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Research Article
Development and Quality Evaluation of Noodles from Wheat Flour Substituted with Maize and Mungbean Malt Flour

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Abstract
Background and Objective: Utilization of flour from local cereals and legumes for partial replacement of wheat flour in noodle production can improve nutrient composition and result in gluten-free noodles. The study aimed at developing noodles from blends of wheat, maize and mungbean malt flours and evaluates the quality of the noodles. **Materials and Methods:** Mungbean grain germinated for 72 h and sun-dried was dehulled, winnowed, milled and sieved into flour. The maize grain was processed into flour after tempering in water, degerming and drying. Mixtures of 100:0:0, 70:20:10, 40:30:30, 20:70:10, 0:70:30, 50:50:0 (wheat:maize:mungbean malt) were obtained. The flours and the blends were analyzed for proximate composition and subsequently used in noodles production. The noodles in addition, were analyzed for physical and sensory properties. **Results:** The results revealed that mungbean malt flour had the highest ash content (2.69%), protein (28.68%) and fibre (4.35%) compared to wheat and maize flours. Protein, fibre and ash contents significantly ($p<0.05$) increased in noodles containing a higher quantity of mungbean malt and less maize flour while fat content decreased. Substitution of wheat flour with mungbean malt flour up to 30% gave noodles with high protein, ash and fibre content and the sensory attributes which compare well with the control. **Conclusion:** The use of 20% maize flour and 30% mungbean malt flour showed great potential in improving the quality of noodles in terms of nutrient contents, physical properties and acceptability.

Key words: Mungbean malt, noodles, composite flour, sensory properties, proximate composition, maiz flour, wheat flour

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Noodles are popular foods in South East Asia and have become accepted and popular in many countries of the World including Nigeria[1]. The success of noodles all over the world is due to its low and affordable prices, convenience and the minimum efforts the products require for cooking. Also due to increasing population and urbanization as well as an increase in working-class mothers, noodles constitute affordable, convenient and time-saving foods for the fast-growing population. Consumption of noodles made from wheat flour is popular in developing countries such as Nigeria. Wheat as major raw material for noodle production has some inherent limitations such as low mineral composition, fibre, protein and high cost compared to local cereals such as maize (due to import duty as it is not cultivated in the tropics for climatic reasons)[2]. Research effort into the development of composite flour from available tubers, cereals and legumes for partial replacement of wheat flour in pasta production has been made. The use of the readily available cereals and inexpensive legume flours to complement the wheat flour can enhance the nutrient content of noodles and decrease the demand for importation of wheat flour. Flours from legumes and cereals other than wheat have also the advantage of being gluten-free hence reduction of incidence of celiac disease prominent among wheat consumers. The demand for noodles has increased significantly and the growth of pasta business has reached 7-10% every year[3,4]. To address the needs for wheat flour, the substitution of wheat flour with other local flour is needed. Maize-mungbean malt-wheat composite flours could be used as an alternative. Maize is abundantly produced in Nigeria, Nigeria, being reported as fifth in terms of annual world production of maize relative to other producing countries[5]. Maize grains are rich in carbohydrates and do contain significant quantities of other nutrients[6] and its demand for feed and industrial uses has recently increased rapidly[7]. Orarudi' (Vigna radiata), one of the lesser-known crops in Nigeria is rich in nutrients. It possesses good quality protein and essential amino acids, though limited in methionine and cysteine. It is a good source of soluble carbohydrate and contains a high amount of crude fibre[8]. Recently, 'orarudi' has gain attention in research as a component of composite flour[9]. Composite flour from maize and mungbean malt has been exploited in complementary food formulation. Incorporation of mungbean malt flour in noodle production is yet to be exploited. The present study aimed at improving the overall nutritional value of noodles through partial replacement of wheat flour with maize and mungbean malt and evaluate the proximate composition, physical properties and the sensory acceptability of the formulated noodles.

MATERIALS AND METHODS

Materials: Mungbean 'orarudi' and maize grains were purchased from the Ogige market in Nsukka, Enugu State, Nigeria. Wheat flour, common salt and palm olein were also obtained from a dealer in the same market.

