Production of Mushroom Based Food Condiment and Nutritional and Anti-nutritional Properties of *Pleurotus Ostreatus*

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Abstract: Nutritional and anti nutritional properties of mushroom (*Pleurotus ostreatus*) and the production of mushroom based food condiment are discussed in this paper. Mushroom (*Pleurotus ostreatus*) was subjected to chemical analyses. The mushroom based food condiment was produced by mixing the flaked dry mushroom with ingredients (pepper, onions, salt, sugar, crayfish) at different levels of 100% (*Pleurotus ostreatus*): 0% (spice mix), 95% (*Pleurotus ostreatus*): 5% (spice mix) and 60% (*Pleurotus ostreatus*): 40% (spice mix). The proximate composition analysis showed that the moisture, protein and carbohydrate content were considerably high with values of 93.38% ± 0.01, 2.17% ± 0.01, 3.11% ± 0.02 respectively. The crude fiber, ash and fat content were also gotten as 0.63% ± 0.04, 0.45% ± 0.02, 0.26% ± 0.03 respectively. *Pleurotus ostreatus* contained essential minerals such as potassium, calcium and magnesium in substantial concentration with result values of 62.59mg/100g ± 0.01, 19.93mg/100g ± 0.02, 9.98mg/100g ± 0.02 respectively and other minerals such as Iron and Zinc with values of 3.40 mg/100g ± 0.01and 3.28 mg/100g ± 0.01 respectively. Vitamin composition showed that Niacin had the highest value of 6.98 mg/100g ± 0.01, while Pantothenic acid had a low value of 0.20 mg/100g ± 0.02. Other vitamin contents obtained were Thiamin 4.43 mg/100g ± 0.02, Riboflavin 4.31 mg/100g ± 0.09 and Vitamin D 3.57 mg/100g ± 0.02. Oxalate was the highest anti nutrient in the mushroom with a value of 3.20 mg/100g ± 0.02 while phytates, tannins and saponins were generally low with values of 0.19 mg/100g ± 0.01, 1.86 mg/100g ± 0.01 and 0.30 ± 0.01 respectively. Sensory evaluation was conducted on the different mushroom based food condiment samples with MW_4 (80%:20%) having the best overall acceptability and MW_1 (95:5) having the least.
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1.0 Introduction

Mushroom has been defined by Chang (1993) as a micro fungus with a distinctive fruiting body which can be either epigenous (appearing above the earth surface) or hypogenous (occurring below the surface) and large enough to be seen with the naked eyes and to be picked by the hand. They are fungi that produce conspicuous fruit bodies (Laessoe, 1998). The distinctiveness of mushroom steps in part, from the fact that it is not truly a vegetable, but a fungus- a plant that has neither roots nor leaves, that does not flower or bear seeds and that does not need light to grow (although some do need light to fruit). Instead, it proliferates in the dark and reproduces by releasing billions of spores (Margen, 1992). All mushrooms are fungi, but not all fungi are mushrooms. For those fungi that produce them, the mushroom plays a similar role to a flower or a fruit in plants. Some part of each mature mushroom produces microscopic spores that are similar to pollen or seeds, sometimes numbering in the trillions. The rest of the fungal organism typically lives in the soil, wood, or some other material and is composed of thread-like strands known as mycelium. The expanding growth of the mycelium often results in circles of mushrooms or fairy rings. Widespread malnutrition with ever increasing protein gap in our country has necessitated the search for alternative protein. It has been estimated that the number of mushrooms on earth is about 140,000, yet only 14,000 (10%) are known (Hawksworth, 2001). Pulses and legumes have been serving to break the gap; however the production of pulses cannot keep up with our requirement due to high population growth. The issue of animal protein cannot be considered as a cheap alternative since animal protein is beyond the reach of the common man in the country and most of the people live below poverty level. Interestingly, many researchers (Tripathi, 2005; Chinda and Chinda, 2007; Ahmed *et al*, 2009 and Ashrafuzzamaan *et al*, 2009), reported that mushrooms are cheap compared with other food items with similar nutritive value such as eggs, meat, milk and fish. They are low in fat and

carbohydrate which make them an ideal food to be eaten by all, including diabetic and obese patients. Edible mushrooms are recommended by the FAO as food contributing to agricultural production and as source of cheap protein. Luckily, Nigeria is richly endowed with good quality mushrooms like *Pleurotus* which could be mass produced for local consumption as well as for international market. Since mushrooms are seasonal, commercial cultivation is therefore necessary to ensure constant availability. Large scale cultivation and processing of mushroom requires a good knowledge of the growth requirement and performance of the substrate on the growth rate and nutritional composition of the mushroom. Nigerians present dependence on mushroom importation for its domestic and other needs makes it imperative for the country to explore its own independent source of mushroom supply to keep pace with its developmental needs and conserve foreign exchange for the nation**,** hence the need for writing this paper. The main objective is to study the nutritional and anti nutritional properties of mushroom (*Pleurotus ostreatus*) which is available in our country Nigeria but underutilized due to lack of knowledge on its nutritional composition and to produce mushroom based food condiment with flaked mushroom. Information obtained from this research will help change the negative mindset of Nigerians concerning the consumption of mushrooms, enabling them to love and cherish them. Due to the seasonal nature of mushrooms, the mushroom based food condiment would help ensure that the mushroom flavor stays all through the year. This paper would also enlighten people on the nutritional properties associated with mushrooms and also impart knowledge on the anti nutritional properties of the mushroom (*Pleurotus ostreatus*).

