ORIGINAL ARTICLE

Nutritive improvement of instant fried noodles with oat bran

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Abstract

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Instant fried noodles have become one of the food products regularly consumed among people of all socioeconomic levels in both urban and rural areas. Oat bran is rich in β-glucan, a soluble fiber in oat. The objective of this study was to utilize oat bran, produced from dehulled oats by dry milling and cooking extrusion to improve the nutritional quality of wheat noodle and to evaluate the noodle quality. Three types of oat bran concentrate (OBC): OBCXF, OBCXEF, OBC native were used to replace wheat flour in noodle production, each type at the levels of 5, 10, and 15% (w/w). The experimental design was 3×3 factorial randomized complete block design. The flours and products were analyzed for moisture, protein, fat, β-glucan, RVA and color. The texture of the products was determined using texture analyzer and sensory test. Protein contents of OBCXF, XEF, native and wheat flour were 22.05, 23.21, 22.00 and 13.16%, respectively. OBC β-glucan content was 16-17%. Increasing the amount of various OBC in the mixes caused the increase in protein content and β-glucan in the products. The texture of the noodles with 5% replacement with OBC was not significantly different from that of wheat noodle. The tensile force was in the range of 17.10-17.96 g. The sensory acceptability of the noodles replaced with 5-10% OBC was not significantly different from wheat noodle ($p<0.05$). Noodle with 10% OBC-XEF had the highest scores in texture, elasticity and accept-

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ability. Thus, instant fried noodle having its wheat partially replaced with 10-15% OBC contained β-glucan in the range of 0.80-1.27 g/serving (50 g), which met the FDA approved health claim which requires 0.75 g/serving, and contained dietary fiber in the range of 3.0-4.5 g/serving. By using 10-15% OBC in the formulation, it was possible to satisfactorily make instant fried noodles.

Key words : oat bran, β-glucan, instant fried noodle, acceptabitity

Since instant noodles were first commercialized in Japan in 1958, their popularity was rapidly spread worldwide. The products were introduced and later produced in Thailand in 1970 (The 3rd World Ramen Summit, 2001). They have since become one of the food products that is consumed by people of all socioeconomic levels in both urban and rural areas of the country. There are two forms of instant noodles: un-fried instant noodles and instant fried noodle. Both are packaged in either plastic bags or cups.

Instant noodles in Thailand have several flavors based on Thai eating preferences. Marketing strategies used by the manufacturers to promote their products include 1) more choices of flavors, 2) different styles and texture, 3) shortened preparation time (rehydration) and, 4) nutrient fortification.

Dry regular instant noodles provide mainly carbohydrates and some proteins, while instant fried noodles also have some fats. Therefore, their nutritional quality may be improved by fortification with certain amino acids, or by addition of meat or egg and vegetables or soluble fiber.

Oat dietary fiber is the fiber of dehulled oats, called groats. The total dietary fiber content in the groats varies from 6 to 9%, about half which is soluble fiber, and the rest is insoluble. The main component of the soluble fiber, which provides most of the physiological effects, is a linear polysaccharide usually called β-glucan. It is located in endosperm cell wall, which is the thickest part in the sub-aleurone layer adjacent to the aleurone layer (Mälkki, 2000).

Oat bran is prepared by separating the outer layers of groats from the starch-containing endosperm by mechanical milling and separating operations. The content of β-glucan in oat bran is thereby elevated to about 6-9%. Oat bran concentrates, prepared by dry milling, contain 15% β-glucan, which can be increased further, up to 25%, if prepared from defatted oat groats.

Addition of oat bran concentrate (OBC) to the diet brings many nutritional benefits. The soluble β-glucan from the oat component is known to contribute a hypocholesterolemic property to food (Inglett and Newman, 1994). Behall *et al.* (1997) reported that oat extract containing β-glucan was effective in lowering blood cholesterol in men and woman. Hallfrisch *et al.* (1995) found that diets containing soluble oat extracts improved the glucose an insulin responses of moderately hypercholesterolemic men and women. Oat β-glucan biological activity was also demonstrated in hamsters (Yokoyama *et al.*, 1998). The U.S. FDA has allowed a health claim for soluble oat β-glucan when consumed at a level of 3 g/d (FDA, 1997a, b). OBC also brings several processing and texture benefits. It is easy to formulate it into health and functional foods, such as breakfast cereals, snacks, and nutrition and energy bars. The objective of this study was to utilize oat bran concentrate as a substitute for wheat flour to improve the nutritional quality of instant noodle.

