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Nutritional and Sensory Properties of Spreads from Two Mushroom Varieties

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ABSTRACT

The chemical, functional and sensory properties of mushroom flour and spread from two varieties were investigated. Flour was produced from untreated and treated (sodium metabisulphite) Pleurotus mushrooms (P. pulmonarius and P. cintrinopileatus) and analyzed for proximate and functional properties. Spread was prepared from the mushroom flour using different quantities of gum arabic (0.1, 0.3 and 0.5%) and compared with spread from corn flour as control. Spreads were evaluated for physicochemical and sensory properties. Proximate composition of the mushroom flour showed that treatment with sodium metabisulphite reduced moisture and ash content while protein, fat, fibre and carbohydrate increased. Functional properties showed that treatment had a significant difference ($p<0.05$) in the bulk density and oil absorption capacity of the mushroom flours, while physicochemical properties of the spread showed that melting point value ranged between (22-29oC), Iodine value (30.41-33.70gI2) and pH (5.75-6.35). Sensory analysis results showed that the spreads from P. cintrinopileatus were acceptable to the panelist at all levels of gum arabic inclusion while spread from P. pulmonarius were acceptable at high concentrations of gum arabic (0.3 and 0.5%). In view of the outstanding health problems of animal/fatty spread consumption, mushroom can be used in the production of acceptable spread with high nutrient content and lower fat levels.

INTRODUCTION

Mushroom is the fleshy, spore bearing fruiting body of a fungus, typically produced above ground on soil or on its food source (Moore, 2003). It is cultivated in many parts of the world presently. A number of different species of mushrooms are grown including *Pleurotus ostreatus, Pleurotus sajor-caju, Pleurotus cytidus*, *Pleurotus citrinopileatus* and *Pleurotus flabellatus* (Alam *et al*., 2008). They have been used as food and food flavoring materials in soups for centuries, due to their unique and subtle flavor. They are highly appreciated for their rich aroma. Edible mushroom in fresh, cooked or processed forms are nutritionally sound, tasteful food source for most people and can be a significant dietary component for vegetarians (Breene, 1990).

Nutritionally fruiting bodies of the mushrooms contain about 39.9 % carbohydrate, 17.5 % protein, 2.9% fats, the rest being fiber and minerals on dry weight basis (Demirbaş, 2001). The rotein content of mushrooms has been reported to be twice that of vegetables and four times that of orange and significantly higher than that of wheat (Okwulehie and Odunze, 2004). Scientific research indicates that the major actions of medicinal mushrooms are stimulating the immune system and protecting against cardiovascular diseases, free radicals, mutagens, and toxins (Moore, 2003).

A spread is a food that is literally smeared onto bread, crackers and other pastry products (Amevor *et al.*, 2018). Spreads can be made from nuts, milk, edible vegetable oil, animal fat or a combination of both such as margarine with cheese and butter as well as those obtained from fruits and vegetables such as jams, preserves and marmalades while cheese spread is mainly made from curd produced from the coagulation of souring milk by the action of an enzyme renin (Man, 2002).

The health consciousness of today's consumers about fat spreads is on the increase due to their high content of saturated fatty acids and cholesterol. Hayakawa *et al.*, (2000) have indicated a strong link between earlier death and consumption of high amounts of trans-fats which had been common in many spread formulations not quite too long ago. There is also a growing trend in the development of other spreads from plant origin such as peanut butter. Jams, jellies and marmalades are also gaining popularity as spreads but these products lacks adequate nutrition as they contain mainly carbohydrate and fruit pulp with deficiencies in protein, fat and minerals (Verma and Gary, 2002). Therefore, there is increasing consumer demand for table spread that is nutritionally balanced, organoleptically acceptable and affordable.

Though, spread is a popular item of the diet of average income earners, several reports have implicated fat-based spreads from hydrogenated and saturated sources as having health implication that needs to be handled through the use of plant materials. Mensink *et al*. (2003) concluded that the saturated fatty acids in triglycerides contribute to elevated blood cholesterol levels and cardiovascular diseases.

Mushrooms are valuable sources of high quality cheap nutrient, which have received little or no attention, especially in Nigeria and hence not often a part of the diet. The nutritional attributes of mushrooms as well as the physical and sensory qualities are such that mushrooms could be utilized to produce a novel nutritious and acceptable spread that would reduce the incidences of fat spread related health challenges. The objective of the study is to produce and evaluate the chemical, functional and sensory properties of mushroom flour and in spread production.

Materials and Methods

Materials

Fresh edible mushrooms (*Pleurotus cintrinopileatus* and *Pleurotus pulmonarius* varieties) were collected from Dilomat farms, Rivers State University, Port Harcourt, Nigeria. Vinegar, corn flour, fresh rosemary, salt, onions, black pepper, vegetable oil and parsley were purchased from Port Harcourt shopping Mall, Rivers State, Nigeria.

Chemicals

All chemicals used for this work were obtained from the department of Food Science and Technology Laboratory, Rivers State University, Port Harcourt and were of analytical grade.

Methods

Preparation of Mushroom Flour

The method of Genenu *et al*. (2017) was used for the preparation of mushroom flour. Three (3kg) kilogram fresh mushroom were soaked in water (4L) containing 10g of sodium metabisulphite for 4 min. Thereafter the excess water was drained using a muslin cloth and spread in trays and oven dried at 60±2°C for 24 h. The oven dried mushrooms were cooled at 37°C, and then ground into powder using a grinder (Philips, HR2021173/AC 220_240V_50/60Hz). The mushroom flour was sieved (0.5mm sieve size), packaged in polythene bags and stored at room temperature for further use.

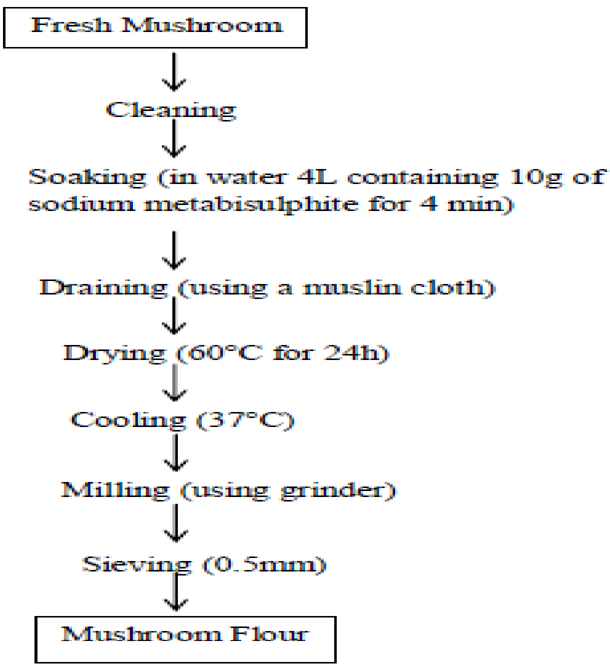

Figure1. *Production of Mushroom flour*

Source: *Genenu et al. (2017).*

Preparation of Mushroom Spread

The mushroom spread was prepared according to the method described by www.allrecipes.com but with slight modifications. Fifty milliliters (50ml) of vegetable oil was poured into a cleaned and dried pan. Three (3.0tsp) teaspoonful of honey and one (1.0) teaspoonful of vinegar were added. This mixture was stirred continuously for 5mins and 20g of mushroom flour added and stirred until a paste was formed. The mixture was heated at low heat for about 2mins then salt added. This was further mixed and different quantities (0.1, 0.3 and 0.5%) of Arabic gum dissolved in 40mls of water each were added to the blend while corn flour was used in the preparation of control. The mixture was further heated for 5mins over low heat and thereafter allowed to cool

Table1. *Recipe for the preparation of mushroom spread*

Ingredients	Amount
Vegetable oil	50ml
Ground onions (dried)	1.0g
Mushroom flour	20.0g
Parsley	1.0g
Salt	1.0g
Gum Arabic	0.3g
Water	0.3ml
Honey	18ml (3teaspoon)
Ground black pepper	1.0g
Rosemary	1.0g
Vinegar	4ml (1 teaspoon)

Source: *www.allrecipes.com*

Sensory Analysis

A twenty-member semi-trained panel consisting of staff and students of the Rivers State University, Port Harcourt, Nigeria was used for sensory evaluation. The sensory attributes of the mushroom spread was evaluated by the panelists who were familiar with spread and were neither sick nor allergic to any of the raw material used for spread production. The mushroom spread prepared using gum was compared with mushroom spread using corn flour as binder and were evaluated for appearance, mouth feel, spread ability, taste, flavor, aroma and overall acceptability. Each attribute was rated on a 9-point hedonic scale as described by Ngoddy *et al*. (1986). Water was provided for panelists to rinse their mouth with between tasting of samples.

