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Addition of edible mushroom (*Pleurotus tuber-regium*) on the nutrient composition and organoleptic properties of wheat-mushroom chinchin

Ojinnaka[1], M.C., Okudu[2], H.O., Ezenwa[3], L.I., Ebereonwu[1], H.O.

[1]Department of Food Science & Technology,Michael Okpara University of Agriculture, Umudike
[2]Department of Nutrition & Dietetics, Michael Okpara University of Agriculture, Umudike
[3]Department of Environmental Sciences, Michael Okpara University of Agriculture, Umudike
Corresponding email: mcojinnaka@yahoo.co.uk

Abstract

The nutrient composition of the wheat-mushroom chinchin and the functional properties of wheat-mushroom flour blends were investigated using standard analytical techniques. The samples contained crude protein in the range of 6.77% in sample 100:0to 13.60% in sample50:50. Crude fat varied with values ranging from 12.63% in sample 100:0 to 12.81% in sample 50:50. Other proximate composition values were in the following ranges: moisture content 6.83 – 7.12%, ash 2.35 – 2.49%, crude fibre 0.89 – 8.41% and carbohydrate 55.56 – 70.52%. The antinutrients determined (alkaloids, saponin, phytate, tannin, phenol and oxalate) were low and within acceptable safe limit. Results of the functional properties showed that the water and oil absorption capacities increased progressively as the rate of addition of mushroom powder increased with values 177 – 273% and 113 – 173% respectively for samples 100:0 and 50:50. The bulk density values decreased from 0.78 - 0.66g/cm^3 as the rate of addition of the mushroom powder increased. The result of the sensory evaluation for the chinchin samples showed samples 100:0 and 90:10 are the most preferred by the members of the panelist.

***Keywords**: mushroom, wheat, chinchin, nutrient, organoleptic*

Introduction

Mushrooms are fungi, biologically distinct from plant- and animal-derived foods. They are the fruiting bodies of macroscopic filamentous fungi that grow above the ground and have been a part of the human diet used as both food and medicine for centuries (Feeney *et al*., 2014). Mushrooms have been widely used as foods (Falconer and Koppell, 1990; Zhang *et al*., 2014), and very often as delicious and nutritious foods (Vinceti *et al*., 2013). They are perhaps the most well-known and documented edible forest product (Chamberlain *et al*., 1998; Zhang *et al*., 2014). Mushrooms contain a large array of nutrients and other natural phytochemicals that have wide ranges of nutritional and health benefits (Cheung, 2010). Mushrooms are quite high in protein (19–35%, including all the essential amino acids) and low in fat. Mushrooms also contain relatively large amounts of carbohydrate and fiber, ranging from 51 to 88% and from 4 to 20% (dry weight), respectively, for the major cultivated species (Zhang *et al*., 2014).

Mushrooms have a great potential due its high and good quality proteins (20–40% on dry weight basis), Vitamins (Vitamin B-complex), and minerals (Singh *et al*., 1995). So mushrooms can be dried and converted into powdered form, which can be used for fortification in baked products like bread, biscuits, etc.(Farzana and Mohajan, 2015).

