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Research Article

Quality evaluation of formulated instant noodles from wheat, rice (Oryza sativa) and mushroom (Agaricus bisporus) flour blends

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ABSTRACT

The purpose of this study is to produce and evaluate qualitatively, instant noodles from wheat, rice and mushroom flour blends. A composite flour of wheat and rice flours (90:10) was obtained as the best blends after a preliminary sensory evaluation and substituted with 10, 20, 30, 40 and 50 % mushroom flour coded as WRM1 (90:10), WRM2 (80:20), WRM3 (70:30), WRM4 (60:40), WRM5 (50:50) and commercial noodles (Indomie) served as the control. The formulated blends were used to produce instant noodles. The instant noodles were analysed for proximate composition, micronutrients (vitamin B_1, B_2 and B_3, iron, potassium, and phosphorus) microbial quality, cooking characteristics, sensory qualities and functional properties of the flour blends using standard procedures. Results showed that mushroom flour increased the crude protein (9.49-15.39 %), ash (1.39-5.31 %), crude fiber (1.50-5.40 %), moisture content (7.92-14.48 %). It, however, decreased the fat (0.5-1.50 %) and carbohydrate content (58.42-77.45 %). Potassium and vitamin B_3 were identified as the predominant micronutrients in the instant noodles samples and increased with level of mushroom addition. Sample WRM1 (90:10) with 10% mushroom flour had the highest mean for all sensory attributes (taste, colour, appearance, texture and overall acceptability) compared to other samples. The total viable count ranged from 4.3 x 10^2 (control) to 1.78 x 10^3 cfu/g in sample WRM4 (60:40). Thus, mushroom flour could be incorporated into instant noodles to obtain an acceptable product rich in dietary fiber, protein, ash, vitamin B_3 and potassium but low in fat and carbohydrate.

INTRODUCTION

Noodles are narrow strips of unleavened dough which is stretched, extruded or rolled flat and cut into one of a variety of shapes (Anon, 2019). Noodle has been increasingly an important food commodity worldwide. In 2018, the World Instant Noodles Association reported that 103.620 million servings were consumed worldwide (World Instant Noodle Association, 2019). 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.

There are many types of noodles, but the "instant" types continue to show increasing popularity globally as these products offer ease in preparation while being economical and tasty (Akanbi et al., 2011). Noodles are produced basically from wheat flour. According to FAO estimate, world would require around 840 million tonnes of wheat by 2050 from its current production level of 642 million tonnes. To meet this demand, developing countries need to increase their wheat production by 77 % (FAO, 2009). However, wheat production in Nigeria has been unpredictable. Reports indicated that until 1985, domestic wheat production in Nigeria was about 66.000 tons (Olugbemi, 1991). In 1988/89 crop production season about 600,000 tons of wheat was produced from a total of 214.000 hectares with an average yield of 2 tons per hectare (Olugbemi, 1991). In 2011 the production was 165,000 metric tonnes which drastically dropped to 60.000 metric tonnes in 2016 (Olugbemi, 1991), thus noodle production depended on wheat importation mostly from the United States since wheat cannot perform well under tropical climate. According to Weigand (2011), African wheat imports will soar from 22.3 million tonnes in 2010 to 51.4 million tonnes in 2050, while the Middle East's imports will double from the region's minor wheat producers, from 14.4 million tonnes to 29.5 million tonnes. Brazilian wheat imports will climb from 6.5 million tonnes in 2010 to 10.5 million tonnes in 2050 in order to fulfill domestic demand. This wheat importation, has resulted in an immerse drain on the economy, suppressing and displacing of indigenous cereals, with a resultant detrimental effect on the agricultural and technological development, and cause of poverty in Nigeria (Kumara, 2015). In order to reduce the impact of wheat importation on the economy, the Federal Government released a policy mandating flour mills to partially or wholly substitute wheat flour (Ammar et al., 2009). This resulted in the adoption of alternative solutions by using flours obtained from other raw materials in combination with wheat flour. In addition to wheat importation, wheat as a major raw material for noodle production has some inherent limitations such as low mineral composition, fiber, protein and high cost compared to local cereals such as rice. Efforts have been put in place via research to develop composite flour from available tubers, cereals and legumes for partial replacement of wheat flour in noodle production. The use of 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 (Onwurafor et al., 2020). To reduce the demand for wheat flour, substitution of wheat flour with other local flour is needed. Rice-mushroom-wheat composite flours could be used as an alternative. Rice is regarded as one of the most appropriate cereal grains for producing gluten-free products owing to its benefits of high digestibility, hypoallergenic properties among others (Marco and Rosell, 2008). Rice-based noodles are prepared from rice cultivars containing high-amylose content, low-gelatinization temperature and high-gel consistency (Yoenyongbuddhagal et al., 2002). Textural and cooking properties of rice-based noodles are dependent upon flour swelling power, pasting properties and gel hardness (Bhattacharya et al., 1999) which directly affects consumer acceptance (Hormdok and Noomhorm, 2007).

In general, products made from cereals are low in sodium, amino acids and total fat. Noodles produced from wheat flour contain 11-15 % protein dry basis but are deficient in lysine and threonine (the first and second limiting amino acid), common to most cereal products (Tongpun, 2006). Cereals are rich in minerals but the bioavailability of these minerals is usually low due to the presence of anti-nutritional factors such as phytate, trypsin inhibitor and polyphenols. Phytic acid is the most important anti-nutrient because it is found in most of the cereals and has strong ability to complex multi-charged metal ions, especially zinc, calcium and iron and makes them unavailable for human body utilization. The absence of lysine makes it difficult for the body to synthesize protein, hormones, enzymes and antibodies which are needed for growth and other functions (Flodin, 1997). Food fortification is adopted to improve the nutritive value of noodles made from cereals.

Mushroom is a macro fungus with a distinctive fruiting body, which can be either epigeous or hypogenous and large enough to be seen with naked eye and to be picked by hand (Chang and Miles, 1992). Mushrooms according to Bano (1993), have about twice the protein content of vegetables four times that of oranges and significantly higher than that of wheat and are high in vitamins such as riboflavin, biotin and thiamine. Mushrooms also present high nutritional value, having some bioactive components, like dietary fibre, antioxidants, minerals, folates, essential amino acids (such as lysine) as well as vitamins B_1, B_2, B_3 and C (Li et al., 2015) and a wide spectrum of mineral substances. It represents a good source of biologically valuable substances for human nutrition. However, it is a perishable product due to its high moisture content. Okafor et al. (2012) showed that there was significant improvement in the bread protein content and nutritional quality of wheat flour utilized in bread production when mushroom powder was added to the wheat. Incorporation of mushroom flour in the preparation of noodles will impart additional health benefits to it. Therefore, the purpose of this study is to produce and evaluate qualitatively, instant noodles from wheat, rice and mushroom flour blends so as to enhance the utilization of mushroom in food processing and improve the nutritional quality of instant noodles via its protein and mineral content and solve nutritional imbalance such as micro-nutrient deficiency and malnutrition.

MATERIAL AND METHOD

Durum wheat (Crown flour mill) flour and vegetable oil (Power oil) were purchased from Ogige market, Nsukka Enugu State, Nigeria. Parboiled seeds of Rice (*Oryza sativa)* were obtained from Adani Rice Mill in Uzo Uwani Local Government Area, Enugu State, Nigeria. Mushroom (*Agaricus bisporu*) was procured from Afor Enyiogugu market, Mbaise, Imo State, Nigeria. The production and analyses of the developed product was carried out in the food processing laboratory of the department of Food Science and Technology, University of Nigeria, Nsukka.

The mushroom (*Agaricus bisporu*) was processed by modifying the method described by Bello et al. (2017). Fresh mushrooms were cleaned, cut into slices (about 3 mm thickness) and dried for 6 hours at a temperature of 50^0C in a hot air laboratory oven (LABE 1201, Divine International, and Delhi). Dried mushroom samples were milled and sifted through an 80 mesh screen to obtain fine powders. The obtained powder was cooled, hygienically packed and stored in air tight container for further use.

The Rice flour was processed by modifying the method described by Iwe et al. (2016). Parboiled rice grains were cleaned, sorted and washed, then steeped in water for 12 hours, drained and dried in a hot air laboratory oven (LABE 1201, Divine International, Delhi) at a temperature of 60^0C for 30 min. It was finely milled using a rice milling machine (Angel bergs, miller Germany) and sieved with a sieve (mesh size 300 μm) to obtain fine flour which was designated as DM/PRF (Dried or Milled Parboiled Rice Flour).