Physicochemical Analysis

The physicochemical compositions of the flour and spread samples which include moisture, ash, fat, crude fiber, crude protein, free fatty acid (FFA), peroxide value (PV), iodine value (IV) and carbohydrate calculated by difference) were determined using the (AOAC, 2012). The pH of the mushroom flour and spreads was determined using a pH meter (TS 625, USA), while melting point was determined using A.O.C.S.C (1989).

Functional Properties

Bulk density was by the method described by Narayana and Rao (1984), Solubility and swelling power was determined according to the method described by Takashi and Sieb (1988), while the method of Sosulski et al. (1976) was adopted for determination of water absorption capacity. Oil absorption capacity was determined by the method of Elkhalifa et al. (2005),

Statistical Analysis

The method of Wahua (1999) was used to analysis the data using analysis of variance (ANOVA). The data was subjected to one-way analysis of variances, all means were separated using Duncan's Multiple Range Test (DMRT) at 5% probability level (p>0.05) using SPSS version 20.0 software 2011.

Results

Proximate (%) Composition of Mushroom Flour

Table 2 shows the proximate composition of the mushroom flour produced from *Pleurotus cintrinopileatus* and *Pleurotus pulmonarius* species. Moisture content of the flours ranged from 5.76-12.00% with the untreated mush room varieties recording the highest and the treated mushroom varieties the lowest. Moisture content of *Pleurotus cintrinopileatus* (12.00%)

specie was higher than *Pleurotus pulmonarius* (10.20%), this may be as a result of varietal differences. There was a significant ($p<0.05$) difference in the moisture contents of the mushroom varieties, with sodium metabisulphite treatment significantly decreasing ($p<0.05$) the moisture content of the mushroom flour. The moisture result of the untreated *Pleurotus* varieties were close to the findings of Ibrahim *et al*. (2017) who reported moisture content in the range of 8.4-9.8% for treated and untreated oyster. The low moisture content of the mushroom flour is desirable and indicates better shelf life and durability, as moisture content of the flour higher than 14%, would encourage mould growth and bacterial action (Moses *et al*., 2012).Crude protein content of the mushroom flour samples ranged from 25.69-36.40% with the treated *Pleurotus pulmonarius* recording highest and treated *Pleurotus cintrinopileatus* lowest.

Protein content in treated *P pulmonarius* variety (36.40%) was found to be significantly ($p<0.05$) higher than the untreated form as well as the treated *P cintrinopileatus* (25.69%), this showed that treatment and variety had effect on protein content. The findings of this study compares well with the report of Ibrahim *et al*. (2017) who stated that crude protein content of *Pleurotus osteatus* treated with sodium metabisulphite (28.60%) was highest than the untreated mushroom sample. Treatment with sodium metabisulphite significantly decreased ($p<0.05$) the protein content of *P. cintrinopileatus* flour while that of *P. pulmonarius* increased.

Fat content of the mushroom samples ranged from 2.48-3.95% with treated samples *Pleurotus cintrinopileatus* specie recording the highest than the untreated mushroom sample *Pleurotus pulmonarius* as the lowest. There was no significant ($p>0.05$) difference in the fat content of the two mushroom varieties, however a significant ($p<0.05$) difference was observed as a result of treated with sodium metabisulphite which was observed to increase the fat content of the mushroom flours. Fresh mushrooms usually contain less fat, the amount being 1-8% of dry weight (Breene, 1990). The findings of this work was supported by the study of Debu *et al*. (2015) who analyzed the lipid content of *Pleurotus ostreatus* in the range of 3.39-4.46%. The fat content of the mushrooms in the present study are also higher than that (1.28-1.42%) reported by Ibrahim *et al*. (2017) for treated and untreated oyster mushroom.

Ash content of the mushroom flour ranged from 6.32-7.89% with untreated *Pleurotus pulmonarius* recording the highest and treated *Pleurotus cintrinopileatus* the lowest. The ash content of the untreated *Pleurotus pulmonarius* was higher than the untreated *Pleurotus cintrinopileatus* (6.78%) which indicates varietal differences, while ash content of untreated samples showed higher value meaning the treatment with sodium metabisulphite reduced ash.

Ash content is an indication of minerals which implies that the *P pulmonarius* specie contain more minerals than *P cintrinopileatus*. The ash content obtained from this study for *P pulmonarius* are in agreement with that of oyster mushroom (7.8-8.50%) as reported by Ibrahim *et al*., (2017).

Crude fibre content ranged from 4.55-6.67% with the treated mushroom varieties 4.94 and 6.67% for *P cintrinopileatus* and *P pulmonarius* respectively recording higher values than the untreated mushroom varieties (4.55 and 6.52% for *P cintrinopileatus* and *P pulmonarius*. There was no significant ($p>0.05$) difference in the crude fibre content of the treated and untreated mushroom samples, however a significant ($p<0.05$) difference was observed in the crude fibre contents of the mushroom varieties. There was an increase in the crude fibre content of mushroom flours after treatment with sodium metabisulphite; The crude fibre content of the mushrooms in the present study were higher than that (3.2-4.8%) reported by Ibrahim *et al*. (2017) for treated and untreated oyster mushroom.

Carbohydrate content ranged from 39.99-51.33% with the treated *P cintrinopileatus* recording the highest and treated *P pulmonarius* the lowest. The carbohydrate content of the untreated *Pleurotus cintrinopileatus*(47.00%) was higher than that for untreated *Pleurotus pulmonarius* (46.66%).

Carbohydrate content of the mushrooms was found to be higher (51.33%) in the treated *P cintrinopileatus* specie than the treated *P pulmonarius* (39.99%). There was no significant difference ($p>0.05$) in the carbohydrate content of the mushroom varieties however, a significant ($p<0.05$) difference was observed with respect to the treated of mushrooms. The carbohydrate values obtained from this study are slightly above the values of 48.85-51.72% obtained by Ibrahim *et al*. (2017) for oyster mushroom.

Table2. *Proximate (%) Composition of Mushroom Flours*

Parameters (%)	Moisture (%)	Crude protein (%)	Fat (%)	Ash (%)	Crude fibre (%)	CHO (%)
PCU	12.00±0.71[a]	27.11±0.00[b]	2.56±0.04[b]	6.78±1.77[ab]	4.55±0.76[b]	47.00±1.24[b]
PCT	7.77±0.00[c]	25.69±0.00[d]	3.95±0.00a	6.32±0.95[b]	4.94±0.34[b]	51.33±0.61[a]
PPU	10.20±0.71[b]	26.25±0.00[c]	2.48±1.27[b]	7.89±0.00[a]	6.52±0.43[a]	46.66±0.40[b]
PPT	5.76±0.01[d]	36.40±0.00[a]	3.93±0.00[a]	7.25±0.21[ab]	6.67±0.04[a]	39.99±0.24[c]

Values are expressed as mean ± standard deviation of duplicate determination. Means with the same letters along the same row are not significantly different (p>0.05).

