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Physicochemical and Protein Quality of Noodles Made with Wheat and Okara Flour Blends

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Abstract: Wheat flour was substituted with okara flour in order to obtain noodles with acceptable physicochemical, protein and sensory quality. Seven substitution levels were tested: 5, 16.25, 20, 27, 35, 38.75 and 50%. As the level of okara flour increased in the blends, the levels of protein, ash, fat and fibre contents of the noodles increased. Increased levels of okara however decreased cooking time but increased cooking losses. The total essential amino acids of noodles from the blends ranged from 26.07-40.37 g/100 g crude protein with histidine or from 43.38-46.49% of the total amino acids. Glutamic acid was the most abundant amino acid in the samples while leucine was the most abundant essential amino acid (5.52-7.86 g/100 g crude protein). Methionine was the limiting amino acid (0.80-1.38 g/100 g crude protein). The predicted protein efficiency ratio, biological value and essential amino acid index of the samples ranged from 1.81-2.88, 53.05-88.8 and 59.4-92.2%, respectively. Sensory evaluation revealed that noodles made with 5% okara and 95% wheat flour was the best in terms of all the attributes studied and was even better than the control (100% wheat). The study has shown that the utilization of okara flour will go a long way in not only increasing utilization of waste but will also encourage the development of variety and value added noodles.

Key words: Noodles, okara, wheat, substitution

INTRODUCTION

The consumption of noodles worldwide in recent years has increased due to ease of cooking, transportation, mechanizations and development of infrastructure (Tudorica *et al*., 2002). Noodles are usually made from wheat semolina or fine flour; they are basically produced by mixing milled wheat flour or semolina with water to form an unleavened dough. This is usually followed by kneading and shaping (Li *et al*., 2014). Noodles are generally rich in carbohydrates but poor in other nutrients such as protein, lipid and fibre contents (Gimenez *et al*., 2012; Gallegos-Infante *et al*., 2010; Li *et al*., 2014). It has been reported that animal-based or plant-based ingredients are incorporated into noodles and pasta to not only provide specific physiological functions but also to serve as nutrition enhancers (Li *et al*., 2014). In fact, the WHO and FDA consider pasta as a suitable vehicle for the addition of nutrients (Chillo *et al*., 2008). The fortification of wheat based products with other food sources is gradually gaining ground with a view of providing improved essential amino acid balance, combat protein calorie malnutrition and micronutrient deficiency. Fortification has also been employed to reduce total dependence on wheat flour which happens to be imported into countries that have unfavourable weather conditions for the cultivation of wheat. Several studies have been carried out with the view of enhancing the nutritional properties of pasta products by partially substituting wheat flour with legume flours (Gallegos-Infante *et al*., 2010; Gimenez *et al*., 2012; Torres *et al*., 2007; Fares and Menga, 2012).

Okara also known as soybean residue, is a pulp consisting of the insoluble parts of soybean which remains after ground soybeans are filtered in the production of tofu and soy milk. On dry basis it contains about 33% fibre, 25% protein and 20% fat (Suruga *et al*., 2011). It has also been reported to contain isoflavones, saponins, phytates, lignans and phytosterols which all have several physiological and therapeutic functions (Li *et al*., 2012). In spite of the potentials that okara may have in the area of human health, most of okara is discarded as industrial waste or sometimes used as animal feed (Suruga *et al*., 2011; Li *et al*., 2012). Currently, small scale production of okara is observed in home cooking where fresh soymilk is produced in household kitchens. However, there is little or no information on industrial products made with okara which are commercially available.

With the knowledge of the rich potentials of okara, this study seeks to investigate the potentials of wheat-okara flour blends in the production of noodles. Specifically, the effects of partial substitution of wheat flour with okara flour on the protein quality, cooking and sensorial properties of noodles were investigated.

MATERIALS AND METHODS

Raw materials: Soybeans were purchased from a retail outlet in Abakaliki, Ebonyi State, Nigeria and cleaned to remove extraneous materials. The grains were immersed in boiling water for about 20 min, soaked overnight, dehulled, wet-milled and filtered. The residue obtained (the okara) was sun dried, milled and sieved through 100 μm

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mesh sieve. The okara flour was stored in plastic airtight containers until needed. Wheat flour used for the noodle preparation was obtained from Golden Penny Flour Mills, Lagos.