Materials and Methods

Raw materials

Wheat flour was purchased from Siam Flour Mills Ltd. Oat bran concentrate (OBC) was obtained from AVENA, Finland. The OBC was high in β-glucan, produced from dehulled oats by dry milling and cooking extrusion. There were three types of the OBC: 1) OBC XF - oat bran extruded flour, with 80-94% of 125-500 µm particle size and 4-20% of 500-1000 µm particle size; 2) OBC XEF oat bran extruded fine flour, with 95% of particle size less than 150 µm; and

3) OBC Native - oat bran native flour, with particle size 100-500 µm. All samples were stored in a cool and dry warehouse till use.

Flour preparation and pasting properties

Wheat flour in noodle formulation was substituted with each type of OBC at 5, 10 and 15% of its dry weight. The flours were analyzed for moisture, protein, fat and ash content according to AOAC (2000). The color of the flours was measured with Spectraflash 600 plus (Datacolor International, USA) and expressed in L*, a*, b*, C*, and H* values. The pasting properties of the flours was determined from 3.00 g flour (dry basis) in 25 g of distilled water by using a Rapid Visco Analyser (RVA) model 3 D (Newport Scientific Pty Ltd., Australia). The sample was heated from 50 to 95ºC at the rate of 12ºC/min with constant stirring at 160 rpm and held at 95ºC for 2.5 min (break down), then cooled to 50ºC at the rate of 13ºC/min (setback) 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 (ºC), peak viscosity (RVU), final viscosity (RVU), trough (lowest viscosity, RVU), break down (different 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).

Instant fried noodle making

The experimental samples were prepared according to the basic formulation (Moss *et al.*, 1987). Instant noodle was made from the prepared flour by mixing with 35% water and proper amounts of salt and alkaline solution. The flours were formed into dough sheets with 3 mm thick 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 for 90 s and placed into a wire basket fitted with a lid, and the basket was dipped in hot palm olein at 150ºC for 1 min and cooled to room temperature before packing in a polyethylene bag.

Noodle color measurement

Noodle color was measured using CIELAB 1976 L*, a*, b* color scale. The measurements were done in triplicate at three random locations on the surface of each noodle sample, using a 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), b* (-b* = blueness, +b* = yellowness), C* = chromaticity, and H* = hue (angle, 0-360).

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 ystem Ltd., Vienna Court, Lammas Rd., Godalming, Surrey GU7 1YL England), using a Spaghetti Tensile grips (A/SPR) and a 100 mm cylinder probe, respectively. The noodles were tested individually, and the result of each sample was an average of ten measurements.

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).

Sensory acceptability

The samples were evaluated for sensory acceptability by 18 trained panelists, using a balanced incomplete block design (t = 10, k = 5, r = 9, b = 18, r = 4). A 9-point hedonic scale (1 = dislike extremely, 9 = like extremely) was used to evaluate the acceptability of product attributes (color, flavor, elasticity, smoothness, firmness, gloss, texture and overall acceptance). For consumer acceptance of instant fried noodles, the samples were evaluated by 100 untrained panelists. The panelists were asked to evaluate the acceptability of the best sample from the experiments.

Statistical Analysis

Data collected from the sensory evaluation were analyzed using ANOVA and mean procedure of SAS (Statistical Analysis System) (SAS, 1989). Duncan's Multiple Range Test was used to detect mean differences.

Results and Discussion

Properties of raw materials

Chemical composition of raw materials are shown in Table 1. Protein content of various OBC was 22.00-23.21%, and of the wheat flour was 13.16%. The β-glucan content was 16-17% in OBC, and fat content was 11.0% and 1.16% in OBC and wheat flour, respectively.

The color of the wheat flour was lighter than of the OBC flours. Among the OBC flours, the OBC XF was of light brown color, darker, and more yellow than other OBC samples. The color of all samples was significantly different from one another at $p<0.05$.

The results from RVA measurements are given in Table 2. The results revealed that incorporation of OBC in the formulation affected the rheological behavior on heating and cooking of the flour samples. The mixes with OBC-XEF showed the highest peak viscosity values, which implied that OBC-XEF can improve the swelling and water absorption properties of the mixes more than other OBCs. This may be because particle sizes of OBC-XEF were smaller than those of the others. Flours with a higher peak viscosity had a higher thickening power than flours with a lower peak viscosity. The final viscosity of the mixes with OBC-XEF was relatively high; therefore, retrogradation occurred more easily as compared with the other samples. Among the OBC groups, native flour had the highest set back values, which reflected retrogradation of the starch, resulting in more firmness of the cooked paste. In white salted noodles, Oda *et al*. (1980) found that starch pasting properties correlate well with noodle eating quality. High starch paste viscosity is indicative of good eating quality of noodles (Moss, 1980; Crosbie *et al*., 1970).