Keys: *PCU=Untreated Pleurotus cintrinopileatus, PPU= Untreated Pleurotus pulmonarius*

PCT= Treated Pleurotus cintrinopileatus, PPT= Treated Pleurotus pulmonarius

Functional Properties of Mushroom Flour

Table 3 shows the functional properties of mushroom flour produced from *Pleurotus cintrinopileatus* and *Pleurotus pulmonarius* species. Bulk density of the mushroom flour ranged from 0.21-0.46g/ml with treated *Pleurotus pulmonarius* recording the highest and treated *Pleurotus cintrinopileatus* the lowest. The bulk density of untreated P.cintrinopiletus flour (0.39g/ml) was higher than the treated flour (0.21g/ml) while that of the treated P.pulmonarius (0.46g/ml) was higher than untreated sample (0.43g/ml). However no significant difference (p>0.05) existed as a result of treatment. The result from this study suggests that treatment with sodium metabisulphite caused displacement of the internal air space within the material which resulted in the reduction of dried mushroom pieces into finer particle during milling when compared with untreated sample. Bulk density has implication in the packaging and transportation of food materials; high bulk density products are known to exhibit better packaging properties than those with low bulk density. High bulk density is desirable in that it offers greater packaging advantage as greater quantity may be packaged within a constant volume (Fagbemi, 1999).The bulk density of the mushrooms studied is lower than the findings of Ayo *et al*. (2018) who reported 0.75g/ml for Pleurotus ostreatus. The low bulk density of these flours could be an advantage in the formulation of baby foods where high nutrients density to low bulk is desired (Ayo *et al.* 2018).

Oil absorption capacity ranged from 1.83-5.80ml/g with treated *Pleurotus pulmonarius* as lowest and untreated *Pleurotus cintrinopileatus* as highest. The oil absorption capacity of treated and untreated P. cintrinopileatus (5.80 and 5.29ml/g) were significantly higher (p<0.05) than that of P. pulmonarius (2.10 and 1.83ml/g) respectively. This is as a result of varietal differences, however treatment with sodium metabisulphite also reduced the oil absorption capacity of the mushroom flour result showing no significant differences (p>0.05). Oil absorption capacity of *Pleurotus pulmonarius* (5.80g/ml) was higher when compared with 4.50g/ml for Pleurotussajor-caju mushroom reported by Prodhan *et al*.(2015). Oil absorption capacity of food materials is important because oil (fat) helps to retain flavor, improve mouth feel and provide feeling of satiety (Arinola and Akingbala, 2018). Pleurotus cintrinopileatus would therefore be useful as a flavor retainer in certain food products and in food preparations that involve mixing like bakery products where oil is an important ingredient (Banigo and Mepba, 2005). The high oil and water absorption capacity of the P pulmonarius is synonymous with the high protein content since protein in foods influences fat and water absorption (Ajani *et al.* 2016).

Water absorption capacity ranged from 2.64-4.40ml/g with treated *Pleurotus pulmonarius* as lowest and untreated *Pleurotus cintrinopileatus* as highest. Water absorption capacity is a very important functional property of flour samples in food preparation. The water absorption capacity of the treated mushroom flour (3.30 ml/g and 4.40 ml/g for P. cintrinoplieatus and P. pulmonarius flour were higher than that of the untreated flours 3.18 and 2.64ml/g for P. cintrinoplieatus and P. pulmonarius flours, respectively. There was no significant difference (p>0.05) in the water absorption capacity of the mushroom flour varieties. The high water absorption capacity of untreated mushroom flours suggests that it will contribute positively to yield and consistency during food preparation (Osundahunsi *et al*. 2003).

The values in the study are higher than the water absorption capacity of Pleurotussajor-caju mushroom (2.40g/ml) reported by Prodhan *et al.* (2015). Water absorption capacity characteristics represent the ability of a product to associate with water under conditions where water is limiting such as dough and paste (Nwoji, 2004). Low water absorption capacity of flour has been attributed to starch damage (Mayaki *et al*. 2003). This pattern of result correlates with the study of Arinola an Akingbala (2013) who reported a decrease in water absorption capacity of bread fruit flour (4.60-4.20ml/g) after treatment with buffer pH 3.

Solubility values of mushroom flour ranged from 22.15-31.10% with treated *Pleurotus pulmonarius* and untreated *Pleurotus cintrinopileatus* flours as highest and treated *Pleurotus cintrinopileatus* was lowest. Solubility of Pleurotus cintrinopileatus decreased after treatment with metabisulphite but increased for P. pulmonarius flour. This difference may be due to differences in chemical composition. Arisa *et al.* (2013) also reported a decrease in the solubility of plantain flour (6.80-5.57%) after treatment with sodium metabisulphite. Solubility is an indicator of the degree of dispersion of granules after cooking (Bhupender *et al*. 2013). The low solubility of treated P.cintrinopileatus could be as a result of low content of amylose. Srichuwong *et al*. (2005) stated that solubility could imply the amount of amylose leaching out when swelling, thus the higher the solubility the higher the amount of amylose leaching.

Swelling power of the mushroom flours ranged from 5.62-10.82g/g with untreated *Pleurotus cintrinopileatus* recording highest while treated *Pleurotus cintrinopileatus* was lowest. Results showed that swelling power of the untreated mushroom flours (10.82 and 10.07g/g for P. cintrinopileatus and P. pulmonarius) were significantly higher ($p<0.05$) than the treated samples (5.62 and 7.40g/g). Swelling power indicate the degree of exposure of the internal structure of starch granules to action of water and a measure of hydration capacity (Raules *et al*.1993). This reduction of swelling power on treatment with sodium metabisulphite may be due to the reinforcement of the crystalline nature of starch granules present in the sample and the associative binding forces within the starch granules by the low pH treatment (Khan *et al*., 2014).

Moisture content of the fresh mushrooms was 90.74% and 90.20% for *Pleurotus cintrinopileatus* and *Pleurotus pulmonarius* respectively. Percentage moisture loss of the mushroom flours after drying 3kg weight mushrooms were 76.18% and 67.08% for *Pleurotus cintrinopileatus* and *Pleurotus pulmonarius* respectively. These values were slightly higher than the findings of Kumela and Solomon (2017) for moisture content of fresh mushrooms (88.75%). Results revealed that moisture loss of P. cintrinopileatus mushroom (76.18%) was higher than for P. pulmonarius (67.08%). Mushroom moisture loss can have adverse effect on the valuable composition due to leakage of some valuable biologically active components such as minerals and soluble proteins (Galoburda *et al*. (2015).

Table3. *Functional Properties of Mushroom Flours*

Samples	Bulk density (g/ml)	Oil Absorption (ml/g)	Water Absorption (ml/g)	Solubility (%)	Swelling power (g/g)	Moisture (%) Fresh weight	Moisture loss (%)
PCU	0.39±0.00[c]	5.80±0.28[a]	3.30±0.14[a]	31.00±1.40[a]	10.82±0.74[a]	90.74±1.07[a]	76.18
PCT	0.21±0.00[d]	5.29±0.28[a]	3.18±0.03[ab]	22.15±1.20[b]	5.62±0.14[c]	90.74±1.07[a]	76.18
PPU	0.43±0.02[a]	2.10±0.14[b]	4.40±0.28[a]	29.00±1.411[a]	10.07±0.01[a]	90.20±0.14[a]	67.08
PPT	0.46±0.00[a]	1.83±0.04[b]	2.64±0.90[b]	31.00±0.00[a]	7.40±0.85[b]	90.20±0.14[a]	67.08

Values are expressed as mean ± standard deviation of duplicate determination. Means with the same letters along the same row are not significantly different (p>0.05).