2.0 Materials and Methods

2.1 Materials Collection

Both the fresh and dried oyster mushroom (*P. ostreatus*) used for this research work were obtained from Diplomat Farms and Services Limited which is located at Faculty of Agric Teaching and Research Farms, Rivers State University of Science and Technology, Nkpolu, Port Harcourt. The *Pleurotus ostreatus* was authenticated at the same place of purchase. The onions, ground pepper, ground crayfish, salt, pepper and sugar were purchased from Ihiagwa main market and stored at their required conditions until when needed.

2.1.1 Sample Preparation

The dried mushroom samples were crushed to flakes enabling easy and accurate determination of their different analysis and to ensure proper production of the mushroom based food condiment. The crayfish and pepper were ground; the onions were dried using an oven, ground and also weighed.

2.2 Determination of Proximate Composition

The proximate composition (crude protein, crude fat, crude fiber, moisture content, ash content) were determined using the method described by Association of Official Analytical Chemists (AOAC, 1990), Kirk and Sawyer (1980) and James (1995).

2.2.1 Moisture Content Determination

This was done by the gravimetric method described by the AOAC (1990). Three grams (3g) of the sample was weighed into a previously weighed moisture dish. The sample in the dish was dried in the oven at 105^{o}C for 3hours. It was cooled in a desiccator and weighed. It was then returned to the oven for further drying. Drying, cooling and weighing were done repeatedly at hourly interval until there were no further diminutions in the weight (that is, constant weight was obtained). The weight of moisture lost was calculated and expressed as a percentage of the weight of sample analyzed. The difference in mass as percentage (% moisture) was calculated

Thus:

$$\frac{W_2-W_3}{W_2-W_1}x\frac{100}{1}$$

Where

W_1 = mass of dish

W_2 = mass of dish+ sample before drying.

W_3 = mass of dish + sample after drying.

2.2.2 Crude Fat Determination

This was determined by solvent extraction gravimetric method described by Kirk and Sawyer (1980). Three grams (3g) of the sample was wrapped in a porous paper (whatman filter paper) and put in a thimble. The thimble was put in a soxhlet reflux flask containing 200ml of petroleum ether. The upper part of the reflux flask was connected to a water condenser. The solvent (petroleum ether) was heated, boiled, vaporized and condensed into the reflux flask, filled up and siphoned over carrying its oil extract down to the boiling flask. This process was allowed to go on repeatedly for 4hrs before the defatted sample was removed. The solvent was then removed and the oil extract was left in the flask. The flask (containing the oil extract) was dried in the oven at 60^{o}c for 30mins to remove any residual solvent. It was then cooled in the desiccator and weighed. The weight of the oil (fat) extract was determined by difference and calculated as a percentage of the weight of sample analyzed. By difference, the mass of oil extracted was determined and thus expressed as percentage;

$$\% \text{ Crude Fat} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \times \frac{100}{1}$$

2.2.3 Crude Protein Determination

This was done by Kjeldahl method described by Chang (2003). The total nitrogen was determined and multiplied with factor 6.25 to obtain protein content.

Two grams (2g) of the sample was mixed with 10ml of concentrated H_2SO_4 in digestion flask. A tablet of selenium catalyst was added to it before it was heated under a fume cup board until a clear solution was obtained (the digest). The digest was diluted to 100ml in a volumetric flask and used for the analysis. The 10ml of the digest was mixed with equal volume of 45% NaOH solution in a Kjeldahl distillation apparatus. The mixture was distilled into 10ml of 40% boric acid containing 3 drops of mixed indicator (Bromo cresol green/ methyl red). A total of 50ml of distillates was collected and titrated against 0.02N EDTA from green to a deep red end point. A reagent blank was also digested, distilled and titrated. The nitrogen content and hence the protein content was calculated using the formula below:

$$\% \text{ Nitrogen} = \frac{V_S - V_B}{W} \times \text{Nacid} \times 0.01401 \times 100$$

Where

V_s = Volume (ml) of acid required to titrate sample.

V_B = Volume (ml) of acid required to titrate blank.

Nacid = Normality of acid.

W = Weight of sample in grams.

% Crude protein = N x Conversion factor.

(100/% Nitrogen in protein) = Conversion factor i.e. 100/16 = 6.25.

N = Nitrogen.

2.2.4 Crude Fiber Determination

Crude fiber was determined by the method of James (1995). Sample (3.0g) processed sample was boiled in 150 ml of 1.25 H_2SO_4 for 30 minutes under reflux. The boiled sample was washed in several portions of hot water using a two-fold cloth to trap the particles. It was returned to the flask and boiled again in 150ml of 1.25% NaOH for another 30 minutes under same conditions. After washing in several portions of hot water, the sample was allowed to drain dry before being transferred quantitatively to a weighed crucible where it was dried in the oven at 105°c to a constant weight. It was thereafter taken to a muffle furnace where it was burnt, only ash was left of it. The weight of the fiber was determined by difference and calculated as a percentage of the weight of sample analyzed.

By difference in mass, the mass of the fiber was determined and given by;

$$\% \text{ fiber} = \frac{W_1 - W_2}{W_3} \times 100$$

Where;

W_1= Weight of sample before incineration.

W_2= Weight of sample after incineration.

W_3= weight of original sample.