Noodle preparation: Wheat and okara flours were mixed in different proportions (100:0%, 95:5%, 83.75:16.25%, 80:20%, 72.5:27.5%, 65:35%, 61.25:38.75% and 50:50%, respectively) where 100% wheat flour served as the control. For each formulation, wheat flour, okara flour and water were thoroughly mixed in a domestic blender (Kenwood) for five minutes to obtain homogenous dough. The dough was kneaded and passed through the reduction rolls of a domestic pasta machine (Ampia 150 Superlusso, Italy). The resulting fresh noodles were dried to less than 8% moisture content, packaged in polythene bags and stored in plastic airtight containers until needed for analysis.

Macronutrient analysis: The okara flour and noodles were analyzed for fat, protein, ash, fiber and moisture using the standard procedures of AOAC (1990). Carbohydrates were determined by difference.

Amino acid analysis: The amino acid profile was determined using the method described by Benitez (1989). Defatted sample (30 mg) was weighed into a glass ampoule. Seven millilitres of 6 N HCl was added and oxygen was expelled by passing nitrogen into the ampoule. The glass ampoule was then sealed with Bunsen burner flame and put in an oven pre-set at 105±5°C for about 22 h. The ampoule was allowed to cool before broken open at the tip and the content was filtered. Amino acid analysis was carried out by ion-exchange chromatography using a Technicon Sequential Multisample Amino Acid Analyzer (Technicon Instruments Corporation, New York, USA). Tryptophan was not determined. Norleucine was the internal standard. The amino acid composition was calculated from the areas of standards obtained from the integrator and expressed as percentages of the total protein.

Determination of nutritional parameters: Nutritional parameters were determined on the basis of the amino acid profiles.

Amino Acid score determination: The amino acid scores were calculated using three different procedures:

i: Scores based on amino acid values compared with hen's whole egg (Paul *et al.*, 1980)
ii: Scores based on essential amino acid scoring pattern (FAO/WHO, 1973)
iii: Scores based on essential amino acid suggested pattern of requirements for preschool children (FAO/WHO/UNU, 1985)

Essential amino acid index (EAAI): The essential amino acid index was calculated using the equation proposed by Steinke *et al.* (1980):

$$\text{EAAI} = \sqrt[8]{\frac{(\text{Phenylal x Val x Threo x Isoleu x Meth x Histi x Lys x Leu})_a}{(\text{Phenylal x Val x Threo x Isoleu x Meth x Histi x Lys x Leu})_b}}$$

where, $(\text{Phenylal x Val x} \ldots\ldots)_a$ in test sample and $(\text{Phenylal x Val x} \ldots\ldots)_b$ content of the same amino acid in standard protein (%; casein), respectively.

Determination of predicted protein efficiency (P-PER): The predicted protein efficiency ratio was calculated according to an equation given by Alsmeyer *et al.* (1974):

$$\text{P-PER} = -0.468+0.454 \text{ x Leu}-0.105 \text{ x Tyr}$$

Determination of predicted biological value (BV): Biological value was calculated according to the following equation given by Oser (1959) cited by Mune-Mune *et al.* (2011):

$$\text{BV} = 1.09 \text{ x EAAI}-11.7$$

Cooking time: Ten grams of each noodle sample were placed into a 500 ml beaker with 200 ml of boiling distilled water. The core strand of the noodle was observed every 30 seconds during cooking as it was squeezed between two transparent glass slides. The cooking time was determined as time when the white core had disappeared (Gimenez *et al.*, 2012).

Water absorption and cooking loss: Water absorption and cooking loss of the noodles were determined as described by AACC (2000). Ten grams of the dried noodles were placed in a beaker containing about 150 ml boiling water. The beaker was covered with a watch glass and noodles were cooked for 10 min. The cooked noodles were allowed to drain for 5 min and weighed. The water absorption was calculated as:

$$\text{Water absorption (\%)} = \frac{\left[\begin{array}{c}\text{Weight of noodles after cooking (g)-}\\ \text{weight before cooking (g)}\end{array}\right]}{\text{Weight of noodles before cooking}}\times 100$$