Keys: *PCU=Untreated Pleurotus cintrinopileatus, PPU= Untreated Pleurotus pulmonarius*

PCT= Treated Pleurotus cintrinopileatus, PPT= Treated Pleurotus pulmonarius

Physicochemical Properties of Mushroom Spreads

Table 4: presents the physicochemical properties of the mushroom spreads produced from *Pleurotus cintrinopileatus* and *Pleurotus pulmonarius* species.

Protein content of spreads ranged from 2.88-5.38% with *Pleurotus pulmonarius* spread containing 0.3% gum arabic recording the highest with a mean value of 5.38%, while *Pleurotus cintrinopileatus* spread with 0.3 and 0.5% gum arabic addition was the lowest. This value was significantly ($p<0.05$) different from all other samples whereas *P cintrinopileatus* spread at all levels of gum arabic inclusion were significantly ($p<0.05$) lower. It could therefore be deduced that spreads from *P pulmonarius* had relatively higher protein content. Protein is an essential component of human diet needed for the replacement of tissue and for the supply of energy and adequate amount of required amino acid. Protein deficiency cause growth retardation, muscle wasting, oedema, abnormal swelling of the body and collection of fluid in the body of children (Mounts, 2000). Protein content of the mushroom spreads were lower when compared to protein content of cashew nut- chocolate spread (10.13-12.47%) as reported by Amevor *et al*. (2018).

Fat content of the spread ranged from 2.40-3.10% with PC 0.1 (Spread produced from *Pleurotus cintrinopileatus* and 0.1% gum arabic) recording the highest and PP 0.3 (Spread produced from *Pleurotus pulmonarius* with 0.3% gum Arabic) as lowest. However, these values were not significantly ($p>0.05$) different from spreads prepared with corn flour. The fat content of the mushroom spreads were much lower when compared to the fat content of cashewnut-chocolate spread (41.25-51.25%) as reported by Amevor *et al*. (2018). This could also be as a result of low fat content of mushroom flour consisting mostly of unsaturated fatty acids, which are less hazardous to the health than the saturated fatty acids of animal fats (Breene, 1990). This is a healthy development in the spread world as fat-based spreads from hydrogenated and saturated sources have health implications such as elevated blood cholesterol levels and cardiovascular diseases (Mensink *et al*., 2003). This means that the mushroom spread produced would reduce the incidences of fat spread related health challenges.

The ash content of the spreads ranged from 33.68-35.76% with the spread produced from *P. pulmonarius* variety (34.50-35.76%) higher than in the *P. cintrinopileatus* variety (33.55-34.80%). However, there was no significant ($p>0.05$) difference in the ash content of the spreads. Ash content of the spreads were much higher when compared to the ash content of cashew nut-chocolate spread (1.31-1.69%) as reported by Amevor *et al*. (2018). This difference is due to the ingredients used in the preparation of mushroom spread such as honey and vinegar. The high ash content of the spreads indicates that the products will be a good source of minerals. Ash is a non-organic compound containing mineral content of food and nutritionally it aids in the metabolism of other organic compounds such as fat and carbohydrate (Mcwilliam, 1978).

Crude fibre content of the spreads ranged from 3.90-8.80% as control spread recorded highest while spreads from *Pleurotus cintrinopileatus* at 0.1% gum arabic and *Pleurotus pulmonarius* at all concentrations of gum arabic were low. Crude fibre of spread from *P cintrinopileatus* with corn flour (8.80%) was significantly ($p<0.05$) high when compared with those with gum arabic (3.90-4.95%). Spreads from *Pleurotus cintrinopileatus* and *Pleurotus pulmonarius* with gum arabic showed no significant ($p>0.05$) difference in crude fibre content. Crude fibre found in this study was high when compared to that of cashew nut-chocolate spread (0.10-0.15%) as reported by Amevor *et al*. (2018). Fiber aids and speeds up the excretion of waste and toxins from the body preventing them from sitting in the intestine or bowel for too long, which could cause a buildup and lead to several diseases (Hunt *et al*., 1980). Higher fibre content may affect the functionality, which is the spreadability of the spread

Carbohydrate content of spreads ranged from 25.01-31.32% with *P cintrinopileatus* spread containing 0.1% gum arabic (31.32%) as highest whereas *P cintrinopileatus* spread with 0.5% gum arabic recorded lowest. Carbohydrate content found in this study was similar to that of cashew nut-chocolate spread (33.42%) as reported by Amevor *et al*. (2018) indicating that spreads are good sources of energy.

Iodine values of the spreads ranged from 30.41-33.70gI_2 with spreads from *Pleurotus pulmonarius*at 0.1 and 0.3% gum Arabic recording lowest while *Pleurtus pulmonarius*at 0.5% having highest value. Iodine value is an indicator of double bindings in the molecular structure which influences the long term stability properties of oil for storage. The higher the iodine value, the more the unsaturation and the higher the susceptibility to oxidation (Anyasor *et al*., 2009). The iodine values obtained in this study are in the range of 30.41-33.70gI_2. According to Erickson (1990), quality fats and margarine should have iodine value of 45-70gI_2 of which the spreads from this study were below the range. This indicates that the spread will undergo faster oxidation, hence the need for improvement on the storage stability. This could be due to the source of raw material (mushroom) used which is a non oil based plant. There was no significant ($p<0.05$) difference in the iodine value of mushroom spreads produced. The iodine values were lower than that of table margarine (66.50gI_2).

pH values of mushroom spreads ranged from 5.75-6.40 with control spread produced from *P pulmonarius* (0.1% gum arabic) recording the highest while spread from *P cintrinopileatus* flour with 0.3% gum arabic addition as lowest. The pH of mushroom spreads produced from *P pulmonarius* (except for spread with 0.3% gum arabic) (6.25-6.35) were significantly ($p<0.05$) higher than the spreads produced from *P cintrinopileatus* (5.80-5.90) but not from the spread with added corn flour (6.40). These range of pH showed that mushroom spread is slightly acidic which will enhance its preservation and storability. These values are higher when compared to the pH of African pear spread as reported by Akusu *et al*. (2018).

The melting point of the spreads ranged from 19-29°C with spread produced from *P cintrinopileatus* flour at 0.5% and 0.3% inclusion of gum arabic as the lowest and highest melting point values respectively. Melting point is an important parameter during the development of table spreads as it helps to determine the spreadability of the product. It also provides a temperature indication at which spreads and margarines ought to be smooth in the palette (Nadeem *et al*., 2017). International standard range for melting point for margarine and butter is 28-34°C which suggests that they should quickly melt in the mouth and be firm enough to tolerate the mechanical work during spread ability (Nadeem *et al*., 2017). The melting point of spread produced from *P cintrinopileatus* with 0.3% gum arabic had melting point of 29°C while others (19-27°C) were below the range.

This is expected due to the origin of the base raw material. Low melting point margarines and spreads are suitable for blending in dough and general baking. Fats with a melting between 40°C and 44°C are considered to be good compromise between convenience in handling and palatability (Nadeem *et al*., 2017). The melting of the mushroom spreads from this study was lower than the melting point of table margarine (35.5°C) as reported by Mahboubeh *et al*. (2014).

