^{a} \pm 0.02$
SB4	32	$76.24^{c} \pm 0.5$	$1.41^{g} \pm 0.1$	$18.86^{g} \pm 0.01$
SB5	32	$73.44^{e} \pm 0.01$	$1.70^{f} \pm 0.01$	$19.16^{f} \pm 0.01$
SB6	32	$71.16^{f} \pm 0.01$	$1.86^{f} \pm 0.05$	$19.23^{ef} \pm 0.01$
SB7	64	$73.53^{e} \pm 0.01$	$2.02^{c} \pm 0.01$	$19.94^{d} \pm 0.01$
SB8	64	$71.49^{f} \pm 0.01$	$2.51^{b} \pm 0.02$	$19.12^{f} \pm 0.01$
SB9	64	$69.30^{g} \pm 0.01$	$2.77^{a} \pm 0.02$	$19.47^{e} \pm 0.01$

The same superscripts in the same column indicate non-significant differences (P>0.05) by ANOVA and DMRT.
L* = lightness (0-100) (0 = black, 100 = white)
a* = (-a* = greenness, + a* = redness)
b* = (-b* = blueness, + b* = yellowness)
C* = chromaticity
H* = hue (angle) (0-360°)

Table 5. Pearson correlations coefficients of tensile force distance, color of instant fried noodles and % composition of rice flour.

		1	2	3	4	5	6
1	Tensile force	…	…	…	…	…	…
2	Distance	0.866**	…	…	…	…	…
3	L*	0.528**	0.457*	…	…	…	…
4	a*	-0.226	-0.275	0.067	…	…	…
5	b*	0.357	0.267	0.969**	0.251	…	…
6	% rice flour	-0.898**	-0.880**	-0.279	0.209	-0.101*	…

**, * Correlation is significant at P<0.01 and P<0.05 respectively.

and iron content significantly affected (P<0.05) sensory acceptability of color, flavor, elasticity, smoothness firmness, brightness and overall acceptability. At each brown rice flour level, the hedonic scale scores for color, elasticity, firmness, acceptability of the products at 30% and 0% RDI were higher than those of the product at 40% and 50% replacement. The sensory scores of iron fortified noodles with 32% RDI, of each variety of brown rice flour, were higher than those containing 64% RDI in overall acceptability.

Therefore, the instant fried noodle containing HW, HP at 30% and fortified with 32% iron of RDI were used for consumer test of rural primary school children (age 6-14 years). The results showed that the frequency of the acceptability scores of HW and HP ware 84, and 88% respectively (ie, "like very much" to "like extremely"). According to the recommended daily allowances and the results of "Nutrition Facts", the noodles with SB, HW, HP at 30% and fortified with 32% iron of RDI had nutritive compositions as shown in Table 7.

3.4 Shelf-life stability of instant fried noodles

The instant fried noodle of SB 4, HW 4, HP 4 were stored at 35±5°C for 4 months. The results of TBA value, the

Table 6. Sensory Scores of noodles prepared from composite flour of brown rice flour and wheat flour.