Chemical composition of instant fried noodle with various OBC

The results of the chemical composition of instant fried noodles with various OBCs are shown in Table 3. Increasing the amount of various OBCs in the mixes raised the protein and β-glucan contents in the products. The noodles with 15% OBC exhibited the highest β-glucan content (1.20-1.27 g/serving) (1 serving = 50 g). β-glucan content

Table 1. Chemical composition and color measurement of raw materials used in noodle production.

Flour	Moisture %	Protein % (5.7)	β-glucan (ds) %	Fat (ds) %	CIELAB SYSTEM L*	a*	b*	C*	H*
OBC-XF	7.72[b]	22.05[b]	16.0	11.0[b]	77.28[d]	3.00[a]	18.04[a]	18.20[a]	80.55[c]
OBC-XEF	7.73[b]	23.21[b]	16.0	11.0[b]	85.99[b]	1.31[c]	13.90[c]	13.96[c]	84.59[b]
OBC-Native	7.60[b]	22.00[b]	17.0	11.0[b]	82.00[c]	2.35[b]	15.30[b]	15.48[b]	81.26[c]
Wheat flour	11.55[a]	13.16[a]	ND	1.16[a]	94.54[a]	0.39[d]	7.57d	7.58[d]	87.00[a]

Means in a column followed by the same superscripts are not significantly different (p>0.05) by ANOVA and DMRT.
ND - not determined
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 2. Pasting properties of wheat flour mixed with OBC-XF, OBC-XEF, or OBC-Native using Rapid Visco Analyser (RVA)*

Sample	(RVU Unit)						
	Peak Viscosity	Trough	Final Viscosity	Break down	Set back	Peak time (min)	Pasting temp. (ºC)
Wheat flour	227.50	137.75	263.00	89.75	35.50	6.13	66.95
OBC-XF							
5 %	234.08	136.33	258.33	97.75	24.25	6.13	67.80
10%	244.58	141.42	268.83	103.17	24.25	6.13	67.80
15%	247.83	151.25	273.92	96.58	26.09	6.13	67.80
OBC-XEF							
5%	258.83	157.50	281.67	101.33	22.84	6.27	67.00
10%	264.92	157.50	285.50	107.42	20.58	6.20	67.00
15 %	261.58	157.67	285.08	103.92	23.50	6.20	67.00
OBC-Native							
5%	243.67	145.83	274.00	97.83	30.33	6.13	68.60
10%	243.58	145.25	274.67	98.33	31.09	6.07	68.60
15%	240.75	146.58	276.42	94.17	35.67	6.07	68.60

*** Mean values of two measurements.**

Table 3. Chemical composition of instant fried noodles with various OBCs**

Noodle	Moisture %	Protein % (Factor = 5.7)	Fat %	β-glucan per serving* (g)	Dietary fiber* (g)
OBC XF					
5%	5.64	13.10	19.62	0.40	2.12
10%	5.51	13.32	20.05	0.80	3.00
15%	5.25	13.34	19.32	1.20	4.50
OBC XEF					
5%	5.59	13.04	19.61	0.40	2.12
10%	5.40	13.10	18.81	0.80	3.00
15%	5.37	13.69	18.94	1.20	4.50
OBC Native					
5%	5.60	13.54	19.15	0.42	2.12
10%	5.57	13.60	20.06	0.85	3.00
15%	5.30	13.73	19.27	1.27	4.50
Control (wheat flour)	.77	12.94	18.05	ND	1.25

*** Serving size of noodle = 50±2 g, US FDA - approved health claim requires 0.75 g β-glucan/serving.**
**** n = 2**
ND - not determined

of the noodles with 5% OBC was 0.40 g/serving. Those with 10-15% OBC had β-glucan in the range of 0.80-1.27 g/serving, which still meets the FDA-approved health claim which requires 0.75 g/serving (FDA, 1997a, b). The noodle samples also had total dietary fiber content of 3.0-4.5 g/serving. Therefore, these noodles can claim to be a good source of dietary fiber and β-glucan.