The cooking loss was determined by pouring the gruel in 200 ml volumetric flask and adjusted to volume with distilled water. Ten millilitres of the solution was pipetted into an aluminium dish and dried to a constant weight at 105°C. The cooking loss was calculated as:

$$\text{Cooking loss (\%)} = \frac{\left[\begin{array}{c}\text{Weight of gruel and dish-}\\ \text{constant weight after drying}\end{array}\right]}{\text{Constant weight after drying}}\times 100$$

Sensory evaluation: Sensory evaluation was carried out using twenty semi-trained panellists who were students of the Department of Food Science and Technology, Ebonyi State University, Abakaliki. Criteria for selection of panellists were that panellists were familiar with noodles and were not allergic to any food. Panellists were instructed to evaluate mouth feel, appearance, firmness, taste and general acceptability of the noodles. A 9-point hedonic scale was used with 1 = dislike extremely, 5 = neither like nor dislike and 9 = like extremely (Ihekoronye and Ngoddy, 1985). Samples were identified with 3-digit code numbers and presented in a random sequence to panellists. The panellists were instructed to rinse their mouths with water after every sample.

Experimental design and statistical analysis: The experimental design was a single factor completely randomized design experiment with three replicates.
Significant differences between the mean values of data obtained from all samples of noodles were determined using analysis of Variance (ANOVA). Difference between means was determined using the Duncan's Multiple Range Test. Significance was accepted at 5% probability level. Coefficients of variation in percentage (CV%) were calculated for data obtained for protein quality. All data were analyzed using SPSS software (IBM SPSS v 20).

RESULTS AND DISCUSSION

Chemical composition of noodles: Table 1 shows the proximate composition of okara flour and noodles made from wheat-okara flour blends. The protein, fibre, fat and ash values obtained for okara flour were quite high. Protein content of the noodles ranged from 11.42-23.22%. Gallegos-Infante *et al.* (2010) reported a protein content of 16.68% for spaghetti with 30% common bean flour but in this study, noodles with 27.5% okara had a protein content of 18.51%. The protein content of the noodles samples increased as the levels of okara flour increased. There was also a steady increase in the fibre content with increase in okara flour. Gimenez *et al.* (2012) also reported that fibre content in spaghetti increased by 2% with the addition of every 10% of broad bean flour, which resulted in 8% for the highest substitution percentage tested. The composition of the different wheat-okara blended noodles varied significantly ($p<0.05$) from the control. It was observed generally that as the level of okara flour increased in the blends, the levels of protein, fibre, fat and ash also increased in the noodles produced. Increase in okara flour however led to a reduction in the carbohydrate content of the noodles produced. Noodles made from 50% wheat flour: 50% okara flour (50W:50OF) had the highest levels of most of the nutrients studied.

Protein quality of noodles produced: The amino acid (AA) composition of the noodles samples produced are presented in Table 2. Glutamic and aspartic acids had the highest concentrations among the groups while leucine and lysine were the most concentrated essential amino acids (EAA) in all the wheat-okara noodles samples. The percentage coefficient of variation (CV%) for the amino acids ranged between 7.57 and 21.2%, with threonine having the least value and lysine having the highest value. The concentrations of total AA (TAA), total essential AA (TEAA), total aromatic AA (TArAA), total acidic AA (TAAA), total neutral AA (TNAA), total basic AA (TBAA), total sulphur AA (TSAA) etc. are presented in Table 3. The TEAA (with His) ranged between 26.07 and 40.37 g/100 g crude protein (cp). There was a variation of 13.94%. The values obtained for wheat-okara noodles were all above half the average value of 56.6 g/100 g cp for egg reference protein (Paul *et al.*, 1980). The TEAA value of 40.37 g/100 g cp obtained for 50:50 (wheat: okara) was close to 44.4 g/100 cp reported for soya bean (Altschull, 1968). The TSAA of the samples ranged from 1.63-2.77 g/100 g cp. All the values in this range were less than half of 5.8 g/100 g cp, the recommended value for infants (FAO/WHO/UNU, 1985). With respect to % Cys in TSAA, values ranged between 49.82 and 56.35 g/100 g cp. It has been reported that the proportion of TSAA which can be met by Cys in man, for rats, chicks and pigs is about 50% (FAO/WHO, 1991). Most of the values obtained, were higher than this. The percentage ratios of TEAA to the TAA in the noodles samples ranged from 43.38-46.49%. All the values were much higher than the values of 39% considered as adequate for ideal protein food for infants, 26% for children and 11% for adults (FAO/WHO/UNU, 1985). The TEAA/TAA values were also close to the value of 50% reported for egg (FAO/WHO, 1990). The TArAA ranged between 5.67 and 8.07 g/100 g cp. The suggested range for ideal infant protein is 6.8-11.8 g/100 g cp (FAO/WHO/UNU, 1985). Noodles made with at least 20% okara flour had values within this range.