Formulation of blends

The flour obtained from rice and wheat was blended in different percentages as shown in Table 1 to produce noodles (procedure written in the production of instant noodles below). The noodles produced from the blended flour were subjected to sensory evaluation in order to obtain the best blend. The noodles were cooked for 10 min, cooled and presented to 20 semi-trained panelists from among students of the Department of Food Science and Technology, University of Nigeria, Nsukka, who are familiar with noodles to assess for appearance, flavor, taste, texture and general acceptability on a 9-point Hedonic scale as described by Ihekoronye and Ngoddy (1985). The samples were presented in coded plastic plates. The order of presentation of samples to the judges was randomized. Clean water was supplied for the panelists to rinse their mouths between evaluations. Noodle from the composite flour was compared with 100 % wheat noodle. Based on the sensory evaluation of the noodles, the blend of wheat and rice flour (90:10) was chosen as the best blend. The best blend was then blended with mushroom flour as shown in Table 2 to produce the final product.

Production of instant noodles

The noodles were produced using the method described by Hou (2001). Four hundred grams (400 g) of each flour blend was mixed differently with 140 ml of water and 4 g of salt and kneaded until the flour forms dough sheets of about 3 mm thickness. The crumbly dough obtained was rested for 30 minutes to mature and then kneaded to uniformly distribute the ingredients and hydrate all the flour particles. The dough was then passed through rotating rollers of a hand operating extruder (LAMI LM-20, China) to

Table 1. Blending ratios of wheat and rice flour

Sample code	WF (%)	RF (%)
WF + RF_0 (100:0)	100	0
WF + RF_{00} (0:100	0	100
WF + RF_1 (90:10)	90	10
WF + RF_2 (80:20)	80	20
WF + RF_3 (70:30)	70	30
WF + RF_4 (60:40)	60	40
WF + RF_5 (50:50)	50	50

Key: WF + RF_0 = 100% wheat flour and 0% rice flour; WF + RF_{00} = 0% wheat flour and 100% rice flour; WF + RF_1 = 90% of wheat flour and 10% rice flour; WF +RF_2 = 80% wheat flour and 20% rice flour; WF + RF_3 = 70% wheat flour and 30% rice flour; WF + RF_4= 60% wheat flour and 40% rice flour**;** WF + RF_5 = 50% wheat flour and 50% rice flour

Table 2. Blending ratios of wheat/ rice flour and mushroom flour

Sample code	Wheat/ local rice flour blend (90:10 best blend) (%)	Mushroom flour (%)
WR/MF_0 (100:0)	100	0
WR/MF_1 (90:10)	90	10
WR/MF_2 (80:20)	80	20
WR/MF_3 (70:30)	70	30
WR/MF_4 (60:40)	60	40
WR/MF_5 (50:50)	50	50

Key: WR/MF_0 = 100 % of the best blend flour and 0% of mushroom flour; WR/ MF_1 = 90 % of the best blend flour and 10 % of mushroom flour; WR/MF_2 = 80 % of the best blend flour and 20 % of mushroom flour; WR/MF_3 (70:30) =70 % of the best blend flour and 30 % of mushroom flour; WR/MF_4= 60 % of the best blend and 40 % of mushroom flour; WR/MF_5= 50 % of the best blend and 50 % of mushroom flour produce a noodle sheet. The sheet was repeatedly folded and passed through the rollers to facilitate gluten development, which gives the noodles its stringy and chewy texture. The gap between the finishing rolls was adjusted to produce the desired thickness of the noodle belt that was then immediately cut in the cutting section of the same machine. The noodles were steamed at 98-100^{o}C for 1-5 minutes, which gelatinizes the starch and improves the texture of the noodles, after which the noodles were dried by frying in oil at 135-145^{o}C for 2 minutes. Small quantities of the developed products/flour in grams (0.1g 1g, 2g, 5g, etc.) were used for analysis.

Analysis of raw materials and noodles produced from wheat, local rice and mushroom

The flours were analyzed for their proximate, functional properties and micro-nutrients while the noodles were analyzed for their proximate composition, cooking characteristics, microbial analysis for one month at seven (7) days interval, sensory attribute and micronutrients.

Determination of proximate composition

The flours and the developed instant noodles were analyzed for their moisture content, crude fiber, ash, protein and fat content using AOAC (2010) method while carbohydrate content was determined by their difference.

Determination of selected functional properties of flour blends

The methods described by Onwuka (2018) were used in the determination of the functional properties of the flour blends. The functional properties determined included the water and oil absorption capacities, bulk density and swelling capacity.

Determination of water and oil absorption capacities

The water absorption capacity of the flours was determined as follows. One (1) gram of sample was mixed with 10 mL of distilled water using a warring whirl mixer. The sample was allowed to stand at ambient temperature (30±2 °C) for 30 seconds and then centrifuged for 30 minutes at 5,000 rpm × g. Water absorption was examined as per cent water bound per gram flour. For oil absorption capacity, one gram of sample was mixed with 10 mL soybean oil (Sp. Gravity: 0.9092) and allowed to stand at ambient temperature (30±2°C) for 30 minutes and then centrifuged for 30 min at 5,000 rpm × g. Oil absorption was examined as percent oil bound per gram flour (Onwuka, 2018).

Absorbed water/ oil = (total water/oil – free water/oil) x density of water/oil

Determination of bulk density

The bulk density was determined as follows. A graduated measuring cylinder of 10 ml capacity was weighed and gently filled with the sample, followed by gently tapping the bottom until there was no further diminution of the sample level after filling to the 10 ml mark (Onwuka, 2018).

The bulk density was calculated as:

Bulk density (g/ml) = Weight of sample (g)/ Volume of sample (ml)

Determination of swelling capacity

The swelling capacity was determined by modifying the method of Prescott et al. (2005). The flour sample (0.1 g) was weighed into a test tube and 10 ml of distilled water added. The mixture was heated in a water bath at a temperature of 50°C for 30 minutes with continuous shaking. In the end, the test tube was centrifuged at 1500 rpm for 20 minutes in order to facilitate the removal of the supernatant which was carefully decanted and the weight of the starch paste taken. This was carried out over a temperature range of 50 – 100°C. The swelling power was calculated as follows:

$$\text{Swelling power} = \frac{\text{weight of strach paste}}{\text{weight of dry starch sample}}$$

Determination of micronutrients, Determination of vitamins, Determination of vitamin B_1 (Thiamine)

Thiamin was determined using AOAC (2010) procedure. Seventy five milliliter (75 ml) of 0.2 N HCl was added to 2 g of sample and the mixture boiled over a water bath (Stuart; RE300B, UK).

After cooling, 5 ml of phosphatase enzyme solution was then added and the mixture incubated at 37°C overnight. The solution was placed in a 100 ml volumetric flask and the volume made up with distilled H_2O. The solution was filtered and the filtrate purified by passing through silicate column. Twenty-five (25) ml of the filtrate was put in a conical flask and 5 ml of acidic KCl exudate, 3 ml of alkaline ferricyanide solution, and 15 ml isobutanol were added, and shaken for 2 min. The solution was then allowed to separate and the alcohol layer taken. About 3 g of anhydrous sodium sulphate was added to the alcohol layer. A 5 ml of thiamine solution was accurately measured into another 50 ml stoppered flask. The oxidation and extraction of thiochrome as already carried out with the sample was repeated using thiamine solution. A 3 ml of 15 % NaOH was added to the blank instead of alkaline ferricyanide. The blank sample solution was poured into fluorescence reading tube and reading taken: Thiamine was calculated as follows:

$$\%\ \text{thiamine} = \frac{X}{Y} x \frac{1}{5} x \frac{25}{V} x \frac{100}{W}$$

Where W= weight of sample; X = reading of sample- reading of blank; Y = reading of thiamine standard – reading of blank standard; V = volume of solution used for test on the column.

Determination of vitamin B_2 (Riboflavin)

The method of AOAC (2010) was used. Two grams (2 g) of the food material was taken in a conical flask. Fifty milliliter (50 ml) of 0.2N HCl was added and boiled in a water bath (Stuart; RE300B, UK) for 1h. The solution was cooled and the pH adjusted to 6.0 using NaOH about I N HCl was added to lower pH (METER TOLED. Seven-Multi. pH MV/ORP-MTW 1.49/01.38. Schwerzenback) to 4.5, then filtered in a 100 ml measuring flask and used to make volume up to mark. To remove interference, two tubes was taken and labeled 1 and 2 for tube 1 and 10 ml of filtration, and 1 ml of water for tube 2 respectively. Then, 10 ml of filtrate was added to 1ml of riboflavin standard. One milliliter (1 ml) of acetic acid (glacial) was added to each test tube, mixed and then 0.5 ml of 3% $KMnO_4$ solution was added. The solution was kept away for 2 min and then 0.5 ml of 0.3 % H_2O_2 added and mixed well. The flourimeter was adjusted to excitation wavelength of 470 nm and emission wavelength of 525 nm. Also, the flourimeter was adjusted to zero deflection against 0.1 N H_2SO_4 and 100 against tube 2. The fluorescence tube was measured. Twenty milligram (20 g) of sodium hydrogen sulphate was added to both tubes and fluorescence measured within 10 seconds and recorded as blank readings.