Sample	Color	Flavor	Elasticity	Smoothness	Firmness	Brightness	Accep tability
0% RDI							
HW1	7.34^{a}±0.53	6.50^{a}±0.71	6.50^{a}±0.75	6.65^{a}±0.82	6.79^{a}±0.80	6.16^{a}±0.71	7.75^{a}±0.76
HW2	7.42^{a}±0.65	6.54^{a}±0.64	5.79^{b}±0.89	5.95^{a}±0.74	5.05^{b}±0.25	6.16^{a}±0.53	6.62^{ab}±1.07
HW3	6.97^{a}±0.83	5.87^{b}±0.93	4.94^{c}±1.49	5.65^{b}±0.53	4.71^{bc}±0.36	5.93^{a}±0.12	5.34^{c}±0.38
32% RDI							
HW4	5.01^{b}±1.07	5.87^{b}±0.76	6.27^{a}±0.86	6.02^{a}±0.76	6.60^{a}±0.89	5.16^{b}±0.11	6.94^{a}±0.99
HW5	5.38^{b}±0.71	6.21^{a}±1.30	5.90^{b}±0.46	5.87^{ab}±0.46	6.16^{a}±0.64	5.31^{b}±0.09	6.80^{a}±0.80
HW6	5.97^{b}±0.92	5.54^{b}±0.93	4.38^{c}±0.99	5.10^{bc}±0.76	4.45^{bc}±0.60	5.05^{b}±0.55	5.17^{c}±0.75
64% RDI							
HW7	5.90^{b}±0.92	5.91^{b}±0.83	6.46^{a}±1.04	5.76^{b}±0.78	6.75^{a}±0.76	5.42^{b}±0.12	6.80^{a}±0.94
HW8	5.64^{b}±0.64	6.50^{a}±0.89	5.94^{b}±1.77	6.50^{a}±0.83	6.08^{ab}±0.79	5.60^{b}±0.18	6.05^{b}±0.86
HW9	5.45^{b}±0.79	6.25^{a}±0.74	5.27^{a}±0.18	5.69^{b}±0.98	5.49^{b}±0.74	5.31^{b}±0.55	5.80^{c}±0.82
0% RDI							
HP1	6.55^{a}±0.78	6.72^{a}±0.91	6.24^{a}±0.91	6.70^{a}±0.20	5.51^{b}±0.28	6.19^{a} ±0.29	6.21^{a} ±0.57
HP 2	6.18^{a}±0.45	6.91^{a}±0.88	6.68^{a}±0.99	6.78^{a}±0.40	6.80^{a} ±0.49	5.90^{ab} ±0.11	6.06^{b} ±0.89
HP 2	6.00^{a}±0.66	6.35^{b}±0.55	5.24^{b}±0.35	5.04^{b}±0.15	4.98^{c} ±0.31	5.34^{6} ±0.09	5.31^{c} ±0.15
32% RDI							
HP 4	5.74^{b}±0.40	6.43^{a}±0.41	6.17^{a}±0.74	6.89^{a}±0.40	6.31^{a} ±0.51	6.27^{a} ±0.35	6.25^{a} ±0.43
HP 5	5.66^{b}±0.11	6.57^{a}±0.41	6.33^{a}±0.75	6.22^{a}±0.80	6.24^{a} ±0.76	6.16^{a} ±0.58	6.02^{b} ±0.61
HP 6	5.51^{b}±0.39	6.28^{b}±0.48	5.50^{b}±0.38	5.96^{a}±0.15	5.57^{b} ±0.54	6.16^{a} ±0.41	5.50^{c} ±0.50
64% RDI							
HP 7	5.77^{b}±0.91	6.02^{b}±0.22	6.31^{a}±0.28	6.41^{a}±0.70	6.54^{a}±0.70	6.31^{a}	6.21^{a}±0.49
HP 8	6.29^{a}±0.94	6.68^{a}±0.35	6.31^{a}±0.51	6.85^{a}±0.29	6.50^{a}±0.74	6.08^{a}	6.03^{b}±0.66
HP 9	5.25^{b}±0.35	5.87^{b}±0.35	4.72^{b}±0.32	5.48^{b}±0.32	5.28^{b}±0.51	5.68^{b}±0.53	5.10^{c}±0.19
0% RDI							
SB1	6.55^{b}±0.51	6.47^{a}±0.54	6.03^{ab}±0.47	6.56^{a}±0.54	6.25^{a}±0.51	6.57^{a}±0.80	6.65^{a}±0.54
SB2	7.18^{a}±0.61	6.84^{a}±0.61	6.51^{a}±0.51	6.58^{a}±0.51	6.73^{a}±0.30	6.57^{a}±0.84	6.56^{a}±0.55
SB2	6.88^{a}±0.84	5.88^{b}±0.18	5.37^{c}±0.11	6.00^{b}±0.10	5.62^{b}±0.20	6.01^{b}±0.21	5.31^{b}±0.21
32% RDI							
SB4	6.48^{a}±0.20	6.14^{a}±0.44	6.18^{ab}±0.91	6.46^{a}±0.21	6.50^{a}±0.22	6.12^{b}±0.21	6.45^{ab}±0.25
SB5	5.96^{c}±0.15	5.88^{b}±0.95	5.92^{ab}±0.82	5.75^{b}±0.56	6.02^{a}±0.41	5.68^{c}±0.34	6.15^{b}±0.29
SB6	5.48^{cd}±0.16	5.95^{b}±0.88	5.14^{c}±0.54	5.45^{bc}±0.59	4.93^{c}±0.41	6.04^{b}±0.20	4.72^{c}±0.17
64% RDI							
SB7	5.88^{cd}±0.50	5.95^{b}±0.14	6.48^{a}±0.55	6.26^{a}±0.31	6.47^{a}±0.44	6.09^{b}±0.22	6.28^{b}±0.24
SB8	5.48^{cd}±0.10	6.21^{a}±0.18	5.77^{ab}±0.81	5.67^{b}±0.59	5.69^{b}±0.34	5.83^{c}±0.11	6.10^{b}±0.31
SB9	5.08^{cd}±0.40	5.25^{bc}±0.15	4.55^{d}±0.59	4.37^{c}±0.55	4.99^{c}±0.31	5.35^{c}±0.89	4.28^{c}±0.32