Table 4. Color measurement of dry instant fried noodle with OBC-XF, OBC-XEF, and OBC-native.

Noodle		L*	a*	b*	C*	H*
OBC-XF	5%	85.16^b	0.81^c	15.88^c	15.90^c	82.09^b
	10%	83.08^c	1.28^b	16.78^b	16.80^b	85.63^c
	15%	80.63^d	1.78^a	17.99^a	18.07^a	84.33^d
Control (wheat Flour)		88.64^a	0.11^d	12.79^d	12.79^d	89.70^a
OBC-XEF	5%	84.63^b	0.76^c	15.68^b	15.73^b	87.18^b
	10%	83.74^c	1.10^b	16.38^b	16.42^b	86.24^c
	15%	81.04^d	1.54^a	17.69^a	17.75^a	85.03^d
Control (wheat Flour)		88.64^a	0.11^d	12.79^c	12.79^c	89.70^a
OBC-N	5%	86.06^b	0.72^b	13.97^b	13.98^b	87.04^b
	10%	83.55^c	1.48^a	15.78^a	15.84^a	84.67^c
	15%	81.50^d	1.59^a	16.22^a	16.30^a	84.38^c
Control (wheat Flour)		88.64^a	0.11^c	12.79^c	12.79^c	89.70^a

Means in a column followed by the same superscripts are not significantly different (p>0.05) by ANOVA and DMRT.
n = 3

The color measurement of dry instant fried noodles.

Table 4 showed the L*, a*, b*, C*, and H* values of the noodles. The L* value (Lightness) of the noodles with the OBCs decreased as the quantity of the OBC flour in the mixes increased. All the noodles prepared from wheat flour mixed with the OBCs (L* = 80.63-86.06, a* = 0.72-1.78, b* 13.97-17.99) had higher a* and b* values and lower L* values than the control (L* = 88.64, a* = 0.11, b* = 12.79) due to the darker color of the OBC flours. The OBC-substituted noodles were significantly more red, more yellow and darker than the control.

Textural characteristics of instant 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 tension-tested to assess their elasticity and break distance in order to determine their extensibility. The results are shown in Table 5. All noodles with 5-15% OBC substitution, except 5% OBC-XEF, had tensile strength (maximum force) values lower than the control. It is clear that noodles incorporated with various OBCs, except OBC-XEF, were considerably less extensible than regular wheat noodles. Addition of OBC flours also affected the firmness and stickiness of the rehydrated noodles, as shown in Table 5. The noodles with OBC-XF and XEF at 5% were not significantly different in elasticity and firmness from those of the control (p>0.05). Noodles substituted with 10% OBC containing finer particles (OBC-XEF) had higher maximum force and extensibility than OBC with coarser particles. Moss *et al.* (1987) also reported that noodles with coarse particles broke easily before or after cooking, and their cooking losses increased.

Sensory evaluation

Table 6 showed the results of sensory evaluation of rehydrated noodles. The noodles with 5-10% OBC-XF, XEF and Native had no significant difference (p>0.05) in elasticity, texture and acceptability compared to the control. Their preference scores for elasticity, texture and acceptability were 6 to 7 (slightly like to moderately like). Table 7 showed the maximum forces for noodles with 10% OBC-XEF, XF, or Native of 16.10, 13.29, and 12.77 g, respectively. Table 8

Table 5. Textural characteristics of rehydrated instant noodle with 5, 10, 15% of various OBCs.

Noodle	Max Force ± SD (g)	Distance ± SD (mm)	Firmness ± SD (g)	Stickiness ± SD (g)
OBC-XF				
5%	16.13±0.70^{ab}	45.16±3.75^{ab}	4365.67±275.29^{a}	190.64±21.22^{c}
10%	12.53±0.87^{c}	27.63±3.50^{b}	3704.90±230.53^{b}	207.01±20.38^{b}
15%	11.64±0.79^{d}	20.00±2.49^{c}	3227.16±170.19^{c}	181.32±12.10^{c}
OBC-XEF				
5%	17.10±1.47^{a}	51.42±6.23^{a}	3915.96±225.19^{a}	215.98±27.97^{ab}
10%	15.32±1.03^{b}	39.52±6.76^{ab}	4076.19±112.57^{a}	231.80±20.24^{a}
15%	12.08±1.14^{c}	24.59±6.34^{b}	3926.70±184.78^{a}	271.59±19.90^{a}
OBC-Native				
5%	14.81±1.36^{b}	47.68±3.97^{ab}	4265.99±189.03^{a}	213.93±23.54^{ab}
10%	12.39±1.09^{c}	24.72±5.33^{b}	3663.10±162.61^{b}	169.05±20.00^{d}
15%	10.28±0.91^{d}	16.98±2.01^{c}	2884.90±135.91^{c}	157.15±14.06^{d}
Control wheat flour	17.96±0.96^{a}	59.85±8.85^{a}	4016.84±117.55^{a}	137.69±23.75e