Calculation:

Wt = weight sample

X = (reading of sample 1) – (reading of sample blank)

Y = (reading of sample + standard tube 2) – (reading of sample + standard blank)

Riboflavin (mg per sample) = X/Y-X x 1/wt

Determination of vitamin B_3 (Niacin)

Five grams (5 g) of the sample was treated with 50 ml of 1 N sulphuric acid for 30 minutes. 0.5 ml ammonia solution was added to it and it was then filtered. To 10 ml of the filtrate, 5 ml of 0.5 % potassium cyanide was added. This was further acidified with 5 ml of 0.02 N sulphuric acids. The absorbance of the resultant solution was recorded at 420 nm. The absorbance obtained from the sample extract was converted to Niacin concentration by means of a calibration curve generated using different standard concentrations (AOAC, 2010).

Determination of minerals

Mineral analysis was determined using the method described by AOAC (2010). Two grams (2 g) of the sample were weighed and subjected to dry ashing for 5 hours in a well cleaned porcelain crucible at 550°C. The resultant ash was dissolved in 5ml of $HNO_3/HCl/H_2O$ (1:2:3) and heated gently on a hot plate until brown fume disappears, remaining the mineral. Deionized water of 5 ml was added and heated until colorless solution is obtained. The solution in each crucible was filtered into 100 ml volumetric flask and the volume made up to 100 ml with the deionized water. The solution was then used to analyze for magnesium, potassium and phosphorus. This was done using Atomic Absorption Spectrophotometer and the absorbance was read at maximum wavelength of absorbance of the respective minerals. The results were expressed as mg/100g.

Cooking characteristics of noodles

Cooking quality of noodles is the most important aspect from the consumer's point of view, including optimal cooking time, swelling or water uptake during cooking, the texture of the cooked product, stickiness, aroma and taste. These cooking factors of noodles were related to the gelatinization rates and chemical composition of the noodles used. Cooking time, cooking quality, solid loss and water absorption were studied as per the methods described by American Association of Cereal Chemists (AACC, 2000).

Optimum cooking time

The optimum cooking time of the noodles was evaluated according to the modified method of

Schoenlechner et al. (2010). One hundred grams of noodles was put into a beaker containing 1 L of boiling water (without salt addition). Every minute, some pieces were taken out and pressed between two glass plates (2.5 cm × 2.5 cm). The optimal cooking time (OCT) corresponded to the disappearance of the white center core.

Determination of cooking yield

Cooking yield was determined according to the method of American Association of Cereal Chemists (AACC, 2000). Ten grams (10 g) of the noodles was added to a beaker containing about 10 ml boiling water. The beaker was covered and the noodles cooked for 10 minutes. The cooked noodles were drained and then weighed. The cooking yield was calculated using the equation:

Determination of cooking loss

The cooking loss was determined according to the method of American Association of Cereal Chemists (AACC, 2000). The gruel obtained after cooking the noodles was poured into a 200 ml volumetric flask and adjusted to volume with distilled water. Ten milliliter of the solution was pipetted into an aluminum dish and dried to a constant weight at 10^{o}C. The cooking loss was calculated as follows:

Microbial analysis

The microbial analysis was determined using the method of Prescott et al. (2005).

Media preparation

Nutrient Agar powder (7 g) was dissolved in distilled water (250 ml). Thirteen grams (13 g) of sabourand Dextrose Agar (SDA) was dissolved in water (250 ml). The mixtures were stabilized by bringing them to boiling while homogenizing by shaking in whirl motion. The mixtures were sterilized by autoclaving for 15minutes at the temperature of 121^{o}C. The ringer solution was allowed to cool after sterilization to about 40-47^{o}C.

Ringer solution preparation

One ringer tablet was dissolved in distilled water (500 ml). The clear solution formed was sterilized by autoclaving for 15 minutes at the temperature of 121^{o}C. The ringer solution was allowed to cool completely to a temperature of 28^{o}C.

Determination of total viable count

The total viable count was determined by the method of Pour Plate Count. The method involved weighing the sample (1 g) into a sterile test tube. A $^{1}/_{4}$ strength Ringers solution (9 ml) was poured into it and also into other test tube arranged for serial dilution. The sample with

$$\text{Cooking yield (\%)} = \frac{\text{weight of noodles after cooking} - \text{weight of noodles before cooking}}{\text{weight of noodles before cooking}} \text{x100}$$

$$\text{Cooking loss (\%)} = \frac{\text{weight of gruel and dish} - \text{weight after drying}}{\text{weight after drying}} \text{x100}$$

the solution was homogenized by shaking. The sample with solution was pipetted (1 ml) into test tube containing Ringers solution (9 ml).

Then, 1 ml of different dilution factor was transferred into the sterile petri dishes and sterile nutrient agar was poured into the same petri dish and was mixed by rocking. When they solidified, they were turned upside down and cultured by incubation for 24 h at temperature of 37^{o}C. At the end of the incubation period, the colonies were counted using the colony counter (Gallenkamp colony counter, CWN 330- 010X) and the number of colonies recorded appropriately.

Determination of mold count

The mold count was determined using Sabouraud Dextrose Agar (SDA) as the plating medium. The sample (1 g) was weighed and put in a test tube prepared for serial dilution. The ringer solution (9 ml) was aseptically transferred serially into other test tubes. Serial dilution of 10^{-1} was used for mould count determination. Appropriate diluent (1 ml) was transferred into the sterile petri dishes. Sabouraud Dextrose Agar was used for culturing the organism for 48 hours at room temperature. The mold colonies were enumerated and calculated as colony forming units (cfu)/g of the sample.

Cfu/g = Number of colonies × reciprocal of dilution factor

Sensory evaluation

The noodles were cooked and assessed by a 20 -man semi- trained panel selected randomly from among students of the Department of Food Science and Technology, University of Nigeria, Nsukka. The samples were evaluated for colour, appearance, mouth feel, aroma, taste, texture and general acceptability on a 9 - point Hedonic scale ranging from 1-9 where 1:dislike extremely and 9: like extremely as described by Ihekoronye and Ngoddy (1985). The samples were presented in coded plates. The order of presentation of samples was randomized. Water was served to the panelist to rinse their mouths in-between sample evaluation.

Data analysis and experimental design

The experimental design that was used is Completely Randomized Design and the mean values were subjected to analysis of variance (ANOVA) using Duncan's Multiple Range Test (DMRT) and SPSS (Statistical Product for Service Solution) version 20 computer was used. Significance was accepted at $p < 0.05$ (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Proximate Composition of Wheat, Rice and Mushroom Flours

The proximate composition (%) of wheat, rice and mushroom flours used in the instant noodles production is as shown in Table 3. There were significant ($p<0.05$) differences among the flour samples in their protein, ash, fat, moisture and carbohydrate content.

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. The protein content of the mushroom flour had the highest (20.88%), while the wheat flour had the least protein content (8.17 %). This makes mushroom flour a good protein supplement. The protein content compared well with 11.91-22.60 % obtained by (Nwagu and Obiakor-okeke, 2014) in the analysis of nutritional profile of three different mushroom varieties A (white button mushroom), B (oyster mushroom) and C (crimini mushroom) consumed in Amaifeke, Orlu LGA, Imo State. It was reported that, with the exception of green peas and pulses, fresh mushrooms had higher protein content than most vegetables (Bora and Kawatra, 2014).

There was no significant ($p>0.05$) difference between samples RF (rice flour) and WF (wheat flour) in their ash content, while sample MF (mushroom flour) differed significantly ($p<0.05$) from the two flour samples. The high ash content of mushroom flour suggests that incorporation of mushroom flour will increase the mineral content of the blends. Ash content represents the total mineral content in foods. It is essential to determine the full nutritional value, quality and stability of the food. Higher ash content will contribute to the flavor and nutrient quality of the product. The rice flour had the lowest ash content (0.5%).

The fat content of the rice flour had the highest value (1.79%), while the wheat flour had the least value (1.15%). The fat content of mushroom flour is low (1.25 %) compared to (2.0 %) obtained by Shah et al. (1997). Crude fat content of mushrooms is usually low, and is from 1.0 % to 6.7 % for certain species collected in China (Xue-mei et al., 2013). According to Liu et al. (2010), the % of total fatty acids for stearic, palmitic, linoleic and oleic acid in *Tricholoma matsutake* was 2%, 9%, 27% and 58%, respectively. Ratio of unsaturated to saturated (UFA/SFA) fatty acids is an important measure to judge stand or fall of fatty acid in mushrooms (Zhang and Ran, 2005).