The predicted protein efficiency ratio (P-PER) ranged between 1.81 and 2.88. Friedman (1996) reported that PER values lower than 1.5 are indicative of low protein quality while values higher than 2 are indicative of high quality protein. All the samples containing okara flour had PER higher than 2 which suggests good protein quality. Biological value is a measure of the proportion of absorbed protein from a food which becomes incorporated into the proteins of the organism's body (Wikipedia, 2016). Biological values which range between 70-100% usually suggest good protein quality (Ijarotimi and Keshinro, 2012). Predicted biological values for noodles in this study ranged between 53.05 and 88.80%. Noodles that contained up to 20% okara flour had predicted biological values above 70%. The essential amino acid index (EAAI) has been reported to be an index of protein quality (Bender, 2005). Oser (1959) reported that a protein material is considered to be of good nutritional quality when the EAAI is above 90%, useful as food when the values are around 80% and inadequate for food when

Table 1: Proximate composition of okara flour and dried noodles (g/100 g db)

	Protein	Fat	Ash	Moisture	Crude fibre	Carbohydrates
Okara flour	32.25±0.22	7.42±0.10	4.10±0.10	6.65±0.02	14.53±0.03	34.88±0.44
Noodles						
0% okara	11.42±0.06[h]	1.08±0.03[g]	1.22±0.02[g]	7.15±0.02[a]	1.57±0.03[g]	77.55±0.07[a]
5% okara	13.62±0.02[g]	1.32±0.02[f]	1.48±0.01[f]	6.96±0.06[b]	2.92±0.02[f]	73.50±0.02[b]
16.25%okara	15.29±0.03[f]	1.85±0.02[e]	1.65±0.01[e]	6.54±0.03[c]	3.94±0.03[e]	70.47±0.03[c]
20% okara	15.89±0.03[e]	2.13±0.01[d]	1.75±0.01[d]	6.04±0.02[d]	4.07±0.03[d]	70.03±0.08[c]
27.5% okara	18.51±0.03[d]	2.63±0.01[c]	1.87±0.01[c]	5.78±0.01[e]	4.34±0.02[c]	66.87±0.1[d]
35% okara	19.76±0.02[c]	2.90±0.01[b]	2.08±0.01[b]	4.49±0.01[f]	5.81±0.02[b]	64.16±0.04[e]
38.75%okara	20.61±0.01[b]	2.91±0.01[b]	2.11±0.01[b]	4.48±0.01[f]	5.83±0.03[b]	63.98±0.02[e]
50% okara	23.22±0.02[a]	3.62±0.02[a]	2.39±0.01[a]	3.87±0.01[g]	7.83±0.07[a]	59.50±0.05[f]

Results are means of three independent determinations. Mean values having different superscripts within the columns are significantly different at ($p<0.05$)

values are below 70%. Values for EAAI ranged between 59.4 and 92.2%. Noodles with up to 16.25% okara flour had EAAI of over 70%.

Presented in Table 4 are the amino acid scores based on hen's whole egg (Paul *et al*., 1980). The highest scores were seen in glycine, glutamic acid and histidine for all the samples whilst serine and methionine had the least scores. The scores generally improved with increase in okara flour. The percentage coefficient of variation between the amino acid levels of the different noodles samples ranged between 8.33 and 20.88%. The essential amino acid scores based on FAO/WHO (1973) provisional amino acid scoring pattern are shown in Table 5. The limiting amino acids in noodles made from 100% wheat flour were Met + Cys (0.47) which was closely followed by Lys (0.57) while the highest score was obtained by Phe + Tyr (0.95). It has been reported that the essential amino acids most often acting in limiting capacity are methionine (and cysteine), lysine, threonine and tryptophan (Oyarekua and Adeyeye, 2011). The addition of okara generally improved the amino acid scores; for noodles made with 50% wheat: 50% okara, the lowest essential amino score was 0.78 (78%) obtained by Met + Cys. The essential amino acid scores based on suggested requirements for pre-school children (2-5 years) is shown in Table 6. Results suggest that noodles made with at least 5% okara flour will not only meet but surpass the suggested requirements for histidine and valine. The results also show that noodles with at least 20% okara has the potential of satisfying most of the essential amino acids requirements of pre-school children.