The world market for the mushroom industry in year 2005 was valued over $45 billion. Commercial varieties include Button, Oyster and Shiitake mushrooms. The white button mushroom was domesticated in France in 17th century and rapidly spread after First World War when reliable spawn was available (Chang and Miles, 1989). There is a large number of wild mushroom species in North and South America. Native Americans and immigrants from Asia or Europe used wild mushrooms as food, medicine and dyes. Some cultures however, do not use mushrooms as a significant source of food, and in some cases have not used it at all in their diets (Wong, 2003). Asian cultures are generally mycophilic. China has longest tradition in collecting mushrooms, not just for consumption as food, but also as an important role in traditional medicine. However, unlike most other mycophilic societies, species of mushrooms that are used in China for food and medicine are generally cultivated. Japan is similar to China in having cultivation play a large role in supplying mushrooms for the diet and medicinal needs of its people (Wong, 2003). European cultures are generally fond of mushrooms but the species favored by each country varies. The Italians prefer the porcini (*Boletus edulis*) and white truffle (*Tuber alba*) while the Germans and Swiss prefer the chanterelle (*Cantharellus cibarius*) (Wong, 2003). Africa appears to be generally mycophilic. There are some regions, such as Nigeria, where mushrooms are a part of everyday life as food, charms and remedies in traditional medicine. Malawi is also a region of mushroom gourmands, whose women have knowledge of the edible and poisonous species. Over 60 edible species are recognized in this area, predominantly belonging to the genera *Amanita*, *Cantharellus* and *Termitomyces* (Wong, 2003). The responsibility of foraging and identifying the mushrooms fall upon the women. In Tanzania, wild mushrooms are used as food. The tradition of collecting edible mushrooms is done almost exclusively by women and children who go on a mushroom foray (Harkonen *et al.* 1995). Over 60 edible mushroom species have been identified in Tanzania (Harkonen *et al.* 1995; Buyck*et al.* 2000). In rural Zambia and Democratic Republic of Congo, mushrooms are widely consumed during "hunger" months from late November through early April. The species favored for eating are restricted to *Termitomyces* but species of *Lactarius*, *Russula*, *Cantharellus* and *Amanita* are also eaten. In Kenya, indigenous mushrooms are still consumed from the wild, but mainly by the communities living around the forests. Wild mushrooms constitute one of the Non Wood Forest Product (NWFP) where some mushrooms and hard wood trees or termites exist in a symbiotic relationship (Buyck *et al.* 2000).

In the recent years, efforts have been made to promote the use of composite flours whereby high
protein crops are used to replace a portion of wheat flour for different food formulations, thereby decreasing the demand for imported wheat and producing protein enriched snack products. Though rich in carbohydrates, wheat has lower protein content of 8-15 g/100 g (Shewry, 2009), compared to mushroom which is 23.5 g/100 g (Khan *et al.*, 2008). Mushrooms also contain negligible fat (1.6 g/100 g dwb), salt (2.3 g/100 g dwb) and sugar contents but are a valuable source of crude fibre (8.7 g/100 g dwb) (Miles and Chang, 2004), thus offering a perfect diet for people trying to lose weight. Information on incorporation of mushroom powder in bakery products is scanty. Thus, this study was designed to evaluate the suitability of replacement of wheat flour by 10, 20, 30, 40 and 50% of mushroom powder on the nutrient and sensory characteristics of chichin snack product.

Materials and method

Sources of raw material

The edible mushroom used in this study were taxonomically identified as (*Pleurotus – tuber – regium)* by the department of Plant science and Bio-technology, Michael Okpara university of Agriculture, Umudike, Abia state, Nigeria. Wheat and other ingredients were obtained from Umuahia main market. Reagents used were of high analytical grade.

Production of mushroom (*Pleurotus tuber – regium*) powder

The method of Vullioud *et al.* (2011) with little modification was used in mushroom powder production. The edible mushrooms were sorted to remove dirts and unwholesome mushrooms. The wholesome ones were washed and chopped into small pieces and oven dried at 40°C for 6 h after which they were milled into flour and sieved. The milled mushroom powder were packaged in airtight container.

Production of wheat flour

The method described by Ndife *et al.* (2014) was used in the production of wheat flour. The whole wheat seeds were cleaned from dirt by sorting out contaminants, washed and oven dried. The dried whole wheat were milled using attrition mill and sieved into fine flour of uniform particle size, by passing them through a 2 mm mesh sieve. The sieved wheat flour were packaged in airtight container.

Blend formulation: Flour blends were prepared by mixing wheat flour to mushroom flour respectively at ratios of 100:0, 90:10, 80:20, 70:30, 60:40 and 50:50. These composite flours were then used to produce wheat-mushroom composite chinchin. The wheat-mushroom chinchin were prepared using the method described by Adegunwa *et al.* (2014).

Nutrient analysis: The moisture content, ash content, crude fat and protein (Nx 6.25), crude fibre were analyzed according to AOAC standard method (AOAC., 2000). The antinutrients were also determined using standard methods.The oxalate, saponin, tannin and phytate determinations were done using the methods described by Onwuka (2005) while the alkaloid test was performed using the method described by Harborne (1973).

Functional properties

The foam capacity were determined by the method of Abbey and Ibeh (1988). The swelling index was performed using the method of Okezie and Bello (1998). The water absorption capacity, oil absorption capacity, bulk density, wettability, emulsion capacity and gelation temperature were determined using the method of Onwuka (2005).