The mushroom flour ranked highest in the fiber content (9.97%). The value was significantly ($p<0.05$) different from the other flours. The fiber contents of the mushrooms are reasonably high, suggesting that the mushrooms would be valuable in improving human health by quickening the excretion of wastes and toxins from the body. Crude fibre is a group of indigestible carbohydrates. It can improve the function of the alimentary tract and also lower blood glucose and cholesterol levels. The values obtained are similar to those obtained by (Nwagu and Obiakor-okeke, 2014). They ranged from 7.94 to 18.63% in the analysis of nutritional profile of three different mushroom varieties consumed in Amaifeke, Orlu LGA, Imo State.

Cereals are usually high in carbohydrate. From the findings, rice flour had the highest value (85.90 %) followed by the wheat flour (77.03%) and mushroom flour had the least carbohydrate value (47.15%). The moisture content of the flours varied from 2.70- 11.92%. Wheat flour (11.92%), rice flour (2.70%) and mushroom flour (10.58%), respectively. All the flour blends had moisture content below 13% hence less susceptible to spoilage and prolonged shelf-life of the flours was assured. The moisture content of the wheat flour was below the maximum moisture content limit of 15.5% stipulated by FAO, (2006). The moisture content of the rice flour 2.70% was below the 10% stipulated standard for dry food products (SON, 1988). There were significant ($p<0.05$) differences among the flour samples.

Micronutrient composition of wheat, rice and mushroom flours.

Vitamins

Table 4 shows the vitamin content of the wheat, rice and mushroom flours. There was no significant ($p>0.05$) difference between samples RF (rice flour) and MF (mushroom flour) in their vitamin content, whereas sample WF (wheat flour) differed significantly ($p<0.05$) from the two samples.

Mushrooms contain several primary vitamins including thiamine, riboflavin, niacin, tocopherol and vitamin D (Kalac, 2013). For other researchers using several species, the content of thiamine, riboflavin, niacin and ascorbic varied from 0.02–1.6, 0.3–4.5, 1.2–6.6 and 1.3– 2.7 mg 100 g/1 dm, respectively (Quan et al., 2007; Wu et al., 2005; Xu et al., 2012; Zhou and Yin, 2008; Zhu et al., 2007).The values for vitamin B_1 (0.25 mg/100g), B_2 (0.07 mg/100g) and B_3 (1.26 mg/100g) obtained from this study were in line with the report. The B-complex vitamins, especially thiamin, riboflavin and niacin offered by natural brown rice promote youthful energy and nourishment to skin and blood vessels (Lloyd et al., 2000).

Table 3. Proximate composition of wheat, rice and mushroom flour

Sample	Protein (%)	Ash (%)	Fat (%)	Fiber (%)	Moisture (%)	Carbohydrate(%)
WF	$8.17^a \pm0.02$	$1.29^a \pm0.73$	$1.15^a\pm 0.03$	$0.96b^a\pm0.02$	$11.92^c\pm0.02$	$77.03^c\pm0.04$
RF	$8.53^b \pm0.01$	$0.50^a\pm0.14$	$1.79^b\pm0.01$	$0.60^a\pm0.28$	$2.70^a\pm0.02$	$85.90^b\pm0.03$
MF	$20.88^c\pm0.03$	$10.15^b\pm0.01$	$1.25^c\pm0.01$	$9.97^b\pm0.02$	$10.58^b\pm0.02$	$47.15^a\pm0.01$

Values are means ± standard deviation of duplicate replications. Means within a column with the same superscript were not significantly ($p < 0.05$) different **Key:** WF= Wheat flour; RF= Rice flour; MF= Mushroom flour

Mineral content of wheat, rice and mushroom flours

Table 5 shows the mineral content of the wheat, rice and mushroom flours. There was a significant ($p<0.05$) difference among the flour samples in their mineral content.

The mostly occurring microelements in mushroom are iron and potassium with phosphorus in significant quantity. Potassium is very important in the maintenance of osmotic balance between cells and the interstitial fluid in animal systems. The potassium content for the different flour samples was highest in mushroom flour (22.90 mg/100g). This value was higher

than the values obtained for the specie *C. ventricosum* (2.7 mg/100g) by Liu et al. (2012) although it was lower than that for the range of values reported by Afiukwa et al. (2013), which was 221.13 mg/100g. Iron, which is essential for the biosynthesis of the oxygen-carrying pigment of red blood cells and the cytochromes that function in cellular respiration, is also present in good amounts in the mushrooms (Wani et al., 2010). The iron content in the mushroom flour is higher than those in rice and wheat flour (4.77 mg/100g). The mushroom flour iron content was lower than that obtained for the specie *C. ventricosum* (6.73 mg/100g) as reported by Liu et al. (2012). The lower value obtained could be as a result of the differences in species. Low levels of phosphorus were observed in three flour samples. The mushroom flour had the highest value (0.18 mg/100g) and wheat flour (0.05 mg/100g) with the least value.

Functional properties of flour blends from wheat, rice and mushroom

The functional properties of flour blends of wheat, rice and mushroom flours are as shown in Table 6.

Water absorption capacity represents the ability of a product to associate with water under conditions where water is limited (Singh, 2001). Percent water absorption varied from 100% to 250% with the blend with no mushroom flour (100:0) having the least value and blend with 50% mushroom powder having the highest value. Water absorption capacity is a critical function of protein in various food products like soups, dough and baked products (Adeyeye and Aye, 1998). Water absorption capacity increased significantly ($p<0.05$) with increasing levels of mushroom flour. This could probably be due to the high protein and fiber content of mushroom flour. Kaur et al. (2013) also observed significant increase in water absorption on addition of more than 8% mushroom powder to semolina for

Table 4. Vitamin content (mg/100g) of wheat, rice and mushroom flours

Sample	vitamin B_1 (mg/100 g)	vitamin B_2 (mg/100 g)	Vitamin B_3 (mg/100 g)
WF	$0.25^{a}\pm 0.04$	$0.07^{a}\pm0.02$	$1.26^{a}\pm0.02$
RF	$0.36^{b}\pm0.02$	$0.05^{a}\pm0.02$	$2.50^{b}\pm 0.14$
MF	$0.28^{ab}\pm0.02$	$0.25^{b}\pm0.02$	$3.00^{b}\pm0.28$

Values are means ± standard deviation of duplicate replications. Means within a column with the same superscript were not significantly ($p< 0.05$) different. **Key**: WF= Wheat flour; RF= Rice flour; MF= Mushroom flour.

Table 5. Mineral content of wheat, rice and mushroom flours

Sample	Iron (mg/100g)	Potassium (mg/100g)	Phosphorus (mg/100g)
WF	$1.10^{a}\pm 0.01$	$1.78^{a}\pm0.02$	$0.05^{a}\pm0.02$
RF	$1.10^{a}\pm0.04$	$4.18^{a}\pm0.01$	$0.11^{ab}\pm0.02$
MF	$4.77^{b}\pm0.02$	$22.90^{b}\pm0.02$	$0.18^{b}\pm0.02$

Values are means ± SD of duplicate replications. Means within a column with the same superscript were not significantly ($p<0.05$) different. **Key:** WF= Wheat flour; RF= Rice flour; MF= Mushroom flour.

pasta extrusion.

The highest value of oil absorption capacity was observed for flour blend of wheat and rice flour without mushroom flour (100:0) 372% and the lowest value (195.3%) for the 90% composite wheat-rice flour and 10% mushroom flour. Increase in the addition of the mushroom flour significantly (p< 0.05) increased the oil absorption capacity. The increment of OAC was due to the high protein contents of the mushroom flour as it increased in the composite flour. This might be due to the presence of protein exposing more non-polar amino acids to the fat and enhancing hydrophobicity; as a result of this, flour absorbs more oil (Oluwamukomi et al., 2011). The water and oil binding capacity of food protein depends upon the intrinsic factors like amino acid composition, protein conformation and surface polarity or hydrophobicity (Kaushal, et al., 2012). The wheat and rice flour without mushroom flour (100:0) blend which had the highest oil absorption capacity could therefore, be a better flavor retainer. The ability of the proteins of these flours to bind with oil makes it useful in food system where optimum oil absorption is desired. This makes flour to have potential functional uses in foods such as sausage production. The oil absorption capacity also makes the flour suitable in facilitating enhancement in flavor and mouth feel when used in food preparation. Due to these properties, the protein probably could be used as functional ingredient in foods such as whipped toppings, sausages, chiffon dessert, angel and sponge cakes among other products.

The swelling capacity was found highest for 50% composite wheat-rice flour with 50% mushroom flour blend (28.0 ml) and lowest for 100 % composite wheat-rice flour blend without mushroom flour (100:0) (15.0 ml). The swelling capacity of flours depends on size of particles, types of variety and types of processing methods or unit operations.

According to Gustavo et al. (2005), the bulk density of food powders depends on the combined effect of interrelated factors such as the intensity of attractive inter-particles forces, particle size, and number of contact points. It is clear that a change in any of the powder characteristics might result in a significant (p✾ 0.05) change in the powder bulk density. Bulk density is an indication of the porosity of a product which influences package design and could be used to determine the type of packaging material required. Low bulk density is desirable and required for infant foods (Omerie et al., 2015).