The same superscripts in the same column indicate non-significant differences (P>0.05) by ANOVA and DMRT.

Table 7. Nutritive value of instant fried noodle.

Noodle	SB4	HW4	HP4	Wheat flour
1. Total calories, kcal / 100 g	481.70±1.30	478.58±1.14	477.79±2.70	485.73±1.58
2. Calories from fat, kcal / 100 g	186.30±1.50	184.14±1.80	180.63±1.90	180.45±1.59
3. Fat, %	20.70±0.50	20.46±0.41	20.07±0.22	20.05±0.05
4. Saturated fat, %	2.80±0.05	2.80±0.04	2.80±0.01	2.80±0.01
5. Cholesterol, mg / 100 g	0.00	0.00	0.00	0.00
6. Protein, % (factor 6.25)	9.38±0.05	9.30±0.08	9.51±0.04	12.94±0.01
7. Total carbohydrate, % (by difference)	64.47±0.01	64.31±0.01	64.78±0.01	61.37±0.01
8. Dietary Fiber, %	6.04±0.01	5.60±0.01	4.88±0.01	1.25±0.01
9. Total sugar, %	2.00±0.01	2.00±0.01	2.00±0.01	2.00±0.01
10. Sodium, mg / 100 g	601.16±5.10	585.46±4.10	646.79±2.20	610.00±2.10
Vitamin A (retinol), µg RE / 100 g	0.00	0.00	0.00	0.00
Vitamin A (b-carotene), µg RE / 100 g	0.00	0.00	0.00	0.00
11. Vitamin A, µg RE / 100 g	0.00	0.00	0.00	0.00
12. Vitamin B1, mg / 100 g	0.06	0.06	0.06	0.06
13. Vitamin B2, mg / 100 g	0.02	0.02	0.02	0.02
14. Calcium, mg / 100 g	5.88±0.01	8.62±0.01	7.23±0.01	7.81±0.01
15. Iron, mg / 100 g	8.36±0.03	8.41±0.01	8.68±0.02	0.86±0.05
16. Ash, %	2.10±0.01	1.97±0.01	2.01±0.01	1.94±0.01
17. Moisture, %	3.35±0.12	3.96±0.04	3.63±0.01	3.77±0.01

Table 8. The physicochemical changes of the instant fried noodle during storage time (0 - 4 months).