Sensory evaluation

The sensory evaluation was performed twenty-four hours after production of the chinchin samples using the method described by Iwe (2002). Twenty panel members (familiar with quality attributes of chinchin) were randomly selected from students and staff of the Department of Food Science and Technology to perform the organoleptic test. Panelists evaluated the chinchin samples on a 9 point hedonic scale quality with 9 = liked extremely, 8 = liked very much, 7 = liked, 6 = liked mildly, 5 = neither liked nor disliked, 4 = disliked mildly, 3 = disliked, 2 = disliked very much and 1 = disliked extremely .

Experimental design and statistical analysis

The experimental design was a single factor completely randomized design experiment with replicates. The data obtained was analyzed statistically using SPSS software (IBM Inc, New York, USA).The results were subjected to one-way analysis of variance (ANOVA) and significant differences in treatment means identified at $p<0.05$ by Duncan's multiple range test.

Results and discussion

The result of the proximate composition of wheat-mushroom chinchin is presented in Table 1. There was no significant differences ($p>0.05$) in the moisture and fat contents of the wheat-mushroom chinchin. However it was observed that the moisture content values were in the range of 6.66 – 7.12% with sample 70:30 having the least value of 6.66% while sample 50:50 had highest moisture content value of 7.12%. The reduction of moisture content of wheat-mushroom composite flours with addition of mushroom flour as anon-wheat flour has been reported by Eddy *et al.* (2007). Reduced moisture content helps the product to keep long. The fat content values ranged from 12.63 – 12.83%. Fat fraction in mushrooms is mainly composed of unsaturated fatty acids like palmitic, oleic, stearic and linoleic acid (Khan *et al.*, 2008).

Table 1: Proximate composition of wheat-mushroom chinchin (%)

Sample Wheat: mushroom	Ash	Crude fat	Crude fibre	Moisture content	Crude protein	Carbohydrate
100:0	$2.35^{c} \pm 0.05$	$12.63^{a} \pm 0.35$	$0.89^{f} \pm 0.13$	$6.83^{a} \pm 0.17$	$6.77^{c} \pm 0.10$	$70.52^{a} \pm 0.13$
90:10	$2.35^{c} \pm 0.01$	$12.85^{a} \pm 0.35$	$1.79^{e} \pm 0.09$	$6.79^{a} \pm 0.07$	$6.89^{c} \pm 0.09$	$69.35^{b} \pm 0.15$
80:20	$2.39^{bc} \pm 0.03$	$12.79^{a} \pm 0.03$	$3.09^{d} \pm 0.04$	$6.87^{a} \pm 0.05$	$7.24^{c} \pm 0.09$	$67.62^{c} \pm 0.15$
70:30	$2.39^{bc} \pm 0.03$	$12.79^{a} \pm 0.04$	$5.17^{c} \pm 0.03$	$6.66^{a} \pm 0.54$	$7.33^{c} \pm 1.11$	$64.67^{d} \pm 0.11$
60:40	$2.44^{ab} \pm 0.04$	$12.83^{a} \pm 0.09$	$6.77^{b} \pm 0.04$	$7.08^{a} \pm 0.03$	$10.91^{b} \pm 0.10$	$59.97^{e} \pm 0.04$
50:50	$2.49^{a} \pm 0.06$	$12.81^{a} \pm 0.15$	$8.41^{a} \pm 0.05$	$7.12^{a} \pm 0.02$	$13.60^{a} \pm 0.10$	$55.56^{f} \pm 0.28$