Proximate composition (%) of instant noodles formulated from wheat, rice and mushroom flour blends

Table 7 shows the proximate composition of the formulated instant noodles from wheat, rice and mushroom flour blends. Variations exist in the proximate composition of noodles from wheat and mushroom flour.

The protein content of the samples ranged from 9.49-15.39%. Sample WRM5 (50:50) had the highest protein content and sample WR0 (100:0)

Table 6. Functional properties of flour blends from wheat, rice and mushroom flours

Sample	Bulk density (g/cm^3)	Water absorption (%)	Oil absorption (%)	Swelling capacity (ml)
A (100:0)	$0.71^{e} \pm 0.02$	$100^{a} \pm 0.28$	$372^{e} \pm 0.00$	$15.0^{a} \pm 0.14$
B (90:10)	$0.69^{cd} \pm 0.01$	$120^{b} \pm 0.00$	$195.3^{a} \pm 0.28$	$20.0^{b} \pm 1.44$
C (80:20)	$0.67^{cd} \pm 0.02$	$150^{c} \pm 0.14$	$260^{b} \pm 0.28$	$22.0^{c} \pm 0.00$
D (70:30)	$0.63^{bc} \pm 0.02$	$200^{d} \pm 0.00$	$269^{c} \pm 0.28$	$25.0^{d} \pm 0.28$
E (60:40)	$0.59^{b} \pm 0.01$	$210^{e} \pm 0.14$	$279^{d} \pm 0.00$	$26.0^{d} \pm 0.00$
F (50:50)	$0.53^{a} \pm 0.02$	$250^{f} \pm 1.97$	$279^{d} \pm 0.56$	$28.0^{e} \pm 0.14$

Values are means ± standard deviation of duplicate replications. Means within a column with the same superscript were not significantly (p<0.05) different. **Key:**A (100:0): 90% wheat and 10 % rice flour +0 % mushroom flour; B (90:10):90% wheat and rice flour + 10 % mushroom flour; C (80: 20):80% wheat and rice flour +20 % mushroom flour; D (70:30):70% wheat and local rice flour +30 % mushroom flour; E (60:40): 60% wheat and local rice flour +40 % mushroom flour; F (50:50): 50% wheat and local rice flour +50 % mushroom flour.

had the least protein value. Substitution of wheat flour with an increasing quantity of mushroom flour increased the protein content of the noodles. The low protein contents of sample WR0 (100:0) is due to incorporation of more quantity of wheat flour and absence of mushroom flour in the blends. Mushroom protein includes all nine essential amino acids required by humans, although it can be limiting in sulphur-containing amino acids, such as cystine and methionine. In terms of the essential amino acid index, amino acid score and nutritional index, mushrooms are between low grade vegetable and high grade meats with values that are close to that of milk, some species even well above milk which is an animal product (Bora and Kawatra, 2014). As a result of this, FAO has recommended mushrooms as a supplementary food item in the context of the world protein shortage for the growing populations of the developing countries. The protein content was within the range (10.54-14.34%) obtained by Bindvi et al. (2017) in instant noodles supplemented with oyster mushroom (*P. ostreatus*). 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.

There were significant ($p<0.05$) differences among the ash content of noodles from the blends. The ash content ranged from 1.39 to 5.31% with sample WRM5 (50:50) having the highest ash content while the CTRL (commercial sample) having the least ash content. The high ash content of the instant noodles might be attributed to the fact that mushroom has been reported to be a good source of minerals as there was a notable increase in the ash content with addition of mushroom. The ash content of a food material could be used as an index of minerals constituents of the food which is necessary for growth and development. The values obtained were higher than those reported by Bindvi et al. (2017) which ranged from 1.84 to 1.76%. This may be attributed to the nutritional varieties in the different species.

The crude fiber content of the samples ranged from 1.50 to 5.40%. Sample WRM5 (50:50) ranked highest and CRTL (commercial product) the lowest value. Fiber content was more in noodles from the composite flour compared to the control and the difference was significant at $p<0.05$. There was no significant ($p> 0.05$) difference between samples WRM4 (60:40) and WRM5 (50:50). Increase in the incorporation of mushroom flour significantly increased the crude fiber content of the instant noodles. The high values obtained might be due to the fact that mushroom used in instant noodles production were rich sources of dietary fibre which therefore increased the fibre content of the product with increase in level of the composite flour incorporation. A high intake of dietary fibre is positively related to different physiological and metabolic effects (NRC, 1989). Fibre prevents constipation. Soluble fibre helps to reduce the cholesterol level in the blood, slows down digestion and sudden release of energy, thus making blood level stable. Food containing at least 3 g/100g dietary fibers (DF) can be referred to as a source of DF. It is high in DF when it contains at least 6 g/100g dietary fibers (FAO, 1995). The consumption of this product will meet the WHO recommendation for dietary fibre intake of about 25 g per day (Sandstead, 1995).

The fat content ranged from 0.5 to 1.50% with sample WR0 (100:0) which had the highest fat content and sample WRM5 (50:50) had the lowest value. Fat content decreased slightly with the addition of mushroom powder. However there was no significant ($p>0.05$) difference among samples WRM1 (90:10), WRM2 (80:20) and WRM3 (70:30). Fat plays a role in determining the shelf-life of foods (Brons et al., 2008). Crude fat content of mushrooms is usually low. It ranged from 1.0% to 6.7% for certain species collected in China as reported by Xue-mei et al. (2013). A high amount of fat could accelerate spoilage by promoting rancidity which could lead to the production of off flavors and odours. Also diet high in fat predispose consumer to different illness such as obesity, heart disease among other ailments. The values obtained from this study were comparable to the values reported by Yin and Zhou (2008) in Yunnan wild edible Boletus. Pedneault et al. (2006) reported that fat fraction in mushrooms is mainly composed of unsaturated fatty acids. 1.0 %.

The moisture content ranged from 7.92 to 14.48 % with sample CTRL (commercial product) having the lowest value and WRM5 (50:50) the least value. The samples varied significantly ($p< 0.05$.) The moisture content of fresh mushrooms is about 70 to 95%, depending on the species, harvest time and environmental conditions, it falls to around 10 to 13% when dried (Breene, 1990). Moisture content is an index of the shelf-stability of food because microorganisms require moisture for their deteriorative activities within the food.

The carbohydrate values obtained ranged from 58.42 to 77.45% and the CTRL (commercial product) with the highest value, WRM5 with

50% mushroom powder incorporation the least value. The carbohydrate value reduced slightly with increase in mushroom flour incorporation. The samples varied significantly ($p<0.05$). The carbohydrate values were comparable to the values (74%) obtained by (Carneiro et al., 2013) and the range (58.11 to 61.98%) obtained by Bello et al. (2017). Carbohydrates in foods provide energy and digestible carbohydrates found in mushrooms are such as mannitol (0.3–5.5% dm) (Vaz et al., 2011), glucose (0.5 to 3.6% dm) (Kim et al., 2009) and glycogen (1.0–1.6 % dm), Diez and Alvarez (2001). Non-digestible carbohydrates form a large portion of the total carbohydrates of mushrooms, and major compounds are oligosaccharides and non-starch polysaccharides such as chitin, β-glucans and mannans (Cheung, 2010). Polysaccharides are the best known and most potent mushroom derived substances with antitumor and immunomodulation properties. The results indicate that noodles from composite especially with a higher content of mushroom flour have enhanced nutrients than those of 100% wheat flour and may benefit consumers more than the control.