2.2.5 Ash Content Determination

This method was done by the furnaces incineration gravimetric method described by James (1995) and AOAC (1984). Three grams (3g) of each of the sample was weighed into a crucible, heated in moisture extraction oven at 550°c until it turned white and free of carbon. The sample was then removed from the furnace, cooled in a desiccator to a room temperature and reweighed immediately. The weight of the residual ash was then calculated as Ash content.

$$\text{Percentage (\%) ash} = \frac{\text{weight of Ash}}{\text{weight of original sample}} \times \frac{100}{1}$$

2.2.6 Carbohydrate Content Determination

The nitrogen free method described by A.O.A.C (1990) was used. The carbohydrate is calculated as weight by difference between 100 and the summation of other proximate parameters as

Nitrogen free Extract (NFE) percentage carbohydrate

$$(\text{NFE}) = 100 - (m + p + f + A + f_2)$$

Where

M=Moisture, P=Protein, F=Fat, A=Ash, F_2= Crude fiber

2.3 Determination of Vitamin Composition

P. ostreatus was analyzed for its vitamin content. Vitamin B_1 (Thiamin), Vitamin B_2 (Riboflavin), Vitamin B_3 (Niacin), Vitamin B_5 (Pantothenic acid) and Vitamin D were determined using the method of Onwuka (2005), Aurand *et al*, (1987).

2.3.1 Determination of Thiamin (Vitamin B_1)

Thiamin was determined according to the method of Onwuka (2005). Ten grams (10g) of the finely ground mushroom sample was mixed in 100ml of 0.1N HCL and were autoclaved at 120°c for 30 minutes, cooled and diluted with 100ml distilled water. Ten milliliter of the extract was passed over a silicate chromatography column and 10ml of warm water was passed over it and eluted with 5 ml potassium chloride solution. Five milliliter of the assay solution was collected in a test tube and 3ml potassium ferricyanide, 15ml isobutanol were added while shaking to oxidize the thiamin to thiochrome. The sample was centrifuged for 1minute. Five milliliter of thiamin working standard is run with each sample. The thiamin content of the sample was determined by comparing the intensity of fluorescence of the sample with that of the working standard.

$$\text{Thiamin } (\mu g/5ml) = \frac{I - I_b}{S - S_b} \times \frac{1}{5} \times \frac{25}{V} \times \frac{100}{W}$$

Where

I = Intensity of fluorescence for sample.

I_b = Intensity of fluorescence for sample blank.

S = Intensity of fluorescence for standard.

S_b = Intensity of fluorescence for standard blank.
V = Eluate volume.
W = Weight of sample.

2.3.2 Determination of Riboflavin (Vitamin B_2):

Riboflavin in the sample was determined by fluorimetric method (Onwuka, 2005). Exactly 10g of the sample was digested in 0.1M HCL in an autoclave at 120°c for 30 minutes and cooled. Protein in the sample was precipitated out by adding ammonium sulphate and centrifuged, and then the pH was adjusted to 6.8 with 0.1M NaOH. Ten milliliter of the sample was transferred to two test tubes. One milliliter riboflavin standard was added to one tube and 1 ml of water was added to the other tube. One milliliter of acetic acid and 0.5ml of 3% potassium permanganate were added to each tube and stirred, then allowed to stand for 2 minutes and 0.5ml of hydrogen peroxide was added. The fluorescence of the samples was measured at 530nm (emission wavelength). Twenty milligrams of sodium hydrogen sulphate were added to both tubes and the fluorescence was measured again as the blank reading.

$$\text{Riboflavin (mg/g sample)} = \frac{x}{X}\frac{y}{Y} - \frac{X}{W}\frac{1}{}$$

Where
x = reading of sample – reading of sample blank
y = (reading of sample + standard tube 2) – (reading of sample+ standard blank)
w = Weight of the sample.

2.3.3 Determination of Niacin (Vitamin B_3):

Niacin content was determined fluorimetrically (Kirk and Sawyer, 1980). Exactly 5mg of the sample was mixed with 0.5ml methyl iodide and mixed well by constant shaking. The sample was placed in the dark for 24 hours where the methyl iodide was allowed to evaporate and then 0.1ml of 10% acetophenone in 80% ethanol was added. After mixing, 0.1ml of 0.1M KOH in 80% ethanol was added and stirred immediately, then allowed to stand for 10 minutes. Concentrated formic acid was added and mixed immediately. A blank assay was also carried out simultaneously. After standing for 5 hours, sample was measured at an emission wavelength of 430nm. The niacin level was obtained from a standard from serial dilution of known niacin level.

$$\text{Niacin (mg/ml)} = \frac{\text{Absorbance of test x Concentration of standard}}{\text{Absorbance of standard}}$$

2.3.4 Determination of Pantothenic acid (Vitamin B_5):

The level of pantothenic acid was determined by microbiological method (Aurand *et al*, 1987). *Lactococcus lactis* was used as the test organism. A standard curve was prepared from serial dilutions containing 0.5 to 5mg of standard pyridoxine solution. To all tubes, a drop of the inoculums was added and incubated at room temperature for 24 hours. It was steamed at 100°c, cooled to room temperature and the absorbance was measured in a colorimeter at 660nm to plot the standard curve. The samples were digested in 0.1N HCL using autoclave at 120°c for 30 minutes, cooled and inoculated with the test organism for 8 hours. The absorbance was measured at 660nm and the level of pantothenic acid was extrapolated from the standard curve. It is calculated as

$$\text{Pantothenic acid} = \frac{\text{Absorbance of test x Concentration of standard}}{\text{Absorbance of standard}}$$