Cooking quality of noodles: Table 7 shows the cooking quality of noodles produced. Okara flour addition caused significant differences ($p<0.05$) in water absorption, cooking time and loss. The noodle samples with okara flour had significantly higher ($p<0.05$) cooking loss than the control. The total content of solids leached out during cooking is referred to as the cooking loss. Pagani *et al*. (2007) reported that low amounts of solids in cooking water is indicative of good cooking quality. This is because the loss of solids represents resistance of noodles to disintegrate during boiling. It has been reported that the weakening and/or disruption of the protein-starch matrix could be responsible for cooking losses (Izydorczyk *et al*., 2005). The increase in cooking loss observed in this study could be due to a disruption of the protein-starch matrix.

The cooking time decreased significantly ($p<0.05$) as the substitution with okara increased. The shortest cooking time (9.03min) was obtained for noodles containing 50% of okara while the control had the longest cooking time (12.30 min). Gimenez *et al*. (2012) also observed that wheat spaghetti presented the longest cooking time when compared to spaghetti made from wheat-bean flour blends. They attributed it to the fact that the central vein of pasta has greater starch content and it is this component that absorbs the water and transfers it into the centre of each pasta strand.

Most of the noodles made from the different wheat-okara blends had significantly higher ($p<0.05$) water absorption values than the control. The highest water absorption (187.1%) was observed in noodles with 35% okara while noodles with 20% okara showed the lowest water absorption (113.2%). Yadav *et al*. (2014) reported that water absorption is indicative of the degree of hydration and could affect the eating quality of noodles. When water absorption is insufficient, the noodle has a hard and coarse texture while excess water absorption leads to soft and sticky noodles (Jin *et al*., 1994).

Sensory quality of noodles produced: Even though most of the samples had good protein and cooking quality, it was necessary to evaluate the sensory quality of the noodles in order to ascertain the consumers' willingness to accept the products. Sensory ratings for the different noodles samples are shown in Table 8. It was observed that substitution of wheat flour with okara flour had a positive effect on the firmness of most of the blends of cooked noodles. Gimenez *et al*. (2012) observed a similar trend when substituting wheat flour with broad bean flour. Noodles made with 50% okara flour had the least ratings for all attributes evaluated while noodles made with 5% okara flour had the best ratings for all the attributes. Noodles made with 20% okara flour had better sensory

Table 2: Amino acid composition of noodles produced from wheat and okara flour blends (g/100 g crude protein) dry matter

	0%	5%	16.25%	20%	27.5%	35%	38.75%	50%			
Amino acid	Okara								Mean	SD	CV%
Lysine (Lys)	3.13	5.00	5.28	5.77	5.99	6.32	6.43	6.98	5.61	1.19	21.2
Histidine (His)	2.22	2.09	2.22	2.29	2.28	3.05	3.17	3.43	2.59	0.53	20.46
Aspartic acid(Asp)	7.89	8.21	8.71	8.90	9.21	9.53	9.85	9.59	8.99	0.69	7.68
Threonine (Thr)	2.61	2.90	3.01	3.01	3.01	3.01	3.18	3.41	3.04	0.23	7.57
Serine (Ser)	2.11	2.29	2.41	3.17	3.20	3.23	3.35	3.52	2.91	0.55	18.90
Glutamic acid (Glu)	10.58	11.23	11.51	12.01	12.51	12.93	13.36	13.78	12.24	1.10	8.99
Proline (Pro)	2.09	2.55	2.78	3.02	3.11	3.25	3.48	3.36	2.96	0.46	15.54
Glycine (Gly)	3.28	3.02	3.11	3.48	3.58	3.74	3.99	4.20	3.55	0.41	11.55
Alanine (Ala)	2.57	2.90	3.07	3.48	3.81	3.89	3.98	3.98	3.46	0.55	15.90
Cystine (Cys)	0.83	1.11	1.17	1.24	1.24	1.38	1.38	1.38	1.23	0.20	15.91
Valine (Val)	3.22	3.53	3.77	3.95	4.44	4.68	4.75	4.50	4.11	0.57	13.87
Methionine (Met)	0.80	0.86	0.96	1.07	1.18	1.23	1.39	1.38	1.11	0.22	19.82
Isoleucine (Ile)	2.48	2.61	2.87	3.00	3.20	3.52	3.65	3.85	3.21	0.64	19.93
Leucine (Leu)	5.52	6.40	6.75	6.81	6.92	7.16	7.57	7.86	6.87	0.72	10.48
Tyrosine (Tyr)	2.15	2.32	2.48	2.65	2.98	3.14	3.14	2.98	2.73	0.38	13.92
Phenylalanine (Phe)	3.52	3.96	4.22	4.40	4.58	4.75	4.93	5.02	4.42	0.51	11.54
Arginine (Arg)	5.10	5.62	6.13	6.30	6.55	6.98	7.32	7.66	6.46	0.86	13.31