Microbial counts of instant noodles from wheat, rice and mushroom flour blends

Table 8 shows the total viable and mold count of instant noodles from blends of wheat, rice and mushroom flours for four weeks' storage. Total viable counts are one of the microbial tests carried out to ensure safety of food products. It is used to determine hygienic conditions during food processing for both raw materials and equipment. It is used to evaluate effectiveness of processing methods, heat treatment and storage conditions for products. Total viable count gives a quantitative idea about the presence of microorganisms in the sample. The total viable count of the noodles samples for the first week ranged from $1.0x10^3$ cfu/g to $8.3x10^2$ cfu/g. Sample WRM1 (90:10) had the highest value while sample WRM2 (80:20) had the lowest value. For the second week TVC ranged from $1.2x10^4$ cfu/g to $9.2x10^3$ cfu/g and sample WRM2 (80:20) had the highest value and sample WRM3 (70:30) had the lowest value. Total viable count

Table 7. Proximate composition (%) of instant noodles from wheat, rice and mushroom flour blends

Sample	Protein (%)	Ash (%)	Fat (%)	Fiber (%)	Moisture (%)	Carbohydrate (%)
CTRL	$10.84^a \pm 0.01$	$1.39^a \pm 0.04$	$0.90^b \pm 0.01$	$1.50^a \pm 0.05$	$7.92^a \pm 0.02$	$77.45^g \pm 0.02$
WR0	$9.49^b \pm 0.01$	$1.66^b \pm 0.02$	$1.50^f \pm 0.01$	$1.79^b \pm 0.28$	$12.21^e \pm 0.02$	$73.35^f \pm 0.00$
WRM1	$10.96^c \pm 0.01$	$2.19^c \pm 0.01$	$1.40^{ef} \pm 0.01$	$2.30^c \pm 0.14$	$8.28^b \pm 0.02$	$74.87^e \pm 0.00$
WRM2	$12.77^d \pm 0.02$	$3.34^d \pm 0.02$	$1.30^{de} \pm 0.00$	$3.38^d \pm 0.28$	$9.73^c \pm 0.00$	$69.48^d \pm 0.02$
WRM3	$13.21^e \pm 0.01$	$4.47^e \pm 0.01$	$1.20^{cd} \pm 0.01$	$4.57^e \pm 0.28$	$11.45^d \pm 0.00$	$65.09^c \pm 0.01$
WRM4	$13.59^f \pm 0.01$	$5.30^f \pm 0.01$	$1.10^c \pm 0.15$	$5.39^f \pm 0.01$	$12.18^e \pm 0.05$	$62.49^b \pm 0.01$
WRM5	$15.39^g \pm 0.01$	$5.31^f \pm 0.01$	$0.5^a \pm 0.28$	$5.40^f \pm 0.22$	$14.48^f \pm 0.05$	$58.42^a \pm 0.05$

Key:CTRL=Control commercial sample; WR0 = 90 % wheat flour +10 % rice flour; WRM1= 90 % wheat/rice flour +10 % mushroom flour; WRM2 = 80 % wheat/rice flour +20 % mushroom flour; WRM3 = 70 % wheat/rice flour +30 % mushroom flour; WRM4 = 60 % wheat/rice flour + 40 % mushroom flour; WRM5 = 50 % wheat/rice flour + 50 % mushroom flour. Values are means ± standard deviation of duplicate replications. Means within a column with the same superscript were not significantly ($p< 0.05$) different.

for the third week ranged from 1.0x10^5 cfu/g to 8.1x10^4 cfu/g, sample WRM2 (80:20) had the highest value and sample WRM1 (90:10) had the least value. For the fourth week of storage, the TVC ranged from 1.7x10^5 cfu/g to 2.95x10^5 cfu/g. Sample WRM2 (80:20) had the highest value and CTRL (commercial product) with the least value. The total viable count of the instant noodles produced increased exponentially with storage time. From the results, it can be deduced that as the storage week progressed, there were visible growth of microorganisms found on the product. The products were produced in a hygienic and conducive environment and stored at room temperature. The favorable condition of storage and pH of the products as well as high nutrient contents of the products must have stimulated the initial increases since microorganisms are ubiquitous. Likewise, the variation in the microbial load of the instant noodles from the various blends might be attributed to the way the samples were handled differently before and during analysis. According to the International Commission on Microbiological Specification of Foods (ICMSF, 1996), total plate counts between zero to 10^3 is acceptable, between 10^4 to 10^5 is tolerable and 10^6 and above is unacceptable. From the storage studies of this research, the developed noodle samples maintained an acceptable microbial count during the storage period. Total mould count is a microbial test carried out to evaluate the presence of spoilage fungi on food samples which makes it unfit for consumption since it can lead to severe health complications. Mold count was done to detect and quantify mold in the samples. For the first week mold count was not detected expect in sample CTRL (commercial product) 1.0x10. For the second week mold count was detected at 1.0x10 level for samples CTRL (commercial product), WR0 (100:0) and WRM3 (70:30). On the third week, CTRL (commercial product) has the highest mold count 4.0x10 cfu/g, WR0 (100:0) and WRM3 (70:30) 2.0x10 cfu/g. Sample CTRL (commercial product) has the highest mold count on the fourth week (9.0x10 cfu/g) and sample WRM3 (70:30) with the lowest value (3.0 x10 cfu/g). The presence of low numbers from the 3rd week of storage suggests post production contamination, especially as the products were loosely packaged in polyethylene bags. The mould load of the products was therefore, within the acceptable level for mould in instant noodles which is 10 cfu/g.

Cooking characteristics of instant noodles made from wheat, rice and mushroom flour blends

Table 9 represents the cooking characteristics of instant noodles formulated from wheat, rice and mushroom flour blends. Cooking yield of the blend samples ranged from 200 to 140%, with sample WRM5 (50:50) having the highest value and WRM1 (90:10) the lowest value. There was no significant ($p > 0.05$) difference in all the samples. Cooking yield is dependent on the ability of noodles to absorb water during cooking. With increased mushroom flour, the cooking yield increased. This trend could probably be because sample WRM5 (50:50) has high water absorption capacity compared to other samples. The cooking yield of the CRTL (commercial sample) was higher than the noodles from the blends which could be probably due to other additives used in production.

Cooking loss is indicated by the loss of solid materials contained in noodle during cooking. Mushroom-supplemented noodles showed a significant increase in cooking loss compared with the control noodle as the mushroom flour increased. The cooking loss of the noodles with 50 % mushroom flour (4.58 per 100 g) was higher than those observed for the control sample (3.80 g per 100 g). All the cooking loss samples were below 8 g per 100 g, the value above which pasta quality was considered unacceptable (Foschia et al., 2015). The higher cooking loss in noodles with added mushroom could be attributed to a loss of continuity of the noodles protein-starch matrix, as a consequence of the competitive hydration tendency of the fibre which leads to uneven distribution of water within the matrix (Tudorica et al., 2002). Similarly, Kaur et al. (2013) studied the effect of button mushrooms on the leaching of solids from pasta and reported that the solids that leached into the cooking water increased as the level of mushroom powder was increased in the blend.

Cooking time is very important to characterize a product as instant. Optimum cooking time of mushroom fortified noodles is given in Table 9. Optimum cooking time of the noodle samples varied from 5.20 to 6.50 min. The addition of mushroom powder in noodles progressively increased the cooking time, although there was no significant ($p< 0.05$) difference between samples even up to 20% level of fortification as wheat flour replacement. This could be attributed to increase in protein content of noodles with addition of mushroom powder, resulting in firmer product. Kaur et al. (2013) also observed increase in cooking time in mushroom supplemented pasta.

Table 8. Total viable and mold counts of instant noodles from wheat, rice and mushroom flour blends

Period of storage	Sample	Total viable count (cfu/g)	Mould count (cfu/g)
	CTRL	1.78×10^3	ND
Week 1	WR0	1.42×10^3	ND
	WRM1	8.3×10^2	ND
	WRM2	1.0×10^3	ND
	WRM3	1.2×10^3	ND
	WRM4	4.3×10^2	ND
	WRM5	6.1×10^2	ND
Week 2	CTRL	2.8×10^4	1.0×10
	WR0	1.3×10^4	1.0×10
	WRM1	9.2×10^3	ND
	WRM2	7.2×10^3	ND
	WRM3	1.2×10^4	1.0×10
	WRM4	3.3×10^3	ND
	WRM5	7.7×10^3	ND
Week 3	CTRL	1.9×10^3	4.0×10
	WR0	1.6×10^5	2.0×10
	WRM1	1.0×10^5	ND
	WRM2	8.1×10^4	ND
	WRM3	1.4×10^5	2.0×10
	WRM4	7.2×10^4	ND
	WRM5	6.1×10^4	ND
Week 4	CTRL	2.9×10^5	9.0×10
	WR0	2.7×10^5	4.0×10
	WRM1	2.1×10^5	ND
	WRM2	1.7×10^5	ND
	WRM3	2.5×10^5	3.0×10
	WRM4	1.5×10^5	ND
	WRM5	2.4×10^5	ND

Key: CTRL = Control commercial sample; WR0 = 90 % wheat flour +10 % rice flour; WRM1 = 90 % wheat/rice flour +10 % mushroom flour; WRM2 = 80 % wheat/rice flour +20 % mushroom flour; WRM3 = 70 % wheat/rice flour +30 % mushroom flour; WRM4 = 60 % wheat/rice flour + 40 % mushroom flour; WRM5 = 50 % wheat/rice flour + 50 % mushroom flour

ND = Not detected

Sensory properties of instant noodles formulated from wheat, rice and mushroom flour blends

Table 10 shows the average mean sensory scores of noodles samples from blends of wheat, rice and mushroom flour. The result in Table 10 shows that there were significant (p ✤ 0.05) difference in all the sensory attributes (colour, appearance, taste, aroma, texture, mouth feel, aftertaste and overall acceptability) of the instant noodles from wheat, rice and mushroom flour blends as well as the sample with 100 % wheat-rice flour blend and commercial noodles. The sample CTRL (commercial sample) and sample with 100 % wheat-rice flour blend (WR0) had the highest level of acceptance for the sensory attributes. However, the sensory acceptability of the noodles from blends of wheat, rice and mushroom flour blends are as follows.