Production of mungbean malt flour: Mungbean malt flour was produced as described elsewhere by Onwurafor *et al.*[10]. Mungbean seeds were sorted, weighed into lots of 200 g in malting bags (25×45 cm) which was subsequently steeped in water (1:3 w/v) for 3 h, air rested for 90 min, re-steeped in water for 3 h, drained and kept in a dark room to germinate for 72 h with the spraying of water each 24 h after which they were sun-dried for 96 h. The dried mung bean malt was dehulled by abrasion in-between the palm, winnowed and milled using a hammer mill, sieved with a sieve (mesh size, 200µm) to obtain mungbean malt flour.

Production of maize malt flour: Maize flour was processed as described by Uvere *et al.*[11]. Maize seeds were sorted, weighed, tempered in water (1:3 w/v) for 15 min and drained, coarsely milled using attrition mill, oven-dried at a temperature of 60°C for 30 min and winnowed. It was finely milled using a hammer mill and sieved with a sieve (mesh size, 200 µm) to obtain flour.

Formulation of wheat, maize and mungbean malt composite flour for noodles production: The wheat, maize and mungbean malt flour were mixed in ratios of 70:20:10, 40:30:30, 20:70:10, 0:70:30, 50:50:0, respectively to obtain samples. Whole wheat flour (100%) was also evaluated alongside the blends.

Preparation of noodles: Noodle was prepared according to the method reported by Reungneepaitoon[12]. Four hundred gram (400 g) of each flour blend was mixed differently with 140 mL of water and 4 g of common salt and conditioned into homogenous dough sheets of 3 mm thickness and rested for 30 min. The dough was passed through the rollers of pasta maker (Ampia 150 Super Lusso). The noodles were steamed for 90 sec and then placed in a wire basket fitted with a lid and the basket was dipped in hot palm olein at 150°C for 1 min and cooled to room temperature before packing. The flow diagram for the preparation of the noodles was shown in Fig. 1.

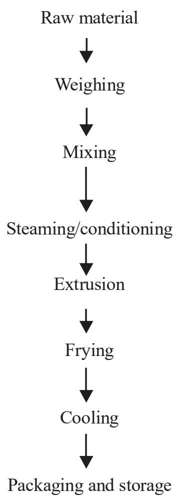

Fig. 1: Preparation of noodles

Determination of the proximate composition of flour blends and noodles: Proximate composition of different flour blends and noodles produced from them were determined using the method described by AOAC[13]. Carbohydrate content of the samples was determined by difference:

$$\text{Carbohydrate (\%)} = 100\text{-(\% moisture+protein+ \%ash+crude fibre+fat)}$$

The calorific content was calculated as:

$$\text{Calorie (kcal/100 g)} = (4\times\text{\% carbohydrate}) +(4\times\text{protein})+(9\times\text{\% fat})$$

Determination of the physical properties of the noodles: The width, height and length of the noodles in centimetre were measured using a micrometre screw gauge.

Sensory evaluation of noodle samples: Sensory evaluation as described by Ihekoronye and Ngoddy[14] was carried out using 20-semi-trained panelists of those who are familiar with noodles. The noodles were cooked for 10 min, cooled and presented to the panelists to assess for appearance, flavour, taste, texture and general acceptability on a 9-Point Hedonic Scale. The sensory evaluation was carried out in a sensory evaluation laboratory at mid-morning (10 am) under controlled conditions. The samples were presented in coded plastic plates. The order of presentation of samples to the judges was randomized. Clean water was presented for the panelists to rinse their mouths in between evaluation. Noodle from the composite flour was compared with 100% wheat noodle.

Experimental design and statistical analysis: Completely randomized design (CRD) was used for this experiment. All the data generated were subjected to one-way analysis of variance (ANOVA) and Duncan Multiple Range Test was used to separate the means using SPSS Version 17.0. Differences of $p<0.05$ were considered statistically significant.