Month	L*	a*	b*	Moisture %	A_w	TBA mg malonaldehyde/kg	Iron content mg/100 g
Supan Buri 90 (SB4)							
0	76.24[a]±0.01	1.41[a]±0.01	18.86[a]±0.01	3.35[a]±0.12	0.43[a]±0.01	1.385±0.15	8.35±0.51
1	-	-	-	-	-	1.304±0.14	8.89±0.28
2	75.51[a]±0.01	1.55[a]±0.01	19.28[a]±0.01	3.77[a]±0.15	0.44[a]±0.01	1.352±0.12	8.42±0.41
3	-	-	-	-	-	1.914±0.15	8.64±0.43
4	74.88[a]±0.02	1.61[a]±0.01	19.94[a]±0.01	3.80[a]±0.01	0.45[a]±0.01	2.131±0.01	8.13±0.12
Homnin 313 (HW4)							
0	73.40[a]±0.01	2.31[a]±0.01	20.92[a]±0.02	3.96[a]±0.04	0.44[a]±0.02	1.482±0.01	8.41±0.12
1	-	-	-	-	-	1.441±0.04	8.28±0.15
2	73.02[a]±0.01	1.98[a]±0.01	20.16[a]±0.01	3.50[a]±0.01	0.45[a]±0.01	1.481±0.05	8.37±0.11
3	-	-	-	-	-	1.957±0.01	8.55±0.41
4	73.16[a]±0.01	1.81[a]±0.02	20.36[a]±0.01	3.71[a]±0.02	0.44[a]±0.01	2.570±0.01	8.38±0.51
Homnin 1000 (HP4)							
0	43.67[a]±0.01	0.94[a]±0.01	2.77[a]±0.01	3.63[a]±0.01	0.44[a]±0.01	1.538±0.01	8.67±0.12
1	-	-	-			1.538±0.01	8.28±0.15
2	42.86[a]±0.04	0.82[a]±0.01	2.52[a]±0.02	3.89[a]±0.02	0.43[a]±0.02	1.843±0.02	8.73±0.11
3	-	-	-			2.010±0.01	8.52±0.18
4	42.88[a]±0.02	0.82[a]±0.01	2.59[a]±0.02	3.81[a]±0.01	0.44[a]±0.01	2.642±0.01	8.80±0.05

color of dry noodles and iron content were shown in Table 8. The TBA values expressed as mg malonaldehyde / kg tended to increase after 3 months. Iron content of noodles was constant throughout the storage.

The L* a* b* value of noodles were not significantly different (P>0.05) during four months storage because the products were packed in metalized plastic. The noodle products which were kept for 4 months storage were still accepted by panelists (Table 9).

Table 9. Sensory Scores of noodles prepared from composite flour of brown rice flour and wheat flour after 4 months.

Sample	Color	Flavor	Elasticity	Smoothness	Firmness	Brightness	Acceptability
HW4-30%	6.13^{b}±0.51	6.53^{b}±0.12	6.80^{ab}±0.19	6.13^{c}±0.22	6.06^{b}±0.16	6.06^{c}±0.21	6.19^{b}±0.10
SB4-30%	6.66^{b}±0.31	6.40^{b}±0.25	6.95^{ab}±0.18	6.86^{b}±0.25	6.20^{b}±0.15	6.26^{c}±0.25	6.23^{b}±0.50
HP4-30%	6.33^{b}±0.22	6.66^{b}±0.22	6.98^{ab}±0.14	6.80^{b}±0.31	6.46^{b}±0.15	6.53^{b}±0.29	6.85^{ab}±0.10
Wheat flour	7.36^{a}±0.14	7.39^{a}±0.11	7.90^{a}±0.19	7.75^{a}±0.16	7.70^{a}±0.01	7.20^{a}±0.20	7.50^{a}±0.20

The same superscripts in the same column indicate non-significant differences (P>0.05) by ANOVA and DMRT.

4. Conclusion

This study revealed that substitution of wheat flour in noodle formulation with high iron rice flour of HW, HP and SB (control) at 30, 40, 50% affected the physical, chemical, textural and sensory properties of the noodles. The noodle substituted with each rice flour variety at 30% and fortified with iron at 32% iron of RDI had higher acceptability scores than those of noodle containing 64% iron of RDI. The developed noodles were accepted by consumer test. After 4 months storage, the products were still accepted by panelists. The products were not significantly different in color and iron content from product of 0 month.

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