2.3.5 Determination of Vitamin D (Calciferol):

The experiment was carried out in the dark to avoid photolysis of vitamin. 0.5g of sample was homogenized and saponified with 2.5ml of alcoholic potassium hydroxide in water bath at 60°c for 30minutes. The saponified extract was transferred to a separating funnel containing 10ml of petroleum ether and mixed well. The lower aqueous layer was then transferred to another separating funnel and the upper petroleum layer extract was repeated until the aqueous layer becomes colorless. A small amount of anhydrous sodium sulphite was added to the petroleum ether extract to remove excess moisture. The final volume of the petroleum ether was noted. The absorbance of the following was read in a spectrophotometer at 450nm and 503nm using petroleum ether as blank. The amount of the total vitamin D was calculated using this formula

$$\text{Vitamin D} = \frac{\text{A450 X Volume of sample X 100 X 4}}{\text{Weight of sample}}$$

2.4 Determination of Mineral Composition

P. ostreatus was analyzed for mineral and trace element compositions. Minerals such as Calcium, Magnesium, Potassium; and trace elements such as Zinc and Iron were determined using the method of AOAC 1990, Onwuka, 2005.

2.4.1 Determination of Calcium Magnesium, Iron and Zinc

2.4.1.1 Sample Digestion:

One gram of the sample in 20ml mixture of 650ml nitric acid, 80ml perchloric acid and 20ml sulphuric acid at 100°c for 5 hours.

2.4.1.2 Measuring absorbance:

The absorbance of individual mineral was measured in atomic absorption spectrophotometer as follows: calcium 430nm, magnesium 285nm, iron 248nm and zinc 215nm. The level of each mineral was extrapolated from a standard curve.

2.4.2 Determination of Potassium by Flame Photometry

2.4.2.1 Sample Digestion:
Two gram of the sample was digested in 20ml mixture of 650ml nitric acid, 80ml perchloric acid and 20ml sulphuric acid at 100°c for 5 hours.

2.4.2.2 **Measuring absorbance:**
The digest was measured in a flame photometer. The potassium level was measured at 589nm.

2.5 **Determination of Anti-nutrient Composition**
Anti-nutrients such as saponins, tannins, oxalates, phytates were determined in the *P. ostreatus* sample using the method of Harbone (1980) and Kirk and Sawyer, (1980)

2.5.1 **Determination of Saponins:**
The saponin level was determined by gravimetric method (Harbone, 1980). Exactly 20g of the dried sample was dispersed in 200ml of ethanol and then heated in a water bath for 4 hours at 55°c. It was then filtered and the residue was re-extracted in 100ml ethanol. The combined extract was reduced to 40ml by evaporation. Twenty milliliter of diethyl ether was added to the concentrate. The solution was evaporated in a water bath and the concentrate was dried to a constant weight in an oven.

$$\% \text{ Saponins} = \frac{\text{Weight of dried residue}}{\text{Weight of original sample 1}} \times 100$$

2.5.2 **Determination of Tannins:**
Tannins level was determined according to the method of Harbone (1980). Exactly 0.5g of oven dried sample was boiled in 50ml distilled water for 1 hour. It was then filtered into 50ml conical flask, cooled and made to volume. The absorbance of the sample was measured in a spectrophotometer at 760nm. The level of tannins was extrapolated from a standard curve prepared from tannic acid. It is calculated as

$$\text{Tannic acid} = \frac{\text{C1 X 100}}{\text{Weight of sample}}$$

2.5.3 **Determination of Phytate:** The level of phytate was determined by spectrophotometric method (Kirk and Sawyer, 1980). The sample was extracted with 100ml of 0.02N HCL with vigorous shaking for 30 minutes. Exactly 10ml of the supernatant was treated with 1.5ml bipyridine solution. The absorbance was measured in a spectrophotometer at 519nm. The amount of the phytate was extrapolated from the standard curve prepared from phytic acid.

2.5.4 Determination of Oxalate: The level of oxalate in the sample was determined by titration method (Onwuka, 2005). Exactly 2.0g of the sample was dispersed in 190ml of distilled water in 250ml volumetric flask. Ten milliliter of 6M HCL was added, then digested at 100°c for 1 hour, cooled and made to volume before filtration. The filtrate was precipitated with ammonium hydroxide and the precipitate was dissolved in 10ml of 20% sulphuric acid. The solution was titrated with 0.05M potassium permanganate.

$$\text{Calcium oxalate} = \frac{T \times (V_{mc})\ (DF) \times 10^5}{ME \times M_f}$$

Where T = Titre value of potassium permanganate.
V_{mc} = Volume-mass equivalent (i.e. 1ml of potassium permanganate = 0.00225 anhydrous oxalic acid).
DF = Dilution Factor.
ME= Molar Equivalent of potassium permanganate.
Mr= Mass of the sample used.

2.6 **Preparation of the Mushroom Based Food Condiment**
The mushrooms were dried at 80°c for 3 hours, ground, weighed and kept in an air tight container. Onions were dried using an oven at 80°c for 3 hours to remove moisture and then ground using a manual blender. The crayfish was also dried at 60°c for 1 hour and ground also using a manual blender. The pepper was dried also at 70°c for 2 hours and then ground using a manual blender. Salt and sugar were also weighed into another container. Each ingredient (figure 3) except the mushroom were weighed accurately and mixed properly to form the base ingredients; then the base ingredients were divided into three different batches with three samples in each of the batches making it nine samples and weighed in different proportions (0%, 5%, 10%, 15%, 20%, 25%,30%, 35%, 40%,) to which mushrooms of different proportions (100%, 95%, 90%, 85%, 80%,75%, 70%, 65%, 60%) were also weighed and added to the nine different base ingredients and mixed properly. They are coded as MW, MW1, MW2, MW3, MW4, MW5, MW6, MW7 and MW8 respectively. Then from each of the nine mushroom condiments 2g is obtained and used in the preparation of pepper soup.