Table4. *Physicochemical properties of mushroom spreads*

Samples	Protein (%)	Fat (%)	Ash (%)	Crude fibre (%)	CHO (%)	Iodine value (gI_2)	pH	Melting Point (°C)
PC 2.5	4.13±0.00[b]	3.00±0.14[a]	35.51±0.40[ab]	8.80±1.41[a]	28.64±0.57[abc]	32.18±1.08[ab]	6.40±1.41[a]	24.00
PC 0.1	3.19±0.44[cd]	3.10±0.14[a]	34.80±0.27[ab]	3.90±0.00[b]	31.32±0.16[a]	30.66±1.08[b]	5.90±0.00[bc]	22.00
PC 0.3	2.88±0.00[d]	3.00±0.00[a]	33.68±0.09[b]	4.45±0.00[b]	28.80±4.10[abc]	33.45±0.72[a]	5.75±0.21[c]	29.00
PC 0.5	2.88±0.00[d]	2.90±0.14[a]	33.55±1.11[b]	4.95±0.00[b]	25.13±0.16[c]	33.45±0.72[a]	5.85±0.07[bc]	19.00
PP 0.1	4.13±0.00[b]	2.55±0.14[b]	35.76±0.35[a]	3.90±0.00[b]	26.13±0.13[bc]	31.41±0.07[ab]	6.25±0.07[ab]	24.00
PP 0.3	5.38±0.00[a]	2.40±0.07[b]	35.27±0.34[a]	3.90±0.00[b]	30.51±2.04[ab]	30.41±1.44[b]	6.35±0.21[a]	27.00
PP 0.5	3.50±0.00[c]	2.43±0.04[b]	34.50±0.70[ab]	3.90±0.00[b]	25.01±1.72[c]	33.70±1.08[a]	6.20±0.28[ab]	24.00

Values are expressed as mean ± standard deviation of duplicate determination. Means with the same letters along the same row are not significantly different (p>0.05).

Keys: *PCF 2.5= Spread produced from Pleurotus cintrinopileatus with 2.5% Corn flour*

PC 0.1=Spread produced from Pleurotus cintrinopileatus with 0.1% gum arabic

PC 0.3=Spread produced from Pleurotus cintrinopileatus with 0.3% gum arabic

PC 0.5=Spread produced from Pleurotus cintrinopileatus with 0.5% gum arabic

PP 0.1=Spread produced from Pleurotus pulmonarius with 0.1% gum arabic

PP 0.3=Spread produced from Pleurotus pulmonarius with 0.3% gum arabic

PP 0.5=Spread produced from Pleurotus pulmonarius with 0.5% gum arabic

Changes in the Free Fatty Acid Content of Mushroom Spread During Storage (4 Weeks)

Figure 2 shows the free fatty acid (FFA) content of mushroom spreads stored for a period of four (4) weeks. Initial FFA content of the mushroom spreads ranged from 0.24-0.39% with *Pleurotus cintrinopileatus* spread (containing 0.3 and 0.5% gum arabic) as lowest while *Pleurotus cintrinopileatus* spread containing corn flour (control) was highest. At weeks 1, 2 and 3, FFA of the spreads were found to range between 0.16-0.25%, 0.35-0.76% and 0.42-1.01%, respectively showing an increase. At week4, FFA values ranged between 0.61-1.15% with *Pleurotus pulmonarius* spread containing 0.5% gum arabic as highest. There was a significant ($p<0.05$) difference in the FFA of the spreads on storage. These values were observed to decrease between week zero and one and increased from week one to the end of the storage periods of four weeks. The increase in FFA of the spreads could be due to the added gum as well as the effect of vinegar used during the preparation of the spreads, which could account for the reason why FFA of the spreads increased after the first week of storage. The FFA is the primary quality attribute for edible grade oil/fat (Akusu *et al*., 2018). The FFA of the spreads after 2-4 weeks of storage was above 0.20% which is the allowable limit for free fatty acids (Nadeem *et al*., 2017).

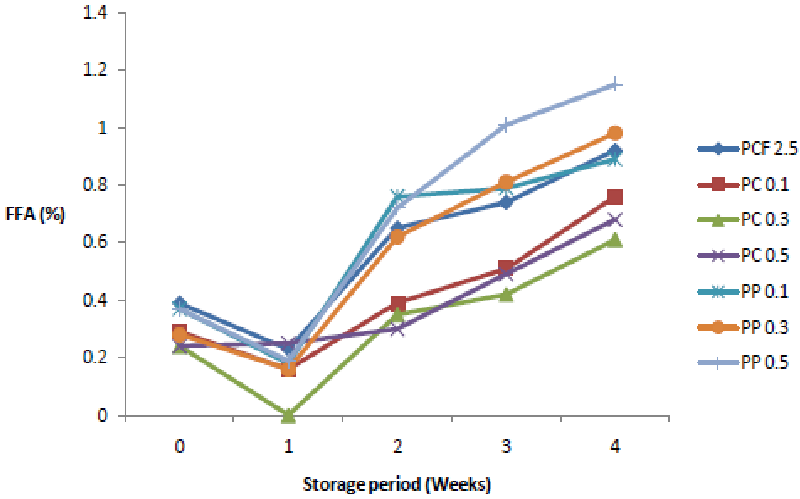

Figure2. *Changes in free fatty acid content of mushroom spreads during storage (weeks)*

Keys: *PCF 2.5= Spread produced from Pleurotus cintrinopileatus with 2.5% Corn flour*

PC 0.1=Spread produced from Pleurotus cintrinopileatus with 0.1% gum arabic

PC 0.3=Spread produced from Pleurotus cintrinopileatus with 0.3% gum arabic

PC 0.5=Spread produced from Pleurotus cintrinopileatus with 0.5% gum arabic

PP 0.1=Spread produced from Pleurotus pulmonarius with 0.1% gum arabic

PP 0.3=Spread produced from Pleurotus pulmonarius with 0.3% gum arabic

PP 0.5=Spread produced from Pleurotus pulmonarius with 0.5% gum arabic

Changes in the Peroxide Value of Mushroom Spreads During Storage (4 Weeks)

Figure 3 shows the peroxide value (PV) of mushroom spreads stored for a period of four (4) weeks. Initial PV of the mushroom spreads ranged from 1.54-1.98% with *P cintrinopileatus* spread containing 2.5% corn flour (control) recording the lowest while *P pulmonarius* and *P cintrinopileatus* spreads with 0.5% gum arabic as highest. At week 1, 2 and 3, PV of the spreads were found to range between 1.05-1.68meq0_2/kg, 0.34-1.22meq0_2/kg and 0.34-0.90meq0_2/kg, respectively, while at week 4, the PV of the spreads ranged between 0.35-0.94meq0_2/kg with *Pleurotus cintrinopileatus* containing 0.5% and 1.0% recording lowest and highest respectively.

There was a significant ($p<0.05$) difference in the initial PV of the spreads produced from *P. cintrinopileatus* while spreads from *P. pulmonarius* showed no significant ($p>0.05$) difference except for the one with 0.5% gum arabic concentration. The peroxide values were observed to decrease in storage for 4 weeks, however, at the fourth week of storage, a slight increase in PV of the spreads was observed. At the end of the storage period, *Pleurotus pulmonarius* spread (0.3% gum Arabic) and *P. cintrinopileatus* (0.5% gum Arabic) had the lowest PV while the *P. cintrinopileatus* spread with 0.1% gum Arabic was highest in PV. Peroxide value is a useful biomarker of the preliminary stages of rancidity, thus the greater the PV, the faster the oxidation of the fat occurring (Sulthana and Sen, 1979).

The decrease in the PV of the spreads is as a result of the vinegar used during preparation of the spreads. The antioxidant activities of polyphenols in vinegar include the abilities to scavenge free radicals, chelate transition metal ions, and reduce oxidants (Sang *et al*., 2007; Perron and Brumaghim, 2009). Peroxide value for all the samples during storage was less than 10meq/kg, indicating that the mushroom spread samples were safe and not prone to oxidative rancidity. Pearson (1990) stated that a rancid taste begins to be noticeable when oil has PV of 10-20 meq/kg.