RESULTS AND DISCUSSION

The proximate composition of wheat, maize and mungbean malt flours used for noodle production are presented in Table 1. The result revealed that mungbean malt flour had the highest ash content (2.69%) while wheat flour had the lowest value (0.86%). Ash content increased with an increase in mungbean malt flour. Malting of mungbean could have contributed to higher ash observed in the flour than wheat flour, an indication that its inclusion may improve the mineral content of the noodle as ash is an index of the mineral content of the food. Trends similar to ash was also observed for protein and fibre. The results for the protein content showed that the composite flour had significantly ($p<0.05$) higher protein content than the value for wheat flour (control) except for sample containing 20% wheat flour, 70% maize flour and 10% mungbean malt flour and 50:50:0 (50% wheat flour: 50% maize flour: 0% mungbean malt. Highest protein content was observed in the sample (40:30:30) containing 40% wheat flour, 30% maize flour and 30% mungbean malt flour and the value was significantly ($p<0.05$) different from the other blends. It was observed that wheat flour had higher fat content compared to maize and mungbean malt flour. Incorporation of maize and mungbean malt flour to form composite flour reduced the fat content compared to the value for wheat flour (control). The low-fat content of mungbean malt flour (1.02%) may be attributed to the malting effect as reported by Mubarak[15] who noted a significant ($p<0.05$) decrease in the fat content of mungbean malted for 72 h and attributed it to use of fat as an energy source during germination and use of degermed maize flour. The low-fat content of the blends implies that the flour may be less susceptible to rancidity. The moisture content of the composite flour varied between 7.70-9.86%. All the flour blends had moisture content below 13% hence less susceptible to spoilage and prolong shelf-life of the flours were assured. Carbohydrate increased as maize flour increased. However, increasing the mungbean malt content resulted in a decrease in carbohydrate content and this could be due to an increase in other components like protein.

Table 1: Proximate composition of flours of wheat, maize and mungbean malt and their composites

Samples	Protein (%)	Crude fat (%)	Crude fibre (%)	Moisture content (%)	Crude ash (%)	Carbohydrate (%)
Wheat flour (WH)	11.18±0.70[b]	1.15±0.13[b]	0.89±0.17[a]	10.29±0.91[c]	0.86±0.09[a]	75.63±0.47[b]
Maize flour (MZ)	7.13±1.05[a]	0.96±0.01[a]	2.05±0.36[b]	7.90±0.18[a]	1.29±0.10[b]	80.67±0.51[c]
Mungbean malt flour (MB)	28.68±0.01[c]	1.02±0.02[b]	4.35±0.89[c]	8.62±0.22[b]	2.69±0.01[c]	54.64±0.65[a]
Composite flour WH:MZ:MB						
100:0:0	11.18±0.70[b]	1.15±0.13[c]	0.89±0.17[a]	10.29±0.91[c]	0.86±0.09[c]	76.44±0.47[b]
70:20:10	13.46±0.33[c]	0.92±0.01[b]	0.98±0.01[a]	9.70±1.05[b]	0.76±0.83[b]	74.18±0.99[c]
40:30:30	16.17±0.21[d]	0.86±0.05[a]	1.04±0.05[a]	9.86±0.24[c]	1.19±0.71[d]	70.88±0.53[a]
20:70:10	9.79±0.13[a]	1.03±0.04[c]	1.26±0.39[b]	7.71±0.29[a]	1.07±0.10[d]	79.14±0.73[e]
0:70:30	12.43±0.28[b]	0.86±0.06[a]	3.15±0.13[c]	7.70±0.40[a]	0.71±0.05[b]	75.15±0.28[b]
50:50:0	8.13±0.16[a]	0.98±0.07[b]	1.12±0.17[b]	9.16±0.86[b]	0.30±0.14[a]	80.31±0.16[d]

Values are Means±SD of three replications. Means within a column with the same superscript were significantly ($p<0.05$) different. Key; WH: Wheat flour, MZ: Maize flour, MB: Mungbean malt flour

Table 2: Proximate composition of wheat, maize and mungbean malt composite flour noodles