2.7 Formulations of Mushroom based Food Condiment
The ground dried mushroom and the spice ingredients were weighed and mixed at different ratios to obtain a mushroom based food condiment. Composites of ground mushroom sample (*P. ostreatus*) and spice condiment was

formulated. 100% of the mushroom sample was used as control. The ratios of the ground mushroom to the spice ingredients was represented in figure 3.

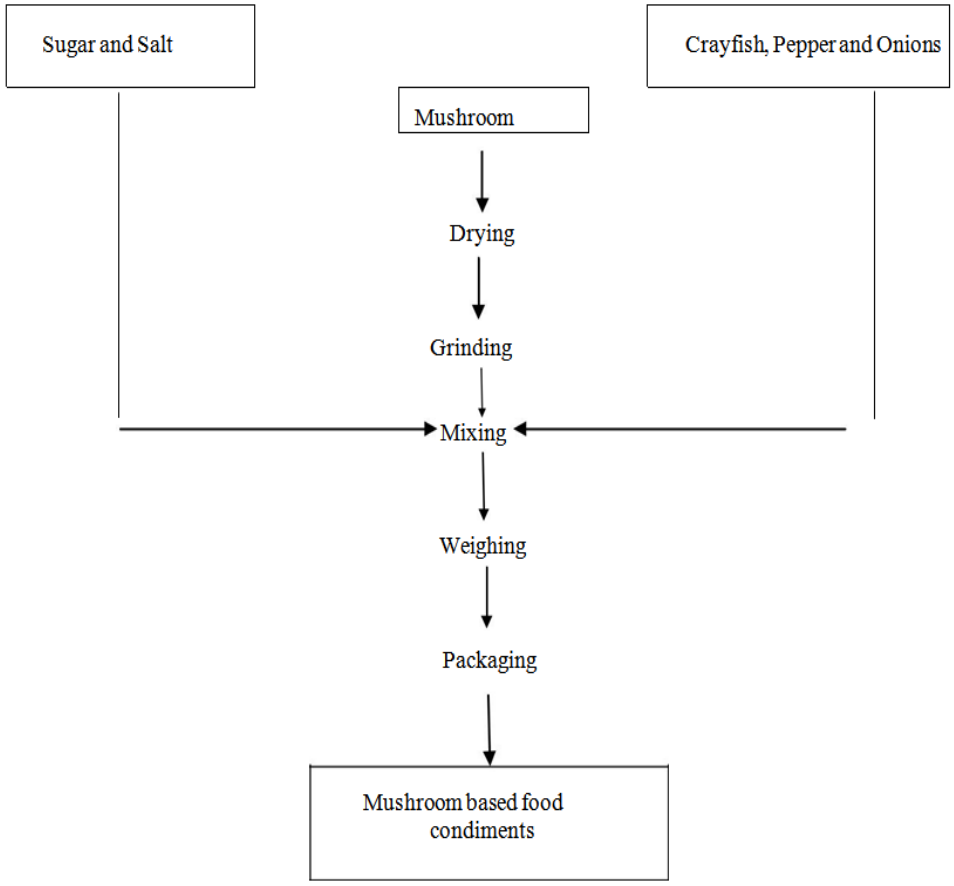

Fig 1: Flow chart for the production of mushroom based food condiment

2.7 Sensory Evaluation of Mushroom Based Food Condiments

Sensory evaluation of the different mushroom based food condiment samples was carried out. The evaluation was carried out by a panel of 15 judges selected from university students using the 9 point hedonic scale.

2.8 Statistical Analysis

The experiments were carried out in triplicates and the results were presented in Mean ± SD (Standard Error). All the data obtained from the sensory evaluation were analyzed using the analysis of variance (ANOVA) procedure by statistical analysis system and mean separation was by Duncan‟s multiple range test at p= 5%.

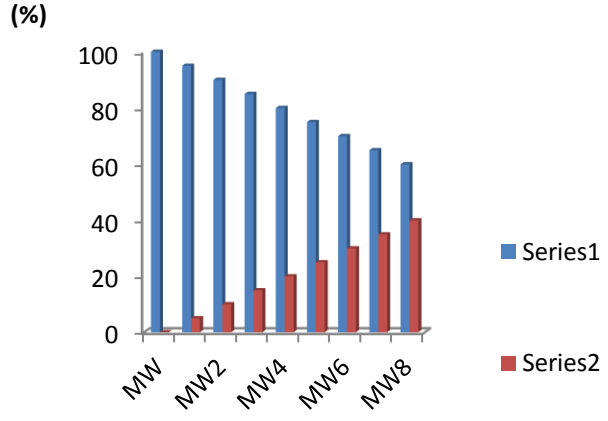

Figure 3: Formulation of Mushroom Based Food Condiments
Series 1= % of Mushroom
Series 2= % of Spice