Table 3: Concentrations of essential, non-essential, neutral, sulphur, basic, aromatic etc. amino acids (g/100 g crude protein) of noodles produced from wheat and okara flour blends

	0%	5%	16.25%	20%	27.5%	35%	38.75%	50%			
Amino acid	Okara								Mean	SD	CV%
Total amino acids (TAA)	60.10	66.60	70.51	74.73	76.88	81.79	84.92	86.84	75.24	9.27	12.32
TNEAA	34.03	36.35	38.36	40.77	41.47	44.18	45.87	46.47	40.94	4.49	10.96
TEAA with his	26.07	30.25	32.15	33.96	35.41	37.61	39.05	40.37	34.36	4.79	13.94
No His	23.85	28.16	29.93	31.67	33.13	34.56	35.88	36.94	31.76	4.35	13.70
TNEAA (%)	56.62	54.58	54.44	54.56	53.94	54.02	54.02	53.51	54.46	0.94	1.73
TEAA with his (%)	43.38	45.42	45.60	45.44	46.06	45.98	45.98	46.49	45.54	0.95	2.09
No His	39.68	42.28	42.45	42.40	43.09	42.25	42.30	42.54	42.12	1.02	2.42
TNAA	31.18	34.45	36.16	39.46	40.39	42.78	44.79	45.40	39.33	5.07	12.89
TNAA (%)	51.88	51.73	51.28	52.80	52.47	52.55	52.74	52.28	52.22	0.54	1.03
TAAA	18.47	19.44	20.21	20.91	21.72	22.46	23.21	23.37	21.22	1.78	8.39
TAAA (%)	30.73	29.19	28.66	27.98	28.25	27.46	27.33	26.91	28.31	1.22	4.31
TBAA	10.45	12.71	13.63	14.36	14.82	16.35	16.92	18.07	14.66	2.46	16.78
TBAA (%)	17.37	19.08	19.33	19.22	19.28	19.99	19.92	20.81	19.38	0.99	5.11
TSAA	1.63	1.97	2.13	2.31	2.42	2.61	2.77	2.72	2.32	0.39	16.81
TSAA (%)	2.71	2.96	3.02	3.09	3.15	3.19	3.26	3.13	3.06	0.17	5.56
Cys in TSAA (%)	50.92	56.35	54.93	53.68	51.24	52.87	49.82	50.74	52.57	2.29	4.36
TarAA	5.67	6.28	6.70	7.05	7.56	7.89	8.07	8.00	7.15	0.88	12.31
TarAA (%)	9.43	9.43	9.50	9.43	9.83	9.65	9.50	9.21	9.50	0.18	1.89
P-PER	1.81	2.19	2.34	2.35	2.36	2.45	2.64	2.88	2.38	0.31	13.02
EAII (%)	59.4	67.3	71.9	75.9	78.9	85.1	89.2	92.2	77.5	11.2	14.45
BV	53.05	61.66	66.67	71.03	74.03	81.06	85.53	88.80	72.76	12.21	16.78

TNEAA: Total non-essential amino acids, TEAA: Total essential amino acids, TNAA: Total neutral amino acids, TAAA: Total acidic amino acids, TBAA: Total basic amino acids, TSAA: Total sulphur amino acids, TArAA: Total aromatic amino acids

P-PER: Predicted protein efficiency ratio, EAAI: Essential amino acid index, BV: Biological value