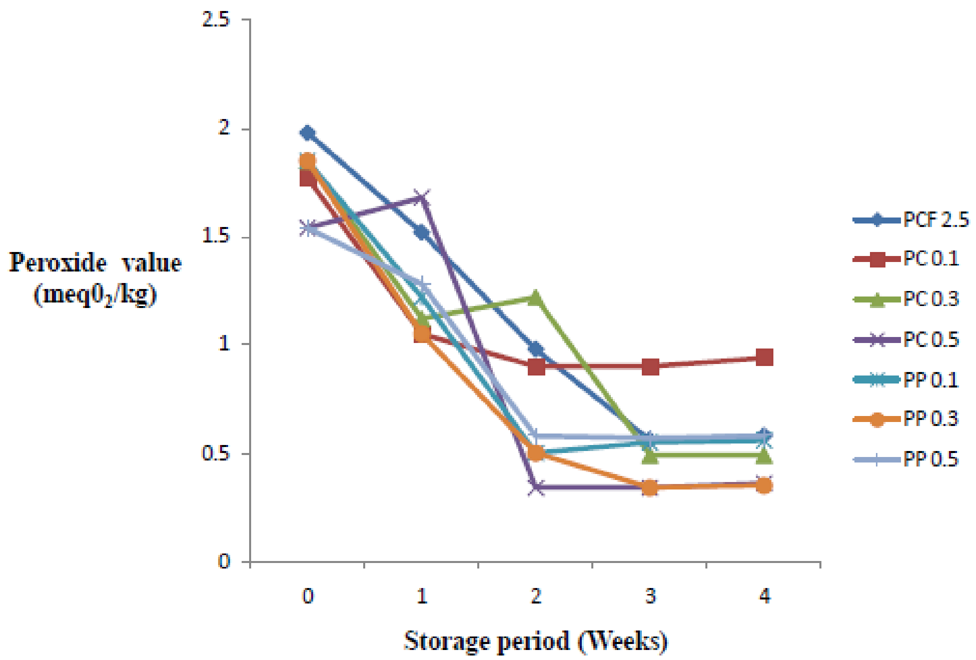

Figure3. *Changes in peroxide values (meq0_2/kg) of the mushroom spread during storage (4 Weeks)*

Keys: *PCF 2.5= Spread produced from Pleurotus cintrinopileatus with 2.5% Corn flour*

PC 0.1=Spread produced from Pleurotus cintrinopileatus with 0.1% gum Arabic

PC 0.3=Spread produced from Pleurotus cintrinopileatus with 0.3% gum Arabic

PC 0.5=Spread produced from Pleurotus cintrinopileatus with 0.5% gum Arabic

PP 0.1=Spread produced from Pleurotus pulmonarius with 0.1% gum Arabic

PP 0.3=Spread produced from Pleurotus pulmonarius with 0.3% gum Arabic

PP 0.5=Spread produced from Pleurotus pulmonarius with 0.5% gum Arabic

Changes in the Moisture Content of Mushroom Spreads During Storage (4 Weeks)

Figure 4: shows the moisture content of mushroom spreads during storage. Initial moisture content of the mushroom spreads ranged from 19.92-30.67% with *Pleurotus cintrinopileatus* spread containing 2.5% corn flour (control) recording the lowest while *Pleurotus pulmonarius* spread with 0.5% gum arabic as highest. However, these values were significantly ($p<0.05$) different from those spreads produced from *P. cintrinopileatus* (0.1 and 0.3% gum arabic). These moisture values were lower when compared to the moisture content of African pear spread (62.00%) as reported by Akusu *et al*. (2018). The low moisture values of spreads in this study may be attributed to the effect of gum and show an increased shelf life of the product.

At week 1 and 2, moisture content of the spreads were found to range between 26.89-42.42% and 34.64-49.21%, respectively, while in weeks three (3) and week four (4), the moisture content ranged between 61.92-72.41% and 69.65-76.71%, respectively with *Pleurotus cintrinopileatus* spread containing 2.5% maize flour recording lowest while *Pleurotus cintrinopileatus* containing 0.5% gum arabic recorded the highest. This shows that moisture content increased with the inclusion of gum.

There was no significant ($p>0.05$) difference in the moisture values of the spread after 4 weeks of storage except for *P. cintrinopileatus* spread containing 0.5% gum arabic which differed significantly ($p<0.05$) from *P. pulmonarius* spread containing 0.5% gum arabic. Water is an unusual component of oils and fats, as the two are non-miscible and the presence of water can be compatible only at very low proportions (Frank *et al*., 2013). In this regard, assaying the moisture content of the spreads generally provides a good indication of the level of the other quality parameters and can also prove very helpful to forecast subsequent variation upon storage. This result is in agreement with the study of Eke-Ejiofor and Beleya (2015) that moisture content of salad cream increased during storage.

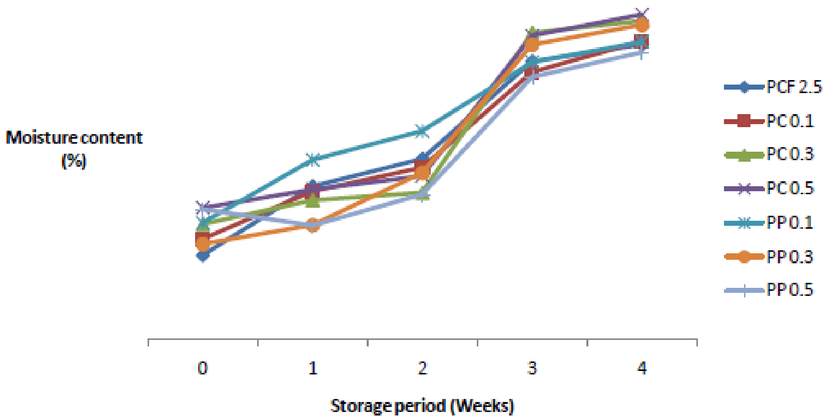

Figure4. *Changes in Moisture content (%) of the mushroom spreads during storage (4 weeks)*

Keys: PCF 2.5= Spread produced from *Pleurotus cintrinopileatus* with 2.5% Corn flour

PC 0.1=Spread produced from *Pleurotus cintrinopileatus* with 0.1% gum arabic

PC 0.3=Spread produced from *Pleurotus cintrinopileatus* with 0.3% gum arabic

PC 0.5=Spread produced from *Pleurotus cintrinopileatus* with 0.5% gum arabic

PP 0.1=Spread produced from *Pleurotus pulmonarius* with 0.1% gum arabic

PP 0.3=Spread produced from *Pleurotus pulmonarius* with 0.3% gum arabica

PP 0.5=Spread produced from *Pleurotus pulmonarius* with 0.5% gum arabic

Sensory Evaluation Results of Mushroom Spread

Table 5 presents the mean sensory evaluation results of mushroom spread produced from two varieties. Appearance of the mushroom spread ranged from 4.75-6.55 with *Pleurotus pulmonarius* spreads (0.3% gum arabic) as lowest and 0.5% gum inclusion as highest Taste ranged from 5.10-6.30 with spread produced from *Pleurotus cintrinopileatus* (0.1% gum arabic) as most preferred. Mouth feel of the spread ranged from 4.95-6.25 with PC 0.1 as most preferred and PCF 2.5 (control) as least preferred. Flavour, aroma and spreadability ranged from 4.80-5.90, 4.40-6.30 and 5.20-6.45 respectively, with the PP 0.1 as the least preferred in all cases. Spreadability scores for the mushroom spread with Arabic gums were more preferred than those added corn flour (control) indicating that mushrooms spreads gum arabic gave better spreadability than those with corn flour. Overall acceptability ranged from 5.25-6.15 with PC 0.1 rated most preferred and PP 0.1 rated least preferred.There was no significant (p>0.05) difference in the mean sensory scores of the mushroom spreads at all levels of gum arabic addition.