3.0 Results and Discussion

3.1 Proximate Analysis Result and Discussion

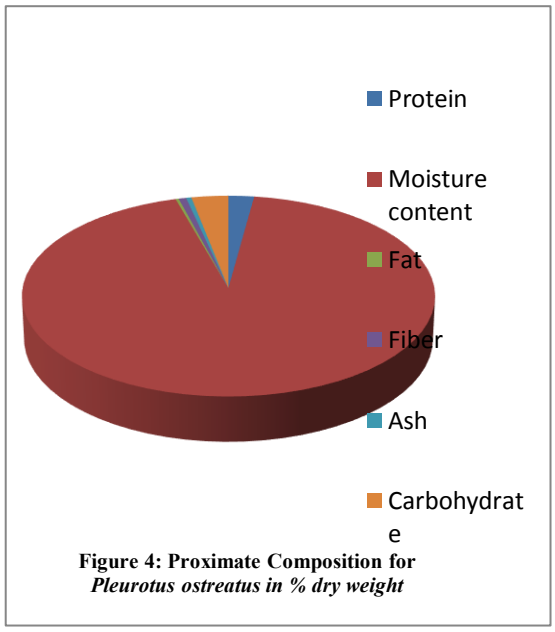

Figure 4: Proximate Composition for *Pleurotus ostreatus* in % dry weight

The proximate composition of the *Pleurotus ostreatus* sample is shown in figure 4. All the results except the moisture content are expressed on dry weight basis (d.w.b) Moisture content was high with a value of 93.38%. This result is in line with the work of Selvaraji *et al*, (2005) who carried out a research on four species of edible mushrooms namely: *Pleurotus ostreatus*, *Pleurotus sajor-caju, Pleurotus florida* and *Pleurotus nk-5* and recorded their proximate compositions. Mushrooms are generally high in moisture content (Stamet, 2006). The high moisture content of the mushroom shows that it is prone to deterioration since food high in moisture content are prone to perishability (Fennema and Tannenbaum, 1996). The fiber content of the sample was gotten as 0.63% (Figure 4). Mushrooms are valuable sources of dietary fiber (Chandravadana, 2010). Fiber when digested in a correct proportion helps to prevent heart disease and can improve digestive health. *Pleurotus ostreatus* is shown to have high protein content 2.17%. This is in agreement with the work done by Khan, (2010). Proteins when consumed generally helps to keep the immune system functioning and helps the body to produce enzymes. It shows that *Pleurotus ostreatus* would also help prevent protein deficiency that might occur among low income families. Proteins are immune boosters and can help in cell division as well as growth (Okeke and Elekwa, 2006). Carbohydrate content was shown as 3.11% indicating that *Pleurotus ostreatus* is a rich source of energy for the body. Carbohydrate provides the body with a source of fuel and energy and aids in proper working of the brain, heart, digestive system and immune system (Ogundana and Fagede, 1982). The fat content and the ash content of *Pleurotus ostreatus* were shown to be 0.26% and 0.45%. Mushrooms are generally cholesterol free and have low fat. They contain unsaturated fatty acids which are less hazardous to health than the saturated fatty acids of animal fats (Yehia, 2012). Fats and oils help to regulate blood pressure and play useful role in the synthesis and repair of vital cell parts (Dutta, 2003).

Dietary ash on the other hand, has proved helpful in establishing and maintaining acid-alkaline balance of the blood system (Barborka, 1970), as well as in controlling hyperglycemic conditions (Gokani, *et al*., 1992).

3.2 Vitamin

The result of 5 vitamins (Vitamin B_1, Vitamin B_2, Vitamin B_3, Vitamin B_5 and Vitamin D) carried out on the *Pleurotus ostreatus* sample are represented in Figure 5. All the results were carried out on a dry weight basis (d.w.b). From the table, *Pleurotus ostreatus* recorded a high value for vitamin B_1, Vitamin B_2, Vitamin B_3 and Vitamin D, while it recorded a low value for Vitamin B_5. Vitamin B_1 (Thiamin) had a value of 4.43 mg/100g. This shows that *Pleurotus ostreatus* is a rich source of thiamin which is water soluble B-vitamin involved with many cellular functions including carbohydrate metabolism, break down of amino acids, production of certain neurotransmitters and multiple enzyme processes. This would also reduce weakness, loss of appetite, nerve degeneration and irritability. *Pleurotus ostreatus* is a

good source of riboflavin as can be seen from Figure 5where vitamin B_2 had a value of 4.31 mg/100g. This shows that. Riboflavin is important in energy metabolism, folate synthesis, conversion of tryptophan to niacin and acts as important coenzyme (FAD/FMN) involved in many reactions. Vitamin B_3 (Niacin) from Figure 5has a value of 6.98 mg/100g and this was the highest vitamin content obtained. This signifies that *Pleurotus ostreatus* is a very rich source of niacin which is important for ATP synthesis (the body is main energy source), synthesis of fatty acids and some hormones and the transport of hydrogen atoms. Vitamin B_5 (Pantothenic acid) had a result value of 0.20 mg/100g from Figure 5. This was the least vitamin content value obtained. It shows that the sample has low Pantothenic acid. Vitamin B_5 plays an important role in cellular metabolism, cognitive health and function, enhancing the immune system and supporting the functions of the nervous system. It also aids in the metabolism of carbohydrates, proteins and fats (for energy). Vitamin D had a value of 3.57 mg/100g. This result may be due to the exposure of the mushroom sample to sunlight during cultivation. Vitamin D is essential for normal growth and development, the formation and maintenance of healthy bones and teeth, and influences the absorption and metabolism of phosphorus and calcium. It is necessary for the proper muscle functioning, bone mineralization and stability. Deficiency of vitamin D in the body results in rickets (poor bone formation), osteoporosis, and pain in the joints. *Pleurotus ostreatus* might help reduce the risk of this deficiency.