**Mean values down the column with the same superscript are not significantly different (p> 0.05)*

These essential fatty acids have been shown to be effective in prevention of coronary heart disease, hypertension, type 2 diabetes and renal disease (Khan *et al.*, 2008).The protein content increased significantly (p<0.05) with increasing mushroom content in the wheat-mushroom chinchin. Sample 50:50 had the highest protein content of 13.60% while sample with 100% wheat had the least protein value of 6.77%. Increase in protein content in wheat-mushroom chinchin with increase in mushroom content indicated that supplementing mushroom flour in wheat flour improves the protein quality of the composite chinchin snacks. Fruiting bodies of *Pleurotus spp*. contain about 26.6-34.1 g/100 g crude protein (Khan *et al.*, 2008). Ndung'u *et al.*, (2015) reported protein content of 21.73 – 45.58% in wheat-mushroom bread samples. There were increased fibre content in the chinchin samples (0.89 – 8.41%). The increased fibre content with increasing supplementation with mushroom flour would ensure sufficient intake of dietary fiber which is beneficial in health maintenance and disease prevention including cardiovascular disease, diabetes, weight regulation and cancer (Theuwissen and Mensink, 2008). Soluble and insoluble fibers in mushrooms offer both anti-tumor properties and also promote digestion and good bowel health. The carbohydrate content declined significantly (p<0.05) with increasing mushroom content in all the composite wheat-mushroom chinchin. The wheat chinchin had the highest carbohydrate content of 70.52%.
The antinutrients of the wheat:mushroom chinchin is shown in Table 2. The results revealed the presence of saponin, phytate,phenol, oxalate, alkaloid and tannin though in very small quantities; not detrimental for human consumption

Table 2: Anti-nutritional composition of wheat-mushroom chinchin (mg/100g)

Sample Wheat: mushroom	Alkaloid	Saponin	Phytate	Tannin	Phenol	Oxalate
100:0	$0.05^{c} \pm 0.01$	$0.03^{b} \pm 0.01$	$0.02^{d} \pm 0.00$	$0.02^{d} \pm 0.00$	$0.07^{e} \pm 0.00$	$0.06^{b} \pm 0.01$
90:10	$0.05^{c} \pm 0.01$	$0.03^{b} \pm 0.01$	$0.02^{d} \pm 0.00$	$0.02^{d} \pm 0.00$	$0.08^{d} \pm 0.00$	$0.06^{b} \pm 0.01$
80:20	$0.07^{bc} \pm 0.01$	$0.05^{ab} \pm 0.01$	$0.03^{c} \pm 0.00$	$0.03^{c} \pm 0.00$	$0.12^{c} \pm 0.00$	$0.07^{ab} \pm 0.01$
70:30	$0.07^{bc} \pm 0.01$	$0.05^{ab} \pm 0.01$	$0.04^{b} \pm 0.00$	$0.04^{b} \pm 0.00$	$0.12^{c} \pm 0.00$	$0.07^{ab} \pm 0.01$
60:40	$0.08^{b} \pm 0.00$	$0.05^{ab} \pm 0.01$	$0.05^{a} \pm 0.00$	$0.05^{a} \pm 0.00$	$0.13^{b} \pm 0.00$	$0.07^{ab} \pm 0.01$
50:50	$0.11^{a} \pm 0.02$	$0.07^{a} \pm 0.01$	$0.05^{a} \pm 0.00$	$0.05^{a} \pm 0.00$	$0.14^{a} \pm 0.00$	$0.08^{a} \pm 0.01$

**Mean values down the column with the same superscript are not significantly different (p> 0.05)*

Isabel *et al.*, (2008) reported presence of polyphenols and flavonoids in mushroom. Saponins in the wheat-mushroom chinchin samples were in the range of 0.03 – 0.07mg/100g. Saponins possess a carbohydrate moiety to a steroid aglycone. They form a group of compounds, which on consumption cause deleterious effects such as haemolysis and permeabilization of the intestine.

The values are lower than the maximum permissible limit of (48.05mg/100g) set by WHO (2003). The phytates were also very low (0.02 -0.05mg/100g) in the samples. Phytates are inositol hexaphosphoric acids which form complexes with salts as calcium, zinc, magnesium, iron and render them unavailable for absorption and utilization in the body (Onimawo and Akubor, 2014). The oxalate content of the chinchin samples were in the range of 0.06 - 0.08mg/100g. Oxalates cause calcium deficiency both in man and in non-ruminants. At a high dose of 1g – 2g of body weight, it is toxic to the kidney and heart (Obiakor-Okeke, 2014). Oly-Alawuba and Obiakor – Okeke(2014) reported values of 0.77 – 1.55mg/100g for phytate, 0.66 – 1.00mg/100g for saponin and 0.23 – 0.51mg/100g for oxalate in three mushroom varieties consumed in Orlu in Southeastern Nigeria.

From the result in Table 3 it has been observed that the level of antinutrients determined decreased as the rate of addition of the mushroom powder increased. Also the values were low because of the processing heat operations during the chichin production.