Noodles WH:MZ:MB	Protein (%)	Crude fat (%)	Ash (%)	Crude fibre (%)	Moisture (%)	Carbohydrate (%)	Energy (kcal/100 g)
100:0:0	9.13±0.09[a]	1.38±0.64[a]	0.97±0.28[c]	0.80±0.54[a]	9.30±1.03[c]	78.42±0.50[c]	362.62±8.22[a]
70:20:10	11.98±0.50[d]	0.89±0.09[a]	1.18±0.09[c]	1.02±0.05[a]	9.09±0.43[c]	75.84±0.21[bc]	361.90±3.60[a]
40:30:30	13.78±0.34[e]	0.89±0.06[a]	1.27±0.04[c]	1.43±0.15[a]	8.83±0.21[bc]	73.80±0.6[b]	358.33±0.77[a]
20:70:10	8.93±0.16[b]	0.83±0.06[a]	1.17±0.11[c]	1.68±0.01[a]	6.79±0.13[a]	80.60±0.20[cd]	365.59±0.02[a]
0:70:30	12.99±1.35[de]	0.94±0.06[a]	1.17±0.04[b]	3.82±0.07[c]	7.24±0.23[a]	73.84±1.68[a]	355.06±1.61[a]
50:50:0	11.11±0.54[c]	0.86±0.03[a]	0.25±0.04[a]	1.36±0.35[c]	8.29±0.43[abc]	78.13±0.50[c]	364.70±0.23[a]

Values are Means±SD of three replications. Means within a column with the same superscript were significantly ($p<0.05$) different. Key; WH: Wheat flour, MZ: Maize flour, MB: Mungbean malt flour

Proximate composition of noodles produced from wheat, maize and mungbean malt composite flour mixed at different ratio: Variations exist in the proximate composition of noodles from wheat, maize and mungbean malt flour (Table 2). The moisture content of noodles from the blends ranged from 6.79-9.09%. Noodle with the highest quantity of maize flour (sample 20:70:10) (wheat: maize: mungbean malt) had the lowest moisture content while noodle with the highest content of wheat flour (sample 70:20:10) had the highest moisture content among the blends though lower than that of 100% wheat (10.29%). The lower moisture content of 20:70:10 could be due to the high quantity of maize flour in the blends. The moisture content is an index of the shelf-stability of food because microorganisms require moisture for their deteriorative activities within the food. Free water, intermediate water and bound water are three forms of water in food[16]. As an important component of many foods, water has a decisive influence on food's chemical and physical properties among others[17,18]. Li *et al.*[19] compared properties of dry noodles and wet noodles and inferred that the later are fresher, with stronger boiling fastness, stronger gluten, better taste and better flavor but conclude that the high moisture of fresh wet noodles can easily lead to spoilage, browning, rancidity and deterioration, damaging appearance, quality and flavor. Noodles from blends 20:70:10 may store better compare to other blends because of its low moisture content.

The protein content of the noodles from the blends ranged from 8.11-13.99%. Substitution of wheat flour with an increasing quantity of mungbean malt flour increased the protein content of the noodles while the reverse is the case with an increase in the quantity of maize flour. The low protein contents of the sample containing 20% wheat flour, 70% maize flour and 10% mungbean malt flour and 50:50:0 (50% wheat flour: 50% maize flour: 0% mungbean malt blends) were due to incorporation of more quantity of maize flour and little and/or absence of mungbean malt flour in the blends. Greater increase in protein content of noodles with an increasing level of mungbean malt flour was observed while the reverse was the case with carbohydrate content. This was expected as mungbean malt flour is a rich source of protein and improves the protein content of cereal[10,20]. The result was in agreement with Yusufu *et al.*[21] who reported a decrease in carbohydrate content of cookies when green bean flour was blended with wheat to produce cookies and Uvere *et al.*[11] who reported a decrease in Maize-Bambara groundnut malt flour complementary food blend. Noodles from the blends with a higher quantity of maize flour have a lower amount of protein than 100% wheat flour noodles attributable to the low quantity of protein in maize flour compared to wheat flour used in the noodle production. The high protein content of the noodles from most blends is significant in curbing protein-energy malnutrition which mostly occurs in regions that their staple food is low in protein but rich in carbohydrates. Noodles have become one of the most staples and popular foods in many parts of the world[22] and are mainly consumed by school children that need adequate protein for growth[23].