Means in a column followed by the same superscripts are not significantly different (p>0.05) by ANOVA and DMRT.
n = 10

Table 6. Mean sensory evaluation scores (1-9 hedonic scale) of rehydrated noodles with OBCs

Treatment		Color	Flavor	Elasticity	Smoothness	Firmness	Gloss	Texture	Acceptability
					Plain noodle				
XF	5%	7.08^{a}	7.00^{a}	6.59^{ab}	7.05^{a}	6.86^{a}	6.28^{ab}	6.64^{ab}	6.86^{ab}
	10%	6.31^{ab}	6.64^{ab}	6.33^{ab}	6.40^{ab}	6.78^{ab}	5.81^{b}	6.40^{ab}	6.35^{ab}
	15%	5.46^{b}	6.37^{b}	5.85^{b}	6.03^{b}	5.59^{c}	5.28^{c}	5.54^{c}	5.44^{c}
XEF	5%	7.13^{a}	6.73^{a}	6.91^{ab}	7.23^{a}	7.18^{a}	6.63^{ab}	7.10^{a}	7.30^{a}
	10%	6.18^{ab}	6.18^{ab}	6.31^{ab}	6.56^{ab}	6.50^{ab}	5.91^{b}	6.55^{ab}	6.45^{ab}
	15%	5.21c	6.02^{b}	5.90^{b}	6.28^{b}	5.88^{bc}	5.59^{bc}	5.86^{c}	5.85^{bc}
N	5%	7.05^{a}	6.92^{a}	6.75^{ab}	6.97^{a}	6.79^{a}	6.61^{ab}	6.86^{ab}	6.72^{ab}
	10%	6.34^{ab}	6.44^{ab}	6.24^{ab}	6.44^{ab}	6.24^{b}	5.74^{b}	6.04^{bc}	6.17^{b}
	15%	5.88^{b}	5.06c	5.56^{c}	5.60^{c}	5.81^{bc}	5.74^{bc}	5.49^{c}	5.30^{c}
Control (wheat flour)		7.43^{a}	7.66^{a}	7.37^{a}	7.50^{a}	7.28^{a}	7.36^{a}	7.52^{a}	7.47^{a}
					Noodle in soup				
XF	5%	7.15^{a}	7.11^{a}	6.58^{ab}	7.14^{a}	6.96^{ab}	6.41^{ab}	6.91^{ab}	7.10^{a}
	10%	6.66^{ab}	6.93^{a}	6.38^{ab}	6.78^{ab}	6.96^{ab}	6.32^{ab}	6.64^{ab}	6.76^{ab}
	15%	5.83^{c}	6.32^{ab}	5.51^{c}	6.14^{b}	6.11^{b}	5.63^{b}	5.78^{c}	5.70^{c}
XEF	5%	7.36^{a}	7.03^{a}	7.39^{a}	7.43^{a}	7.64^{a}	7.08^{a}	7.48^{a}	7.63^{a}
	10%	6.80^{ab}	6.35^{ab}	6.51^{ab}	6.93^{ab}	6.80^{ab}	6.38^{ab}	6.95^{ab}	6.87^{ab}
	15%	6.32^{b}	6.09^{ab}	6.13^{ab}	6.23^{b}	6.09^{b}	5.93^{b}	5.91^{b}	6.00^{bc}
N	5%	7.17^{a}	7.08^{a}	6.81^{ab}	7.12^{a}	6.90^{ab}	6.91^{ab}	6.98^{ab}	6.98^{ab}
	10%	6.81^{ab}	6.89^{a}	6.23^{ab}	6.67^{ab}	6.37^{b}	6.32^{ab}	6.57^{ab}	6.40^{ab}
	15%	6.36^{b}	6.53^{ab}	5.72^{c}	6.08^{b}	5.92^{b}	5.76^{b}	5.74^{c}	5.66^{c}
Control (wheat flour)		7.68^{a}	7.02^{a}	7.44^{a}	7.69^{a}	7.38^{a}	7.63^{a}	7.49^{a}	7.57^{a}