Sample WRM1 (90:10) was rated high while noodle sample WRM5 (50:50) had the lowest level of preference. According to Hou (2001), flour colour, protein content, ash content, yellow pigment and polyphenol oxidase activity are important factors responsible for noodle colour. The preference for colour decreased with increasing amount of mushroom flour and decreasing amount of wheat flour. This could probably be due to the decrease in the brightness of the noodles colour of the mushroom flour. Noodle sample WRM5 (50:50) did not differ significantly (p ✤ 0.05) from WRM4 (60:40).

The average mean scores for mouth feel ranged from 2.00-4.95. Sample WRM1 had the highest mouth feel while WRM5 had the lowest value. There is no significant (p ✤ 0.05) difference between the mean scores of the noodles WRM2 (80:20) and WRM3 (70:30) and between WRM5 (50:50) and WRM4 (60:40). However samples CTRL (commercial sample), WR0 (100:0) and WRM1 (90:10) differed significantly (p ✤ 0.05).

The aroma of the noodles from the blends ranged from 4.90-7.15 with sample WRM5 (50:50) having the highest value and sample WRM1 (90:10) the lowest value. Characteristic flavour substances of wild-grown mushrooms could be classified into nonvolatile (taste) and volatile components (smell). Various volatile compounds such as terpenes, aromatic alcohols, aldehydes, ketones, eight carbon compounds and their derivatives, are the major aroma compounds in mushrooms. Eight-carbon volatiles are produced by oxidation of free linoleic acid catalyzed by lipoxygenase (Cheng et al., 2012). With increase in the mushroom flour, there was increase in the aroma of the samples. The preference for aroma for samples WRM4 (60:40) and WRM5 (50:50) did not differ significantly (p ✤ 0.05) from WR0 (100:0). CTRL (commercial sample) differed significantly (p ✤ 0.05) from all the samples.

Table 9. Cooking characteristics of instant noodles formulated from wheat, rice and mushroom flour blends

Sample	Cooking yield (%)	Cooking loss (%)	Optimum cooking time (mins)
CRTL	$220^{a} \pm 0.14$	$3.80^{a} \pm 0.02$	$5.20^{a} \pm 0.02$
WR0	$100^{b} \pm 0.28$	$4.20^{b} \pm 0.01$	$6.50^{b} \pm 0.02$
WRM1	$140^{c} \pm 0.42$	$4.35^{c} \pm 0.02$	$7.40^{c} \pm 0.28$
WRM2	$150^{d} \pm 1.13$	$4.40^{cd} \pm 0.04$	$7.80^{d} \pm 0.14$
WRM3	$160^{e} \pm 0.14$	$4.48^{de} \pm 0.05$	$8.04^{de} \pm 0.01$
WRM4	$190^{f} \pm 0.40$	$4.52^{ef} \pm 0.05$	$8.20^{e} \pm 0.02$
WRM5	$200^{g} \pm 0.28$	$4.58^{f} \pm 0.02$	$8.55^{f} \pm 0.02$

Values are means ± standard deviation of duplicate replications. Means within a column with the same superscript were not significantly (p ⊚ 0.05) different. **Key:**CTRL=Control, commercial sample; WR0 = 90 % wheat flour +10 % rice flour; WRM1 = 90 % wheat/rice flour +10 % mushroom flour; WRM2 = 80 % wheat/rice flour +20 % mushroom flour; WRM3 = 70 % wheat/rice flour +30 % mushroom flour; WRM4 = 60 % wheat/rice flour + 40 % mushroom flour; WRM5 = 50 % wheat/rice flour + 50 % mushroom flour

The taste of the formulated noodle blends ranged from 1.65-5.60 with sample WRM1 (90:10) having the highest value and sample WRM5 (50:50) having the lowest value. This could probably be because of the increasing proportion of mushroom flour in the samples and consumers did not find it very appealing. The preference for taste of CTRL (commercial sample) and WR0 (100:0) differed significantly (p ⚜ 0.05) from the preference of the other samples.

The appearance of the formulated noodles from blends of wheat, rice and mushroom flour ranged from 4.80-1.55 with sample WRM1 (90:10) having the highest value and sample WRM5 (50:50) the least value. This is probably because, the noodles from 100% what-rice flour had longer noodles strands, a relatively brighter colour and less stickiness unlike the samples with increasing proportion of mushroom flour.

The texture of the formulated noodles from the blends ranged from 3.95-1.30. Sample WRM1 (90:10) ranked highest while sample WRM5 (50:50) was ranked the lowest. Starch characteristics, protein content and quality play major roles in governing the texture of cooked noodles (Hou, 2001). The preference for texture dropped with increase in mushroom flour incorporation. There was no significant (p ⚜ 0.05) difference between the mean scores of the samples but they differed significantly (p ⚜ 0.05) from CTRL (commercial sample) and WR0 (100:0).

Micronutrient content of formulated instant noodles from wheat, rice and mushroom flour blends

Vitamin content of formulated instant noodles from wheat, rice and mushroom flour blends

The vitamin content of formulated instant noodles from wheat, rice and mushroom flour blends are presented in Table 11. As vitamins are very unstable, a lower value in the sample was expected, since heat processing was used which could contribute to the losses. Cooking and industrial processing of mushroom was found to have pronounced effects on the amount of vitamins in the product. Vitamin B_1 and B_2 are lost during industrial processing (canning) of Boletus at a rate of 21–57% and 8–74%, respectively (Zhou and Yin, 2008). Thiamin stability affected by formulation, processing, and storage has been reported by Bui and Small (2007a, 2007b, 2008) in noodles, and it was inferred that the potential to use thiamin in noodles where alkaline salts are used is limited due to its instability at higher pH. But with addition of mushroom flour there was an increase in the vitamin content. The values varied significantly (p⚜ 0.05) ranging

Table 10. Sensory evaluation of instant noodles from wheat, rice and mushroom flour blends

Sample	Colour	Mouthfeel	Aroma	Taste	Appearance	Texture	Overall acceptability
CTRL	$8.80^{f}\pm0.41$	$8.45^{e}\pm 0.60$	$8.30^{c}\pm0.80$	$8.60^{f}\pm0.50$	$8.65^{f}\pm0.48$	$8.45^{e}\pm0.51$	$8.60^{f}\pm 0.59$
WRO	$7.15^{e}\pm0.74$	$6.85^{d}\pm0.74$	$6.70^{b}\pm0.73$	$6.70^{e}\pm0.86$	$7.30^{e}\pm0.47$	$6.75^{d}\pm0.71$	$6.95^{e}\pm0.60$
WRM1	$4.50^{d}\pm1.53$	$4.95^{c}\pm1.23$	$4.90^{a}\pm1.16$	$5.60^{d}\pm1.04$	$4.80^{d}\pm1.50$	$3.95^{c}\pm1.31$	$4.40^{d}\pm1.35$
WRM2	$1.23^{c}\pm 0.27$	$3.65^{b}\pm1.38$	$4.70^{a}\pm1.17$	$3.90^{c}\pm0.91$	$2.90^{c}\pm 1.5$	$2.85^{b}\pm1.34$	$3.15^{c}\pm1.30$
WRM3	$0.93^{b}\pm0.21$	$3.20^{b}\pm 1.24$	$4.75^{b}\pm1.58$	$3.20^{b}\pm0.76$	$2.30^{bc}\pm1.17$	$2.40^{b}\pm1.14$	$2.50^{bc}\pm1.14$
WRM4	$0.68^{a}\pm0.15$	$2.35^{a}\pm 1.03$	$6.40^{b}\pm1.14$	$2.15^{a}\pm0.81$	$1.65^{ab}\pm0.98$	$1.55^{a}\pm0.75$	$1.95^{ab}\pm1.05$
WRM5	$0.36^{a}\pm 0.08$	$2.00^{a}\pm1.07$	$7.15^{b}\pm1.30$	$1.65^{a}\pm0.93$	$1.55^{a}\pm0.82$	$1.30^{a}\pm0.57$	$1.75^{a}\pm1.02$

Values are means ± standard deviation of duplicate replications. Means within a column with the same superscript were not significantly (p⚜ 0.05) different. **Key:** CTRL= Control, commercial sample; WR0 = 90 % wheat flour +10 % rice flour; WRM1 = 90 % wheat/rice flour +10 % mushroom flour; WRM2 = 80 % wheat/rice flour +20 % mushroom flour; WRM3 = 70 % wheat/rice flour +30 % mushroom flour; WRM4 = 60 % wheat/rice flour + 40 % mushroom flour; WRM5 = 50 % wheat/rice flour + 50 % mushroom flour from 0.34 to 0.20 (mg/100 g) for vitamin B_1, 0.65 to 0.06 (mg/100 g) for vitamin B_2 and (3.68-1.20 mg/100 g) for vitamin B_3. Noodle sample WRM3 (70:30) had the highest content of vitamin B1, while sample WRM2 (80:20) had the highest for vitamin B2 and WRM5 (50:50) had the highest for vitamin B3 and CTRL (commercial sample) had the lowest value in all the vitamins.