Table 4: Amino acid scores of noodles produced from wheat and okara flour blends based on hen's whole egg amino acid profile

	0%	5%	16.25%	20%	27.5%	35%	38.75%	50%			
Amino acid	----------	----------	----------	---------- Okara	----------	----------	----------	----------	Mean	SD	CV%
Lysine (Lys)	0.51	0.81	0.85	0.93	0.97	1.02	1.04	1.13	0.91	0.19	20.88
Histidine (His)	0.93	0.87	0.93	0.95	0.95	1.27	1.32	1.43	1.08	0.22	20.37
Arginine (Arg)	0.84	0.93	1.01	1.04	1.08	1.15	1.21	1.26	1.07	0.14	13.08
Aspartic acid(Asp)	0.73	0.76	0.81	0.83	0.86	0.89	0.92	0.89	0.84	0.07	8.33
Threonine (Thr)	0.51	0.57	0.59	0.63	0.59	0.59	0.62	0.67	0.60	0.05	8.33
Serine (Ser)	0.27	0.29	0.31	0.40	0.40	0.41	0.42	0.45	0.36	0.07	19.44
Glutamic acid (Glu)	0.88	0.94	0.96	1.00	1.04	1.08	1.12	1.15	1.02	0.09	8.82
Proline (Pro)	0.55	0.67	0.73	0.79	0.82	0.86	0.92	0.89	0.78	0.12	15.38
Glycine (Gly)	1.09	1.10	1.06	1.16	1.19	1.25	1.33	1.41	1.20	0.12	10.00
Alanine (Ala)	0.48	0.54	0.57	0.65	0.71	0.72	0.74	0.74	0.64	0.10	15.62
Cystine (Cys)	0.46	0.62	0.65	0.69	0.69	0.77	0.77	0.77	0.68	0.11	16.18
Valine (Val)	0.43	0.47	0.50	0.53	0.55	0.62	0.63	0.60	0.54	0.07	12.96
Methionine (Met)	0.25	0.27	0.29	0.33	0.37	0.38	0.43	0.42	0.34	0.07	20.59
Isoleucine (Ile)	0.44	0.47	0.51	0.54	0.57	0.63	0.65	0.69	0.56	0.09	16.07
Leucine (Leu)	0.66	0.77	0.81	0.82	0.83	0.86	0.91	0.94	0.82	0.09	10.98
Tyrosine (Tyr)	0.54	0.58	0.62	0.66	0.75	0.79	0.79	0.75	0.69	0.10	14.49
Phenylalanine (Phe)	0.69	0.78	0.83	0.86	0.89	0.93	0.97	0.98	0.87	0.10	11.49

Table 5: Essential amino acid scores of noodles produced from wheat and okara flour blends based on FAO/WHO (1973) provisional amino acid scoring pattern

	0%	5% kara	16.25%	20%	27.5%	35%	38.75%	50%			
Amino acid	----------	----------	----------	---------- Okara	----------	----------	----------	----------	Mean	SD	CV%
Ile	0.62	0.65	0.72	0.75	0.80	0.88	0.91	0.95	0.79	0.12	15.19
Leu	0.79	0.91	0.96	0.97	0.99	1.02	1.08	1.15	0.98	0.11	11.22
Lys	0.57	0.91	0.96	1.05	1.09	1.05	1.17	1.27	1.01	0.21	0.21
Met+Cys	0.47	0.56	0.61	0.66	0.69	0.75	0.79	0.78	0.66	0.11	16.67
Phe+Tyr	0.95	1.05	1.12	1.18	1.26	1.32	1.35	1.34	1.20	0.15	12.50
Thr	0.65	0.73	0.75	0.79	0.75	0.75	0.79	0.85	0.76	0.06	7.89
Val	0.64	0.71	0.75	0.79	0.89	0.94	0.95	0.90	0.82	0.12	14.63

Table 6: Essential amino acid scores of noodles produced from wheat and okara flour blends based on requirements of pre-school children (2-5 years)