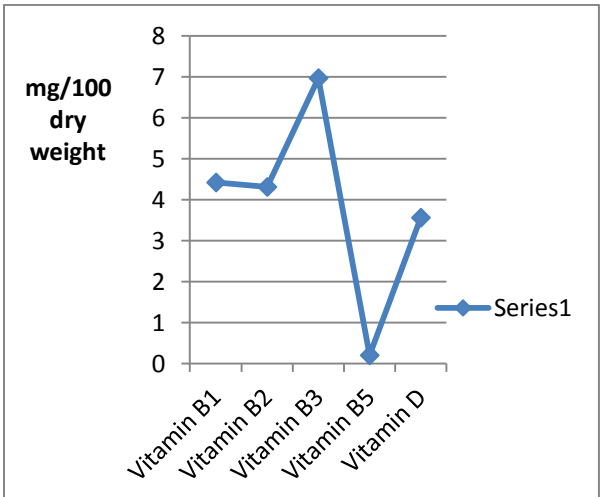

Figure 5: Vitamin Content in *Pleurotus ostreatus*

3.3 Mineral

The tabular representation of the mineral content of *Pleurotus ostreatus* sample is shown in figure. The minerals being determined in the sample include: potassium, calcium, magnesium, zinc and iron. All results were obtained on dry weight basis. From the table, it shows that *Pleurotus ostreatus* contains a high concentration of potassium 62.59 mg/100g. This shows that the sample is rich in potassium which is needed by the body for proper fluid balance, nerve transmission and muscle contraction (Ogundana and Fagede, 1982). The next abundant mineral that was observed was calcium which recorded a value of 19.93 mg/100g as shown in figure 6. Calcium is very important in the body for healthy bones and teeth; helps muscles relax and contract, important in nerve functioning, blood clotting, blood pressure regulation and boosting immune system (Ogundana and Fagede, 1982). From the table, Magnesium content was shown to be 9.98 mg/100g which is reasonably high. Magnesium is essential for making protein, muscle contraction, nerve transmission and boosting immune system.

3.4 Anti-nutrient

The result of the anti-nutrient content of *Pleurotus ostreatus* is shown in figure 7 or table 1. The antinutrients determined in the *Pleurotus ostreatus* sample were oxalates, phytates, tannins and saponins. From the figure, it shows that the oxalate value was 3.20 mg/100g, tannin content was 1.86 mg/100g, Saponins content was 0.30 mg/100g and phytate content was 0.19 mg/100g. The level of oxalates in the *Pleurotus ostreatus* was not high to pose any health risk since it was below the tolerable oxalate limit which is 105 mg/100g (WHO, 2003). Oxalates have been known to form complexes with Calcium, Magnesium and Iron leading to the formation of insoluble oxalate salts resulting in oxalate stone (Chai and Lieman, 2004; Munro and Bassir, 1969), known as "Kidney Stones". Saponins are known to have both beneficial and deleterious effects on human health. The undesirable effect of saponins include increased permeability of small intestinal mucosa cells and the consequent inhibition of nutrient transport, growth depressing action and reduction of protein digestibility probably by the formation of sparingly digestible saponin-protein complex (Jimoh *et al.,* 2011).

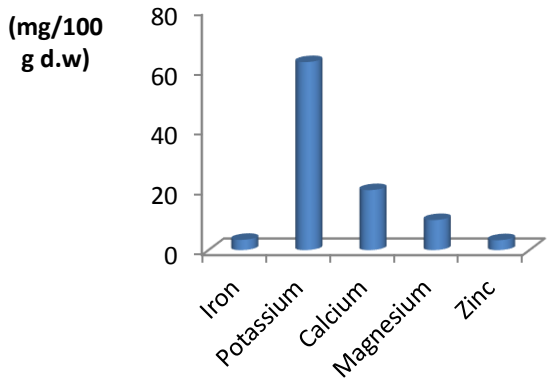

Figure 6: Mineral Content of *Pleurotus ostreatus*

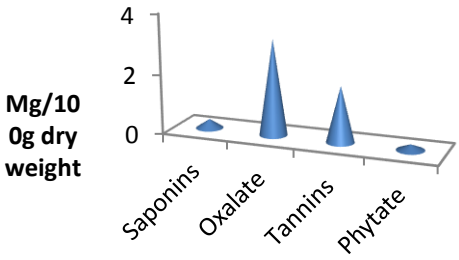

Figure 7: Anti-nutrient compound content in *Pleurotus ostreatus*

Therefore, *Pleurotus ostreatus* is very useful in the body (Ogundana and Fagede, 1982). Zinc and Iron were the minerals showing least concentration present in *Pleurotus ostreatus* as shown from the figure 6. Zinc is needed for making protein and genetic material; has a function in taste perception, wound healing, normal fetal development, production of sperm, normal growth and sexual maturation. Zinc content gotten from the table was 3.28 mg/100g. Iron on the other hand, was shown to be 3.40 mg/100g. Iron is part of a molecule (hemoglobin) found in red blood cells that carries oxygen in the body needed for energy metabolism. This is in agreement with Caglarlmak (2007). This result is in agreement with results of the study of some cultivated mushrooms like *Agaricus bisporus* and *Pleurotus pulmerius* (Edeoga and Gomina, 2000).

Highly toxic under experimental conditions, acute saponin poisoning is rare in both animals and man (Nwinuka *et al.,* 2005). Desirably, saponins have anti-carcinogenic immune modulations and regulation of cell proliferation properties. They form strong insoluble complexes with cholesterol and bile, making them unavailable for absorption (Oakenfull and Sidhu, 1990).