The water absorption capacity varied from 177 – 273% with sample 50:50 having the highest water absorption capacity value of 373g%. It was observed that the water absorption capacity increased as the rate of addition of mushroom powder increased. The high water absorptivity reported in the present study suggests that a variety of mushroom flours may be used in the formulation of some foods such as sausage, dough, processed cheese, baked products and soups (Aremu *et al*., 2008). The results showed that the blends would be useful in bakery products where hydration to improve handling is desired and in ground meat, doughnuts, and pancakes where oil absorption property is of prime importance (Mepba *et al*., 2007). Lin *et al.* (1974) reported 130% water absorption for soy flour and 227.3% and 196.1% respectively for two commercial soy protein concentrates namely, Isopro and promo soy. Kinsella,(1976) had earlier reported that the ability of food materials to absorb water is sometimes attributed to the protein content. This suggests that increase in water absorption in the blends can be useful in bakery products such as bread, cakes, cookies that requires hydration to improve dough handling characteristics (Kiin-Kabari *et al*., 2015). Similar trend was also observed in the oil absorption capacity of the blends. The oil absorption capacity of the flour blends also increased progressively as the level of addition of the mushroom powder increased with the lowest value of 113% being recorded in sample 100:0 (100% wheat).

Table 3: Functional properties of wheat-mushroom composite flour blends

Samples Wheat: mushroom	Swelling index (%)	Water absorption capacity(%)	Oil absorption capacity(%)	Bulk density(g/cm^3)	Gelation temperature (°C)	Wettability (secs)	Emulsion capacity (%)	Foam capacity (%)
100:0	$1.31^{e}\pm0.01$	$177^{f}\pm0.15$	$113^{e}\pm0.05$	$0.78^{a}\pm0.00$	$76.67^{e}\pm1.16$	$23.00^{e}\pm2.00$	$45.90^{f}\pm0.17$	$16.46^{f}\pm0.45$
90:10	$1.38^{d}\pm0.03$	$197^{e}\pm0.06$	$125^{de}\pm0.10$	$0.78^{ab}\pm0.00$	$80.67^{d}\pm1.16$	$27.00^{d}\pm1.73$	$47.03^{e}\pm0.42$	$21.07^{e}\pm0.08$
80:20	$1.45^{c}\pm0.02$	$213^{d}\pm0.06$	$134^{cd}\pm0.05$	$0.77^{b}\pm0.01$	$81.33^{d}\pm0.58$	$30.33^{cd}\pm1.16$	$48.00^{d}\pm0.30$	$24.48^{d}\pm0.31$
70:30	$1.49^{bc}\pm0.01$	$233^{c}\pm0.06$	$143^{bc}\pm0.05$	$0.74^{c}\pm0.00$	$85.33^{c}\pm1.16$	$33.00^{c}\pm1.73$	$48.93^{c}\pm0.25$	$30.83^{c}\pm0.12$
60:40	$1.51^{b}\pm0.03$	$257^{b}\pm0.06$	$152^{b}\pm0.05$	$0.69^{d}\pm0.00$	$88.67^{b}\pm1.16$	$42.67^{b}\pm3.06$	$49.60^{b}\pm0.17$	$35.64^{b}\pm0.30$
50:50	$1.57^{a}\pm0.01$	$273^{a}\pm0.11$	$173^{a}\pm0.16$	$0.66^{e}\pm0.00$	$91.33^{a}\pm1.16$	$51.33^{a}\pm1.16$	$52.33^{a}\pm0.06$	$39.71^{a}\pm0.23$

The highest oil absorption capacity of 173% was found in sample 50:50. Oil absorption capacity is important since oil acts as a flavour retainer and increases the mouth feel of foods. It has been reported that variations in the presence of non-polar side chains, which might bind the hydrocarbon side chains of oil among the flours, explain differences in the oil binding capacity of the flours (Adebowale and Lawal, 2004). The oil absorption capacity followed similar pattern as water absorption, increasing with increase in the level of mushroom in the flour blends.