Means in a column followed by the same superscripts are not significantly different (p>0.05) by ANOVA and DMRT.
n = 18

Table 7. Textural characteristics of rehydrated instant noodles measured with Texture Analyser (TA - XT2i)

Treatment	Max Force ± SD (g)	Distance ± SD (mm)
OBC-XF 10%	13.79±0.96[b]	29.39±2.50[c]
OBC-XEF 10%	16.10±1.12[ab]	39.31±2.99[b]
OBC-Native 10%	12.77±1.03[b]	24.38±2.24[d]
Control (wheat flour)	17.96±1.11[a]	51.96±2.56[a]

Means in a column followed by the same superscripts are not significantly different (p>0.05) by ANOVA and DMRT.
n = 10

Table 8. Mean sensory scores (1-9 hedonic scale) of rehydrated noodle with 10% of different OBCs

Treatment	Color	Flavor	Elasticity	Smoothness	Firmness	Gloss	Texture	Acceptability
				Plain noodle				
OBC-XF 10%	7.00[a]	6.13[bc]	6.20[b]	6.20[b]	5.93[b]	6.13[bc]	6.13[c]	5.93[b]
OBC-XEF 10%	6.90[a]	6.47[ab]	6.47[ab]	7.00[a]	6.47[ab]	6.47[ab]	6.83[ab]	6.56[ab]
OBC-Native 10%	7.13[a]	5.60[c]	6.13[b]	5.87[b]	6.20[b]	5.93[c]	6.33[bc]	5.97[b]
Control (wheat flour)	6.93[a]	7.30[a]	7.43[a]	7.17[a]	7.27[a]	7.10[a]	7.43[a]	7.43[a]
				Noodle in soup				
OBC-XF 10%	7.00[a]	6.80[a]	6.07[c]	6.47[b]	6.27[b]	6.40[b]	6.20[c]	6.13[c]
OBC-XEF 10%	7.20[a]	7.03[a]	6.80[ab]	7.10[ab]	6.73[ab]	7.07[a]	6.87[ab]	6.90[ab]
OBC-Native 10%	7.07[a]	6.30[a]	6.67[b]	6.07[c]	6.40[b]	6.27[b]	6.47[bc]	6.37[bc]
Control (wheat flour)	7.10[a]	6.93[a]	7.66[a]	7.73[a]	7.63[a]	7.33[a]	7.67[a]	7.70[a]

Means in a column followed by the same superscripts are not significantly different (p>0.05) by ANOVA and DMRT.
n = 18

Table 9. Consumer test on acceptability of rehydrated instant noodles with 10% OBC-XEF.

Acceptability of consumer (100 persons)	Hedonic scale (1-9 scores)	% Frequency*	
Like extremely	9	0	84
Like very much	8	24	
Like moderately	7	47	
Like slightly	6	13	
Neither like nor dislike	5	8	16
Dislike slightly	4	2	
Dislike moderately	3	4	
Dislike very much	2	2	
Dislike extremely	1	0	

*** 84% of the consumers like the noodles at the scores of 6-9.**

showed the sensory scores of the 10% OBC-substituted noodles compared with the control. The noodles with 10% OBC-XEF had higher elasticity, firmness, texture and acceptability scores than with other OBCs. Therefore, they were used for consumer test. The results, as presented in

Table 9, showed that the frequency of the acceptability scores of the 10% OBC-XEF-substituted noodles, i.e. like slightly to like extremely (6-9), was 84%.

Conclusion

Substitution of wheat flour in noodle formulation with OBC-XF, OBC-XEF, and OBC-Native at 5, 10, and 15% affected the physical, chemical, textural and sensory properties of the noodles. OBC with fine particles (OBC-XEF, extruded fine flour, particle size less than 150 μm) was easier to incorporate and produced more uniform doughs than those with coarse particles (OBC-Native, 100-150 μm). The chemical, physical and sensory properties of the products varied with the type and amount of the OBC added. With 10% substitution, they enhanced the nutritional value of the noodles by raising their soluble fiber content (β-glucan) beyond the 0.75 g/serving required by the FDA for health claims. The products can also claim to be a good source of dietary fiber. Among the OBC-substituted noodles, those with 10% OBC-XEF produced the best quality noodles, with 84% consumer acceptance frequency.

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