Table5. *Mean sensory scores of mushroom spread*

Sample	Appearance	Taste	Mouthfeel	Flavor	Aroma	Spreadability	Overall Acceptability
PCF	5.15[bc]	5.70[ab]	4.95[b]	5.30[bc]	5.15[ab]	5.50[ab]	5.30[a]
PC 0.1	6.15[ab]	6.30[a]	6.25[a]	5.75[abc]	5.90[a]	6.10[ab]	6.15[a]
PC 0.3	5.95[abc]	6.25[a]	5.65[ab]	6.00[ab]	6.30[a]	5.45[ab]	6.05[a]
PC 0.5	5.75[abc]	5.55[ab]	5.40[ab]	6.45[a]	6.30[a]	5.90[ab]	6.00[a]
PP 0.1	5.90[abc]	5.40[ab]	5.10[ab]	4.80[c]	4.40[b]	5.20[b]	5.25[a]
PP 0.3	4.75[c]	5.10[b]	5.30[ab]	6.05[ab]	5.80[a]	6.45[a]	5.65[a]
PP 0.5	6.55[a]	5.85[ab]	5.35[ab]	5.95[ab]	5.70[a]	6.45a	6.10[a]

Means with the same letters along the same column are not significantly different (p>0.05).

Keys: PCF 2.5= Spread produced from *Pleurotus cintrinopileatus* with 2.5% Corn flour

PC 0.1=Spread produced from *Pleurotus cintrinopileatus*with 0.1% gum arabic

PC 0.3=Spread produced from *Pleurotus cintrinopileatus*with 0.3% gum arabic

PC 0.5=Spread produced from *Pleurotus cintrinopileatus*with 0.5% gum arabic

PP 0.1=Spread produced from *Pleurotus pulmonarius*with 0.1% gum arabic

PP 0.3=Spread produced from *Pleurotus pulmonarius* with 0.3% gum arabic

PP 0.5=Spread produced from *Pleurotus pulmonarius* with 0.5% gum arabic

CONCLUSION

The present study shows that treatment of mushroom flour with sodium metabisulphite decreased the moisture content while increased fat, ash and crude fibre contents of the mushroom flours were observed. Treatment of mushroom also resulted to a decrease in protein and an increase in carbohydrate content of *P. cintrinopileatus* while the reverse was observed for *P. pulmonarius*. There was a difference in bulk density and solubility between *P. pulmonarius* and *P. cintrinopileatus*, which may be due to varietal differences as well as the effect of treatment with sodium metabisulphite.

Both flours recorded a decrease in oil and water absorption capacities and swelling power after treatment. Results also revealed that spread produced from *P. pulmonarius* were better in terms of protein and ash while mushroom spread from *P. cintrinopileatus* were better in terms of fat, crude fibre and carbohydrate. Iodine values were higher for *P. cintrinopileatus* and lower for *P. pulmonarius* while the reverse was obtained for pH. Increase in the concentration of gum arabic resulted to a decrease in fat, ash and carbohydrate and an increase in protein content of the mushroom spreads while an increase was reported for iodine value and pH, however, spreads produced with corn flour were higher in terms of crude fibre. Melting point of both spreads from *P.cintrinopileatus* and *P. pulmonarius* was higher at 0.3% gum arabic addition. There was an increase in moisture content of spreads while FFA increase was observed, with a corresponding decrease in peroxide value of mushroom spreads was observed which then increased after third week of storage, however, these values were within standard specification. Sensory analysis results showed that the spreads from *P. cintrinopileatus* were acceptable to the panelist at all levels of gum arabic inclusion while those from *P. pulmonarius* were acceptable at high concentrations of gum arabic (0.3 and 0.5%), however no significant difference ($p<0.05$) was observed in the overall acceptability of the spread. The study has demonstrated the use of different species of mushroom in the preparation of a nutritionally acceptable spread for domestic consumption.

REFERENCES

[1] Ajani, A.O., Fasoyiro, S.B., Arowora, K.A., Ajani, O.O., Popoola, C.A., and Zaka, K.O (2016). Functional Properties of Composite Flour made from Wheat and Breadfruit. *Applied Tropical Agriculture*, 21(2):89-93.

[2] Akusu, M.O., Wordu, G.O. and Obiesle, C. (2018). Spreadability, Acceptability and Compositional properties of table spreads produced from African Pear (*Dacryodes edulis*) pulp. *Asian Food Science Journal*, 3(3):1-8.

[3] Alam, N., Amin, R., Khan, A., Ara I., Shim, M.J., Lee, M.W. and Lee, T.S. (2008). Nutritional analysis of cultivated mushrooms in Bangladesh - *Pleurotus ostreatus*, *Pleurotus sajor-caju*, *Pleurotus florida* and *Calocybe indica*. *Mycobiology* 36(4): 228-232.

[4] Amevor, P.M., Laryea, D. and Barimah, J. (2018). Sensory evaluation, nutrient composition and microbial load of cashew nut-chocolate spread. *Cogent Food and Agriculture*, 4:1-10.

[5] Anyasor, N., Ogunwenmo, O., Oyelana, A., Ajar, D. and Dangana, J. (2009). Chemical analysis of groundnut oil. *Pakistan Journal of Nutrition*, 8(3):269-272

[6] AOAC (2012). Official Methods of Analysis of AOAC international. 19th Edition. AOAC International, Gaithersburg, Maryland, USA

[7] AOCSCc 3-25 (1989). The determination of melting point in open capillary tubes (slip point) for palm oil products', AOCS press, Champaign, IL

[8] Arisa, N. U., Adelekan, A. O., Alamu, A. E. and Ogunfowora, E. J. (2013). The effect of pretreatment of plantain (Musa Parasidiaca) flour on the pasting and sensory characteristics of Biscuit. *International Journal of Food and Nutrition Science* 2(1): 10-24

[9] Arinola, S. O. and Akingbala, J. O. (2018). Effect of pre-treatments on the chemical, functional and storage properties of breadfruit (*Artocarpus altilis*) flour. *International Food Research Journal* 25(1): 109-118.

[10] Ayo, J.A., Ojo, M.O., Omelagu , C.A. and Kaaer, R.U (2018). Quality Characterization of Acha Mushroom Blend Flour and Biscuit. *International Journal of Nutrition and Food Science*. 7(3):1-9

[11] Banigo, E.B. and Mepba, H.D. 2005. Certain functional properties of wheat-breadfruit composite flours. In: Proced.29th Annual Conference of Nigerian Institute of Food Science and Tech. (NIFST). pp 49b-49c.

[12] Bhupender, S.K., Rajnesh, B. and Baljeet, S.Y. (2013). Physicochemical, functional, thermal and pasting properties of starches isolated from pearl millet cultivars. *International Food Research Journal* 20(4):1555-1561

[13] Breene, W.M. (1990). Nutritional and medicinal value of speciality mushrooms. *Journal of Food Protection*, 53(10):883-894.

[14] Demirbas, A. (2001). Heavy metal bioaccumulation by mushrooms from artificially fortified soils. *Food Chemistry*, 74(3): 293-301.

[15] Erickson, D.R. (1990). Edible fats and oils processing: Basic principles and modern practices: World Conference Proceedings.*The American Oil Chemists Society, Champaign, Illlnois.*

[16] Eke-Ejiofor, J. and Beleya, E.A. (2015) Effect of packaging materials on the storage conditions of salad cream from cassava, sweet potato and three leaf yam starches. *International Journal of Biotechnology and Food Sciences*, 3(5):57-62.

[17] Elkhalifa, A.O., Schiffler, B and Bernhardt, R. (2005). Effect of fermentation on the Functional properties of sorghum flour. Journal of *Food Chemistry*. 92:1-5.