	0%	5%	16.25%	20%	27.5%	35%	38.75%	50%			
Amino acid	----------	----------	----------	---------- Okara	----------	----------	----------	----------	Mean	SD	CV%
Ile	0.87	0.93	1.03	1.07	1.14	1.26	1.30	1.38	1.12	0.18	16.07
Leu	0.84	0.97	1.02	1.03	1.05	1.08	1.15	1.19	1.04	0.11	10.58
Lys	0.54	0.86	0.91	0.99	1.03	1.09	1.11	1.20	0.97	0.20	20.62
His	0.93	1.10	1.17	1.21	1.21	1.61	1.67	1.81	1.34	0.31	23.13
Met+Cys	0.65	0.79	0.85	0.92	0.97	1.04	1.11	1.09	0.93	0.16	17.20
Phe+Tyr	0.90	0.99	1.07	1.21	1.20	1.25	1.28	1.27	1.15	0.14	12.17
Thr	0.77	0.85	0.89	0.94	0.89	0.89	0.94	1.00	0.90	0.07	7.77
Val	0.92	1.01	1.08	1.13	1.27	1.34	1.36	1.29	1.18	0.16	13.56

Table 7: Cooking quality of noodles made from wheat-okara flour blends

	Cooking time (min)	Water absorption (%)	Cooking loss (%)
0% okara	12.30±0.01^{a}	130.3±0.06^{f}	10.20±0.01^{h}
5% okara	12.20±0.01^{b}	120.5±0.01^{g}	11.90±0.01^{g}
16.25%okara	11.55±0.01^{c}	155.3±0.01^{b}	13.99±0.01^{f}
20% okara	11.50±0.01^{c}	113.2±0.01^{h}	15.02±0.01^{e}
27.5% okara	11.03±0.06^{d}	146.4±0.01^{d}	15.98±0.01^{d}
35% okara	10.10±0.01^{e}	187.1±0.01^{a}	16.69±0.01^{c}
38.75%okara	9.50±0.01^{f}	148.7±0.01^{c}	16.98±0.01^{b}
50% okara	9.03±0.06^{g}	138.4±0.01^{e}	18.26±0.01^{a}

Results are means of three independent determinations. Mean values having different superscripts within the columns are significantly different at **(p 0.05)**

Table 8: Sensory scores of noodles produced from wheat and okara flour blends

	0%	5%	16.25%	20%	27.5%	35%	38.75%	50%
Parameters	Okara							
Appearance	6.30±0.04^{d}	7.60±0.15^{a}	6.30±0.08^{d}	6.70±0.25^{b}	6.50±0.08^{c}	6.10±0.02^{f}	6.25±0.01^{e}	5.50±0.10^{g}
Taste	6.10±0.08^{d}	7.00±0.37^{a}	6.20±0.20^{c}	6.60±0.15^{b}	5.70±0.02^{e}	6.11±0.01^{d}	5.65±0.03^{f}	4.10±0.30^{g}
Mouth feel	6.57±0.01^{b}	7.36±0.32^{a}	5.95±0.08^{c}	6.55±0.03^{b}	5.60±0.05^{f}	5.70±0.01^{e}	5.90±0.01^{d}	4.05±0.23^{g}
Firmness	5.47±0.41^{d}	7.25±0.01^{a}	6.05±0.03^{c}	6.36±0.23^{b}	6.19±0.01^{bc}	5.93±0.03^{c}	5.90±0.01^{c}	5.35±0.01^{d}
General acceptability	6.27±0.30^{bc}	7.65±0.27^{a}	6.51±011^{b}	6.65±0.10^{b}	5.90±0.50^{c}	6.32±0.01^{bc}	6.37±0.01^{bc}	4.75±0.02^{d}

Mean values with different superscripts across the row are significantly different at ($p<0.05$)

ratings than the control (100% wheat) and also had superior protein quality than the control and noodles with 5% okara flour. This suggests that with respect to both protein and sensory quality, noodles made with 20% okara flour has great potentials.

Conclusion: This study has revealed that okara flour at various levels of supplementation had considerable effects on the quality of noodles. The nutritional quality improved, cooking time decreased and cooking loss increased as a function of the okara flour added to the noodles. According to sensory evaluation, overall acceptance of noodles was best at 5% level of okara flour. This was closely followed by noodles made with 20% okara flour (which was significantly better than the control with respect to sensory and protein quality). This study has shown that the utilization of okara flour will go a long way in not only increasing utilization of waste but will also encourage the development of variety and value added noodles.

Conflict of interest: This is to state that there was no conflict of interests.

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