The foaming capacity of the composite wheat-mushroom flour blends ranged between 16.46 to 39.71% with sample 50:50 having the highest value. The foaming capacity increased with increasing contents of mushroom powder in the blends. The blends depicted high foam stability and may find application in baked and confectionery products. Product foam ability is related to the rate of decrease of the surface tension of air/water interface caused by absorption of protein molecules. Graham and Phillips (1976) observed that flexible protein molecules such as β (beta) casein, which can rapidly reduce surface tension, gave good foam ability, whereas a highly ordered globular protein molecule such as lysozyme, which is relatively difficult to surface denature gave low foam ability.
The bulk density of the composite flour blends decreased as the rate of addition of the mushroom powder increased (0.78 – 0.66g/cm^3). Samples 100:0 and 90:10 had the same bulk density value of 0.78 g/cm^3.Low bulk density of flour are good physical attributes when determining transportation and storability since the products could be easily transported and distributed to required locations. The low bulk density recorded in the blends could also be an advantage in the formulation of baby foods where high nutrient density to low bulk is desired (Mepba *et al*., 2007).The emulsion capacity values range between 45.90% in sample 100:0 (100% wheat) to 52.33% in sample 50:50. These values are lower than the values reported for varieties of mushroom sample flours of 76.0 – 87.0mlg–1 by Adeyeye *et al.* (2005). However, the values are much higher than for soybean flour (18.0%) and wheat flour (11.0%) (Lin *et al*., 1974). The emulsion capacity were in the range of 45.90% – 52.33%. The solubility of a protein is usually affected by emulsifying activity. This could be because of its hydrophilicity of hydrophobic balance, depending on the surface active agent, can form and stabilize the amino-acid composition, particularly the protein emulsion by creating electrostatic repulsion on oil surface. Lin *et al.* (1974) reported the emulsion capacities of wheat flour, soy flour, sunflower flour and protein concentrates and isolates from soy and sunflower flours to be in the range of 10.1 to 25.6% with the exception of sunflower (in which 95.1% oil emulsified).
The result from the sensory evaluation for wheat-mushroom chinchin is presented in Table 4. The flavour for the control sample (100% wheat) received the highest rating score of 8.10 and this was significantly different from the other samples. Sample 90:10 had the highest taste score of 8.19 (mean score values of 8 and above translates to like very much) while the least score was obtained by sample 4.86. Both samples 100:0 and 90:10 scored 6.71 respectively in terms of general acceptability and this translates to like slightly in the hedonic scale. It was observed that increasing mushroom flour affected the taste, texture and thickness of the wheat-mushroom chinchin.

Table 4: Sensory scores for wheat-mushroom chinchin

Samples Wheat:mushroom	Flavour	Smoothness	Thickness	Appearance	Taste	Overall acceptability
100:0	8.10^a ± 0.77	7.95^a ± 0.92	8.00^a± 0.55	7.38^b ± 1.20	8.00^a ± 0.71	6.71^a ± 0.56
90:10	8.00^a ± 0.63	7.95^a ± 0.59	7.81^a± 0.40	7.90^a ± 0.83	8.19^a ± 0.81	6.71^a ± 0.64
80:20	7.48^b ± 0.51	7.00^{a}b± 1.05	7.71^a± 1.06	6.67^c ± 0.80	6.86^b ± 1.53	6.00^b ± 0.84
70:30	7.14^{bc} ± 0.73	6.73^{bc} ± 1.12	7.00^b± 0.84	6.48^c ± 0.75	5.81^c± 1.33	5.48^c ± 0.51
60:40	6.76^c ± 1.04	6.29^c ± 1.23	6.90^b± 0.83	5.76^d ± 0.77	6.24^{bc} ± 1.37	5.52^c ± 0.68
50:50	5.10^d ± 0.94	5.24^d ± 0.77	5.71^c± 0.85	5.43^d ± 0.63	4.86^d ± 1.06	4.71^d ± 0.72

**Mean values down the column with the same superscript are not significantly different (p> 0.05)*

Conclusion

The protein content of wheat-mushroom composite chinchin snacks ranged from 6.77 – 13.60%. Water and oil absorption capacities of the wheat-mushroom flour blends increased with increasing mushroom powder contents while bulk densities decreased simultaneously.

The consumer preference for the chinchin snacks were higher in samples 100:0 and 90:10. The results from the study shows that mushroom can be incorporated in food formulations both for children and adults alike in food product development.

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