Table 1: Anti-nutrient compound content in *Pleurotus ostreatus*

Nutrient	Content (mg/100g d.w.)
Saponins	0.30 ± 0.01
Oxalate	3.20 ± 0.02
Tannins	1.86 ±0.01
Phytate	0.19 ± 0.01

*This results were carried out in triplicates and expressed in their mean.

Erdman (1999) reported that dietary level of phytate of 1% (1000mg/100g) or more has been reported to interfere with mineral availability. Phytate level of 0.19mg/100g is present in *Pleurotus ostreatus* which is much lower than 1000mg/100g reported by Erdman. This low phytate would not affect mineral availability. Based on this phytate level, *Pleurotus ostreatus* can be consumed without fear of harm to human with respect to phytic acid toxicity.

The level of tannin in *Pleurotus ostreatus* which was 1.86mg/100g was lower than the fatal dose of 30mg/100g (Inuwa *et al.,* 2011) daily intake for humans. Tannins are complex, phenolic polymers which are capable of inhibiting the activities of trypsin, chymotrypsin, amylase and lipase (Inuwa *et al.,* 2011). Tannins can provide astringent reactions in the mouth. It has been reported to have the capability of decreasing the digestibility of proteins when they interact with proteins, and form insoluble complexes. It also interacts with dietary iron by chelating with it and preventing iron absorption.

3.5 Sensory Evaluation of Mushroom Based Food Condiment

The tabular representation of the result of the sensory evaluation of the various mushroom based food condiment samples done by a 15-man panelist is shown in Table 2. The analysis carried out by the panelist scores for taste of the mushroom based food condiment samples showed a significant difference ($p \leq 0.05$). The taste score of the different mushroom based food condiment samples ranged from 8.80 to 5.20 with MW (100% mushroom and 0% spice) having the lowest score of 5.20 and MW8 (60% mushroom and 40% spice) having the highest score of 8.80 indicating that the panelists liked the taste of the product very much. This might be due to high spice content of 40% and low mushroom content of 60% in

MW8. MW having the least score of 5.20 indicates that the panelist liked the score least. This might be attributed to the fact that only coarse ground mushroom was used in the preparation of the mushroom based food condiment. From the table, MW8, MW7 (65% mushroom and 35% spice) and MW6 (70% mushroom and 30%) were not significant different ($p \leq 0.05$), MW2 (90% mushroom and 10% spice) was significantly different ($p > 0.05$) from other samples. The scores for aroma ranged from 8.467 to 4.800. MW had the highest score of 8.467 and it was significantly different ($p > 0.05$) from the rest of the samples. MW7 had the least score of 4.800 and was not significantly different from MW5 (75% mushroom and 25% spice), MW6 and MW8. MW had the highest score for aroma and this is due to the flavor impacted by the mushroom since MW which was the control had 100% mushroom and MW7 and MW8 had the least mushroom composition of 60%. For mouthfeel analysis, MW5 had the highest score of 8.400 while MW had the least score of 5.067. This signifies that MW5 was best accepted by the panelists and MW was least liked among the samples. The low ratings for MW may be due to the coarse ground mushroom sample (larger particle size). MW5, MW6, MW7, MW8 were not significantly different ($p \leq 0.05$) in the scores of the mouth feel. For overall acceptability, MW4 (80% mushroom and 20% spice) was the most preferred among the panelist with a score rating of 8.267, while MW had the least score rating of 5.533 and was the least preferred. All the samples however scored above 5.0 in all parameters assessed except samples MW7 and MW8 that scored 4.800 and 4.867 respectively in aroma. The high scores of the samples showed that all the samples had a good acceptance by the panelist.

Table 3.1: Result on the Sensory Analysis

Samples	Taste	Aroma	Mouthfeel	Overall acceptability
MW	5.200^{f}	8.467^{a}	5.067^{d}	6.200^{de}
MW1	5.733^{f}	6.938^{b}	5.467^{d}	5.533^{e}
MW2	6.667^{e}	6.267^{c}	6.267^{c}	7.133^{b}
MW3	7.267^{d}	5.867^{cd}	7.133^{b}	6.333^{cd}
MW4	7.467^{cd}	5.933^{c}	7.200^{b}	8.267^{a}
MW5	7.867^{bc}	5.267^{de}	8.400^{a}	7.00^{bc}
MW6	8.267^{ab}	5.133^{e}	8.067^{a}	6.267^{cde}
MW7	8.267^{ab}	4.800^{e}	8.200^{a}	7.400^{b}
MW8	8.800^{a}	4.867^{e}	8.000^{a}	7.600^{ab}
LSD	0.588	0.666	0.578	0.757

4.0 Conclusion and Recommendation

From the chemical analyses, it can be deduced that the mushroom specie (*Pleurotus ostreatus*) is rich in nutrients such as vitamins (vitamin B_1, B_2, $B_3$and D); minerals (potassium, calcium, magnesium, iron and zinc); protein, carbohydrates and dietary fiber. The anti-nutrients levels in *Pleurotus ostreatus* were very low and found not to be toxic to human health. From the sensory evaluation carried out on the mushroom based food condiment samples, it can be concluded that the different mushroom samples were generally accepted among the panelists. I recommend that more research work be carried out on the nutritional, medicinal and anti-nutritional properties of not just *Pleurotus ostreatus* but on other mushroom species. People should also be more enlightened on the numerous nutritional benefits as well as the medicinal properties of *Pleurotus ostreatus* as well as other mushroom species. This would help low income families which could make use of the mushroom as meat substitutes. Also, proper packaging and storage conditions should be developed so as to prevent the rapid deterioration of *Pleurotus ostreatus* due to its high moisture content.

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