[18] Fagbemi, T.N. (1999). Effect of blanching and ripening on functional properties of plantain (Musa ab) flour.*Plants Food for Human Nutrition* 54: 261-269.

[19] Frank, N.G., Albert, M. E. and Astride, E. M. (2013). Some quality parameters of crude palm oil from major markets of Douala, Cameroon. *African Journal of Food Science,* 7(12):473-478.

[20] Galoburda,R., Kuka, M., Cakste, I. and Klava, D (2015). The effect of blanching temperature on the quality of microwave-vacuum dried mushroom *Cantharellus cibarius. Agronomy Research* 13(4):929–938

[21] Genenu, A., Adamu, Z. and Satheesh, N. (2017). Effect of mushroom flour on proximate composition and dough rheological properties of whole wheat flour bread. *Annals in Food Science and Technology*, 18(3):413-423.

[22] Hayakawa, K., Linko, Y.Y. and Linko, P. (2000). The role of trans fatty acids in human nutrition. *Journal of Lipid Science and Technology* 102: 419-425.

[23] Hunt, S., Groff, I. L. and Hobbrook, J. (1980). Nutrition, Principles and Chemical Practice. John Wiley and Sons, New York, USA. Pp. 49-52; 459 – 462.

[24] Ibrahim, T.A., Adaramola-Ajbiola, K.M., Adesuyi, A.T., Olarewaju, J.O. and Akinro, E.B. (2017). Effect of pre-treatments and drying methods on the chemical quality and microbial density of wild edible oyster mushroom.*Arch Food Nutri.Sci,* 1:39-44

[25] Khan, K. H., Ali, T. M. and Hasnain, A. 2014. Effect of chemical modifications on the functional and rheological properties of potato (solanum tuberosum) starches *The Journal of Animal and Plant Sciences* 24(2): 550-555.

[26] Kumela D. T., and Solomon, A. (2017). Nutritional quality of Oyster Mushroom (*Pleurotus Ostreatus*) as affected by osmotic pretreatments and drying methods.*Food Science and Nutrition*, 5:989–996.

[27] Mahboubeh, Z., Yahya, M., and Peyman, A. (2014) Investigation of physicochemical properties of table margarine during storage time in ambient temperature. *European Journal of Experimental Biology*, 4(3):188-190.

[28] Man, D. (2002). Shelf Life.Food Industry Briefing Series.Blackwell Science. Oxford. UK, pp 67-72.

[29] Mayaki, O. M., Akingbala, J. O., Bacchus-Taylor, G. S.H. and Thomas S. (2003). Evaluation of breadfruit (Artocarpus communis) in traditional stiff porridge foods. *Journal of Food, Agriculture and Environment* 1(12): 54–59.

[30] Mcwilliam, M. (1978).Food fundamental 3rd edition.California State University Los Angeles. P 27-29.

[31] Mensink, R.P., Zock, P.L., Kester, A.D.M. and Katan, M.B. (2003). Effects of dietary fatty acids and carbohydrates on the ratio of serum total to HDL cholesterol and on serum lipids and apolipoproteins: a meta-analysis of 60 controlled studies. *American Journal of Clinical Nutrition* 77: 1146-1155.

[32] Moore, M. (2003). Immortal mushrooms, In; Prescription for Dietary Wellness, 2nd ed., Balch, R. (ed), Penguin Group Inc., New York. Pp. 167-168.

[33] Mounts, T.L. (2000).The Chemistry of Components, 2nd Edn.Royal Society of Chemistry.

[34] Moses, O., Olawuni, I. and Iwouno, J.O (2012). The Proximate Composition and Functional Properties of Full-Fat Flour, and Protein Isolate of Lima Bean *(Phaseolus Lunatus).* 1:349. doi:10.4172/scientificreports.349

[35] Nadeem, M., Imran, M., Taj, I., Ajmal, M. and Junaid, M. (2017). Omega-3 fatty acids, phenolic compounds and antioxidant characteristics of chia oil supplemented margarine. *Lipids in Health and Disease*, 16:102

[36] Narayana, K. Narasinga, Rao M.S. (1984): Effect of partial proteolysis on the functional properties of winged pea (*Psophocapus tetragonolobus*) flour. *Journal of Food Science*,49:944 – 947.

[37] Ngoddy, P.O., Enwere, N.J and Onuorah, V.I (1986). Cowpea flour performance in Akara and *Moi-Moi* Preparation. Tropical Science 26: 101-119.

[38] Nwoji, V.C. (2004). Effect of processing on the storage stability and functional properties of cowpea (*Vigna unguculata*) flour in the production of cowpea bean (akara) and paste (moin-moin). In: Proced. 29th Annual Conference of Nigeria Institute of Food Science and Tech. (NIFST).pp 199.

[39] Okwulehie, I.C. and Odunze, E.I. (2004). Evaluation of the myco-chemical and mineral composition of some tropical edible mushrooms. *Journal of Sustainable Agricultural Environment*, 6:163-170.

[40] Osundahunsi, O. F., Fagbemi, T. N., Kesselman, E. and Shimoni, E. 2003. Comparison of the physiochemical properties and pasting characteristics of flour and starch from red and white sweet potato cultivars. *Journal of Agricultural and Food Chemistry* 51: 2232-2236

[41] Pearson, D (1990). Chemical analysis of foods.6th Edn.Churchhill, J.A; Glouceter palace.London. Starch Wikipedia, the free encydopedia.

[42] Pearson, D. (1970). Chemical analysis of food.7th edition. J&A Churchill, London, pp 17-19

[43] Perron, N.R, and Brumaghim , J.L. (2009). A review of the antioxidant mechanisms of polyphenol compounds related to iron binding. *Cell Biochem Biophys* 53:75–100

[44] Prodhan, U.K., Linkon, K. M., Al-Amin, M. and Alam, M. (2015). Development and quality evaluation of mushroom (*pleurotussajor-caju*) enriched biscuits.*Emirates Journal of Food and Agriculture*. 27(7):542-547

[45] Raules, J., Valencia, S. and Nair, B. (1993). Effect of processing on the physicochemical characteristics of guinea flour (Chenopodium guinea Wild). *Starch* 46(1): 13 – 19.

[46] Sang, S., Buckley B. and Ho, C-T., Yang, C.S. (2007). Autoxidative quinone formation in vitro and metabolite formation in vivo from tea polyphenol (–)-epigallocatechin-3-gallate: studied by real-time mass spectrometry combined with tandem mass ion mapping. *Free Radical Biol Med* 43:362–71.

[47] Sosulski, F.W., Garatt, M.O., Slinkard, A.E (1978). Functional properties of ten legume flours. *International Journal of Food Science and Technology* 9: 66-69.

[48] Srichuwong, S. Suharti, C., Misharti, Mishima, T. Isono, M. and Isamatu, M. (2005). Starches from different botanical sources. Contribution of starch structure to swelling and pasting properties.*Carbohydrate polymer* 62(1):25-34.

[49] Sulthana, S.N. and Sen, D.P. (1979). Studies on deep fat frying: changes during heating of oil. *Journal of Food Science and Technology*, 16:208

[50] Takashi, S. and Seib, P.A. (1988). Paste and gel properties of prime corn and wheat starches with and without native lipids. *Journal of Food Chemistry*, 65: 470 – 474.

[51] Verma, B.B. and Gary, F.C (2002). Devlopment of technology for development of *Chhana* based jam like product. Annual report (2002-2003) NDRI. Pp: 40 (2002).

[52] Wahua, T.A.T (1999). Applied Statistics for Scientific Studies.African Link Press, Aba, Nigeria.

[53] Wikipedia, 2011 (Accessed, 2019). Mushroom Wikipedia, the free encyclopedia. Retrieved from http://en.wikipedia.org/w/index.php? title mushroom and oldid=456373633. Categories: fungi.

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