A diet that is more deficient in protein than energy may be more likely to cause kwashiorkor[24]. Various authors gave similar reports of protein increase when wheat flour was substituted with other legumes[22] while lower protein content was reported for noodles made from blends of wheat and sorghum flour[25].

Fibre content was more in noodles from the composite flour compared to the control and the difference was significant at $p<0.05$. Noodles from 0:70:30 (WH:MZ: MB) flour had the highest fibre value (3.82%). More fibre was observed in the noodles containing a higher quantity of mungbean malt and maize flour compared to those with more wheat flour. This was expected as mungbean malt and maize flour used for noodle production contains more fibre than wheat flour. The high crude fibre of the composite noodle indicates that it will be more effective in the delay of gastric emptying and reduction in serum cholesterol than that from 100% wheat flour suggesting the noodle will be good for diabetic patients and health-conscious individuals. Less fibre content was reported in noodles from blends of wheat, acha and soybean composite flours[23]. There were significant ($p<0.05$) differences among the ash content of noodles from the blends. The ash content of the noodles was influenced by mungbean malt flour and this can, in turn, affect the mineral content of the noodles. The ash is an index of the mineral content of the food sample which is necessary for growth and development.

The fat content of the noodles from the blends ranged from 0.83-0.94% with sample 40:30:30 (WH:MZ: MB) having the least fat content among the blends. Noodles from composite flour containing more mungbean malt flour have reduced fat content compared to others. This was expected as mungbean malt flour used in the formulation of the noodles had low-fat content compared to wheat and maize flour. The low-fat content of mungbean malt may be attributed to malting losses incurred as a result of dry matter loss, mainly due to growth and respiration of the embryo and the enzymatic activities in the grains[26]. The relatively low-fat content of the food blends may contribute to the extension of shelf-life of the noodles by retarding the onset of rancidity. The low-fat content of noodles from the blends could make the product excellent food for diabetic and obese patients. There was no significant ($p>0.05$) difference among the samples.

Noodles from composite flour containing more maize flour (20:70:10) had the highest carbohydrate content as expected compared to other blends and the difference was significant ($p<0.05$). Noodles produced from composite flour with a higher quantity of mungbean malt had generally low carbohydrate content compared to others and this may be attributed to the low carbohydrate content of mungbean malt flour. The results indicate that noodles from composite especially with a higher content of mungbean malt flour have enhanced nutrients than those of 100% wheat flour and may benefit consumers more than the control. The calorie values for the different blends ranged from 355.06-365.59 kcal. Energy values of noodles differed not significantly ($p>0.05$) among the blends. The higher calorie value of sample 50:50:0 may be due to the high content of maize flour in the noodle.

Physical characteristics of noodles formulated from flours of wheat, maize and mungbean malt blended at different ratios: The results of the physical characteristics of the noodles from wheat, maize and mungbean malt composite flours were shown in Table 3. The width of the noodle produced from composite flour of wheat/maize/mungbean malt varies from 0.57-0.63 cm which was significantly ($p>0.05$) different from those of the wheat flour noodles. The size of the noodles depended on the diameter of the nozzle of the pump and the distance between the mesh sieve and the steam. The length of the noodles produced from the wheat, maize and mungbean malt composite varied from 8.85-24.23 cm. Increasing the quantity of the mungbean malt and maize flour significantly ($p<0.05$) decreases the length of noodles. This may be caused by the low content of wheat flour in the blends showing that the elasticity of the dough decreased due to a reduction in gluten. The noodles made from wheat flour was the longest, this was probably due to the gluten network.