Thiamin functions as the co-enzyme thiamin pyrophosphate (TPP) in the metabolism of carbohydrates and branched-chain amino acids. Hence, when there is insufficient thiamin, the overall decrease in carbohydrate metabolism and its inter-connection with amino acid metabolism (via α-keto acids) have severe consequences, such as a decrease in the formation of acetylcholine for neural function. According to FAO (2001), the required daily intake of thiamin for the adult male and female is 1.2 mg/100g and 1.1 mg/100g, respectively. The sample WRM5 (50:50) containing 0.32 mg/10 g provides about 27% of the required daily intake for the adult male and 29% for the adult female. The major cause of hypo-riboflavinosis is inadequate dietary intake as a result of limited food supply, which is sometimes exacerbated by poor food storage or processing. According to FAO, (2001) the required daily intake of riboflavin for the adult male and female is 1.3 mg/100 g and 1.1 mg/100 g respectively. Sample WRM5 (50:50) containing 0.10 mg/100g noodles from wheat, rice and mushroom flour blends provides about 7 % of the required daily intake for adult male and 9 % for adult female. The contents of vitamins B_1 and B_2 found in the noodles indicate that mushrooms could not be considered as sources of vitamins B_1 and B_2, since their contribution in terms of these vitamins to the diet is not significant although they might have contributed to the sums of these nutrients in the diet.

Niacin (nicotinic acid) deficiency classically results in pellagra, which is a chronic wasting disease associated with a characteristic erythematous dermatitis, that is bilateral and symmetrical, a dementia after mental changes including insomnia and apathy preceding an overt encephalopathy, and diarrhea resulting from inflammation of the intestinal mucous surfaces (Tannenbaum et al., 1991). The required daily intake of niacin for the adult male and female is 16 m/100g and 14 mg/100g respectively (FAO, 2001), and sample WRM5 (50:50) had the highest value (3.68 mg/100g) providing about 23% and 26% for both male and female adult, respectively.

Mineral content of instant noodles formulated from wheat, rice and mushroom flour blends

The mineral content of the instant noodles formulated from wheat, rice and mushroom blends is presented in Table 12. The iron content in this study ranged from 0.49 – 3.42 mg/100 g. Sample WR0 (100:0) had the lowest value and sample WRM5 (50:50) had the highest value and it was lower than the recommended daily allowance (RDA) - 10 mg of iron per day (Sandstead, 1995). Thus, it could be deduced from the Table that both the control sample and the WR0 (100:0) were not a good source of iron. Iron content increased significantly ($p<0.05$) with addition of mushroom powder. All the values varied significantly (p✤ 0.05). The values obtained in this study was similar to those reported by Bello et al. (2017) who reported 1.68 – 2.89 mg/100g in biscuit made from wheat and mushroom flour blends. Iron is a major component of hemoglobin that carries oxygen to all parts of the body. Iron also has a critical role within cells assisting in oxygen utilization, enzymatic systems, especially for neural development, and overall cell function.

The potassium content of the samples ranged from 1.86 to 16.00 mg/100g. With CTRL (commercial product) having the lowest and WRM5 (50:50) having the highest value. The potassium content of the instant noodles increased with increase in the mushroom flour addition indicating that mushroom is a good source of minerals. The values obtained in this study were lower than the values obtained by other researchers; 40.63 - 154.07 mg/100g (Bello et al., 2017). The result could be attributed to variation in the different species of mushroom. All the values varied significantly (p ✤ 0.05).

Phosphorous content of the samples ranged from 0.16 to 0.070 mg/100g with sample WRM5 (50:50) having the highest and sample CTRL (commercial product) with the lowest value. These values were lower than 12.5 - 54.62 mg/100g reported by Bello et al. (2017). There was no significant (p ✤ 0.05) difference between sample CTRL (commercial product) and samples WRO (100:0), WRM1 (90:10) and WRM2 (80:20). The mineral composition obtained in this study showed that there was an increase in the phosphorous, iron and potassium content of the noodles with an increase in the level of mushroom flour addition. This is an indication that mushroom is a good source of minerals as shown in Table 12.

CONCLUSION

The study has shown that acceptable noodles could be produced from blends of wheat, rice and mushroom flour. Noodles from the composite flours were richer in nutrients and may confer nutritional advantages to consumers compared to the control. The incorporation of mushroom flour in noodles formulation affected the chemical, cooking and sensory properties. Mushroom flour therefore could be incorporated into instant noodles to obtain a product rich in dietary fiber, protein, vitamin B_3 and potassium and low in fat. Based on the study, the use of 10% mushroom and 50 % mushroom flour

Table 11. Vitamin content of instant noodles formulated from wheat, rice and mushroom flour blends

Sample	Vitamin B_1 (mg/100g)	Vitamin B_2 (mg/100g)	Vitamin B_3 (mg/100g)
CTRL	$0.20^{a} \pm 0.01$	$0.06^{a} \pm 0.02$	$1.20^{a} \pm 0.28$
WR0	$0.22^{ab} \pm 0.02$	$0.07^{a} \pm 0.01$	$2.90^{b} \pm 0.14$
WRM1	$0.24^{abc} \pm 0.01$	0.07a ±0.02	$3.00^{b} \pm 0.14$
WRM2	$0.26^{abc} \pm 0.02$	$0.65^{b} \pm 0.21$	$3.20^{bc} \pm 0.02$
WRM3	$0.34^{d} \pm 0.01$	$0.04^{a} \pm 0.03$	$3.25^{bc} \pm 0.07$
WRM4	$0.30^{bcd} \pm 0.04$	$0.09^{a} \pm 0.02$	$3.60^{cd} \pm 0.28$
WRM5	$0.32^{cd} \pm 0.04$	$0.10^{a} \pm 0.02$	$3.68^{d} \pm 0.02$

Values are means ± standard deviation of duplicate replications. Means within a column with the same superscript were not significantly (p✤ 0.05) different. **Key:** CTRL: Control commercial sample; WR0 = 90 % wheat flour +10 % rice flour; WRM1 = 90 % wheat/rice flour +10 % mushroom flour; WRM2 = 80 % wheat/rice flour +20 % mushroom flour; WRM3 = 70 % wheat/rice flour +30 % mushroom flour; WRM4 = 60 % wheat/rice flour + 40 % mushroom flour; WRM5 = 50 % wheat/rice flour + 50 % mushroom flour

Table 12. Mineral content of instant noodles from wheat, rice and mushroom flour blends

Sample	Iron (mg/100g)	Potassium (mg/100g)	Phosphorus(mg/100g)
CTRL	$0.73^{b} \pm 0.02$	$1.86^{a} \pm 0.02$	$0.07^{a} \pm 0.01$
WR0	$0.49^{a} \pm 0.02$	$2.48^{b} \pm 0.02$	$0.08^{ab} \pm 0.01$
WRM1	$2.02^{c} \pm 0.14$	$12.48^{c} \pm 0.56$	$0.09^{abc} \pm 0.01$
WRM2	$2.21^{d} \pm 0.28$	$13.40^{d} \pm 0.01$	$0.10^{abc} \pm 0.01$
WRM3	$2.32^{e} \pm 0.14$	$14.00^{e} \pm 0.04$	$0.13^{bcd} \pm 0.02$
WRM4	$3.18^{f} \pm 0.28$	$15.20^{f} \pm 0.02$	$0.14^{cd} \pm 0.02$
WRM5	$3.42^{g} \pm 0.28$	$16.00^{g} \pm 0.02$	$0.16^{d} \pm 0.02$

Values are means ± standard deviation of duplicate replications. Means within a column with the same superscript were not significantly (p✤ 0.05) different. **Key:** CTRL: Control, WR0=90 % wheat flour +10 % rice flour; WRM1 = 90 %wheat/rice flour +10 % mushroom flour; WRM2 = 80 %wheat/rice flour +20 % mushroom flour; WRM3 = 70 %wheat/rice flour +30 % mushroom flour; WRM4 = 60 %wheat/rice flour + 40 % mushroom flour; WRM5 = 50 %wheat/rice flour + 50 % mushroom flour showed great potential in improving the quality of noodles in terms of overall acceptability and nutrient contents respectively, and in turn beneficial to the consumers. Substitution of wheat flour with rice flour up to 10% is suggested as it compares well with the control in acceptability. It was also observed that decrease in the protein content of noodles was improved by the addition of mushroom flour to the blend up to 50%.

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