Sensory properties of noodles produced from wheat, maize and mungbean malt composite flour: Table 4 shows the mean score for sensory attributes of colour, flavour, taste, texture and overall acceptability of noodles produced from

Table 3: Physical property of noodles produced from wheat, maize and mungbean malt composite flour

Noodles WH:MZ:MB	Width (cm)	Height (cm)	Length (cm)
100:0:0	0.52 ± 0.06^{a}	0.03 ± 0.01^{a}	26.90 ± 0.85
70:20:10	0.57 ± 0.02^{ab}	0.03 ± 0.01^{a}	24.23 ± 0.01
40:30:30	0.61 ± 0.01^{bc}	0.04 ± 0.01^{ab}	14.40 ± 1.27
20:70:10	0.63 ± 0.01^{bc}	0.05 ± 0.01^{b}	10.85 ± 0.63
0:70:30	0.63 ± 0.04^{bc}	0.05 ± 0.01^{b}	8.85 ± 0.49
50:50:0	0.60 ± 0.03^{bc}	0.04 ± 0.01^{ab}	17.60 ± 1.27

Values are Means±SD of three replications. Means within a column with the same superscript were not significantly different ($p>0.05$). Key; WH: Wheat flour, MZ: Maize flour, MB: Mungbean malt flour

Table 4: Sensory score of noodles produced from wheat, maize and mungbean malt composite flour

	Sensory attributes				
Noodles Wh:M:MB	Colour	Flavour	Taste	Texture	General acceptability
100:0:0	8.45±0.51^{e}	8.40±0.50^{c}	8.85±0.63^{d}	8.60±0.50^{c}	8.75±0.81^{c}
70:20:10	8.35±0.35^{e}	8.25±0.72^{c}	8.65±0.48^{d}	8.00±0.85^{c}	8.50±0.68^{c}
40:30:30	7.05±0.60^{c}	7.45±0.51^{b}	7.25±0.44^{c}	6.50±1.39^{b}	7.10±0.71^{b}
20:70:10	6.45±0.51^{b}	7.40±0.50^{b}	6.60±0.59^{b}	2.20±1.19^{a}	5.75±1.55^{a}
0:70:30	5.65±0.67^{a}	6.70±0.65^{a}	5.30±0.80^{a}	2.55±1.05^{a}	6.05±0.94^{a}
50:50:0	7.50±0.51^{d}	7.25±0.44^{b}	6.60±0.88^{b}	6.15±1.46^{b}	7.25±0.44^{b}

Means within a column with the same superscript were not significantly (p>0.05) different. Key; WH: Wheat flour, MZ: Maize flour, MB: Mungbean malt flour

wheat, maize and mungbean malt composite flour. Noodles from composite flour containing 70:20:10 (WH:MZ: MB) flour scores highest in sensory attributes of colour (8.35), flavor (8.25), taste (8.65) and texture (8.00) showing that the noodles were extremely liked by the panelists and these values were not significantly (p>0.05) different from scores for the above attributes for 100% wheat flour noodles. The high scores indicate their preferences over other blends. Noodles from 40:30:30 (WH:MZ: MB) were also moderately liked by the panelists in all the sensory attributes too showing that incorporation of mungbean malt up to 30% is acceptable in noodles production. However, increasing the amount of maize and mungbean malt flour decreased the colour acceptability of noodles. This may be due to a decrease in the brightness of the noodle as a result of increasing the amount of mungbean malt and maize flour which changes the colour to light brown. The brownish colour may be due to the reaction between mungbean malt protein and sugar[27], though the effect had little impact on panelist's perception of the colour of the noodles (sample 40:30:30) as the score indicated very much liked. Other samples perform slightly lower than the control and the above two samples in all the attributes evaluated.

CONCLUSION

The study has shown that acceptable noodles could be produced from blends of wheat, maize and mung bean malt flour. Noodles from the composite flour were richer in nutrients and may confer nutritional advantages to consumers compared to the control. Based on the study, the use of 20% maize flour and 30% mungbean malt flour showed great potential in improving the quality of noodles in terms of nutrient contents, physical properties and acceptability. Substitution of wheat flour with maize flour and mungbean malt flour in noodles production up to 20 and 30%, respectively are suggested as it compares well with the control in acceptability.

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