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Evaluation of Starch Components, Pasting and Functional Properties of PleurotusTuberregium Flour from Air Dried Sclerotia

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Abstract

Pleurotus tuberregium is one group of mushroom that produce edible sclerotia and is used for various culinary and medicinal purposes. Flour was produced from the air dried sclerotia and starch components, pasting and functional properties were evaluated. It had a total and resistant starch contents of 73.63% and 12.37% respectively while its amylose content was 20.03%. Its amylose and resistant starch contents classified it as regular and high resistant starch flour. Its pasting properties revealed it had pasting temperature and peak time of 60.16°C and 5.97min respectively. Results on breakdown viscosity, set back viscosity and set back ratio revealed a high tendency of the flour to retrograde after gelatinization and when shear stress is applied. It had low swelling capacity, moderate dispersibility index and high gelatinization temperature with values of 4.17g/g, 53% and 94°C respectively. This therefore suggests that flour from air dried *Pleurotus tuberregium* sclerotia can be utilized in food formulations where high resistant starch is relevant for nutritional purposes and as thickeners in food products. However, there is need for technological modification to improve its pasting properties so as to generate flour with a high stability ratio and a low set back ratio and so withstand retrogradation and with improved resistance to shear stress.

Keywords: *Pleurotus tuberregium* sclerotia, Air-dried flour, Resistant starch, Pasting properties, Dispersibilty index, Amylose, Amylopectin, Set back ratio, Stability ratio, Gelatinization temperature.

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Contents

Contribution of this paper to the literature
This study has provided information on the nutritional, technological usefulness and functionality of flour from air dried *Pleurotus tuberregium sclerotia.* The research has shown that flour from air dried sclerotia has resistant starch but there is need for technological modification to improve its pasting properties.

1. Introduction

Edible mushrooms form part of diet in many human populations because of their unique flavour, texture or for their nutritional benefits such as having antioxidant activity. Some mushroom species produce sclerotia which are edible and used for various purposes. The search for new food ingredients with good functionality and nutritional value has resulted to the exploitation of mushrooms and has been of interest to food technologists lately. The utilization of mushroom flours is limited due to absence of knowledge about their functional and compositional characteristics and their interactions [1]. *Pleurotus tuberregium*is a tropical edible mushroom that produces edible sclerotium/underground tuber as well as mushroom [2]. The sclerotium of *Pleurotus tuberregium* is a compact mass of hardened mycelium containing food reserves which help the fungi survive environmental extremes [3]. It is highly nutritious containing good quality protein and carbohydrate with little fat [4].

Major reserve carbohydrates in foods is starch comprised of polymer units namely amylose and amylopectin. The relative proportion of amylose and amylopectin and their organization within starch granules determine the functional properties of the starch and consequently its range of industrial applications in foods, pharmaceuticals etc [5]. Starch contributes to textural properties of many foods and is commonly used in food and industrial applications as thickener, stabilizer and gelling agent [6]. Pasting properties are functional properties associated with the ability of an item to act in paste-like manner [7]. Dietary starches are important sources of energy for humans which during digestion, a portion goes undigested in the upper gastrointestinal tract and so is referred to as resistant starch. Lately, there is a lot of interest in resistant starch for its potential health benefits as is to soluble fibre as well as its functional properties [8]. The physical properties of resistant starch makes it a functional ingredient that provides good handling and improve texture in the final product [9].

Mushrooms have the ability to develop a morphological form known as sclerotium which is a compact mycelia structure under unfavorable conditions and can remain dormant until there is suitable environmental conditions required for fruiting bodies germination [10]. This mycelia structure known as the sclerotia serve as food reserve for fruiting bodies and is consumed as food by man. It is in view of this that starch components, pasting and functional properties of flour produced from air dried *Pleurotus tuberregium* sclerotia was evaluated. This will provide information about its usefulness in food formulation and its functional characteristics as a healthy food ingredient.

2. Materials and Methods

2.1 Sclerotia Collection and Preparation of Flour Sample

Pleurotus tuberregium sclerotia was purchased from a local market in Umuahia, Abia State, Nigeria. The outer dirty brown back was peeled using stainless steel knife while the inner white mass of sclerotia was cut in small pieces of 5mm thickness and air dried on stainless tray in the laboratory (room temperature 25±2°C). The air dried sclerotia was milled using a blender (Master Chef, India) at speed No2 into fine flour and was packaged in an airtight container and stored at room temperature prior to analysis.

2.2 Analysis of Starch Components.

2.2.1 Determination of Total Starch:

Total starch was determined by the AOAC method 996.11 described by Mccleary, et al. [11]. 50g of the flour was passed through a 0.5mm screen and 100mg of the sieved flour was weighed into a glass centrifuge. The tube was tapped to ensure all the samples falls to the bottom of the tube before 0.2mi ethanol (80% v/v) was added and the contents were stirred on a vortex mixer before 2ml dimethylsulphoxide was added and stirred continuously on the vortex mixer for 3min. Subsequently the tube with its contents were placed in a vigorously boiling water bath for 5min. Immediately3ml of thermostable α-amylase was added and the tube was incubated in a boiling water bath for 6min with intermediate vigorous stirring after 2,4, and 6min to ensure homogeneity. After which, the tubes were placed in a water bath at 50°C and 0.1ml amyloglucosidase suspension was added to the mixture and the contents were stirred on a vortex mixer and incubated at 50°C for 30min. After this step, the contents were transferred to a 100ml volumetric flask and distilled water was used to rinse tube contents thoroughly and the volume was adjusted to 10ml and mixed thoroughly before centrifuging at 3000rpm for 10min. 1ml of the supernatant was diluted to 10ml with distilled water. A reagent blank, glucose standard and test sample were subjected to endpoint analysis using GOD-PAP reagent. For the test sample, 0.1ml of diluted supernatant was dispensed into a test tube and 3ml GOD-PAP reagent was added, the blank contained 3ml GOD-PAP reagent and 0.1,m water while the standard contained 3ml GOD-PAP reagent plus 0.1ml glucose standard. All these were incubated at 50°C for 20min and absorbance were read at 510nm against the reagent blank. Total starch was calculated as shown in Equation 1:

$$\text{Starch } (\%) = \Delta A \text{ X } \frac{F}{W} \text{ X FV X } 0.9 \qquad (1)$$

ΔA is sample GOD-PAP absorbance read against reagent blank.
F is the factor used to convert from absorbance to µg of glucose.
W is weight of sample analysed in mg.
FV is final volume of solution used.

2.2.2. Determination of Amylose and Amylopectin

Amylose was determined by the iodine colorimetric method described by Mohana, et al. [12]. The flour sample was defatted prior to analysis.100mg of the defatted flour was weighed into 100ml volumetric flask to which 1ml

95% ethanol and 9ml 1N NaOH were added and mixed thoroughly. After which it was heated on boiling water bath to gelatinize the starch and later on cooled to room temperature. 5ml of the gelatinized starch solution was dispensed into a 100ml volumetric flask to which 1ml of 1N acetic acid and 2ml of iodine solution were added and the volume made up to 100ml with distilled water. All the contents were thoroughlyvortexed mixed and allowed to stand for 20mins. The absorbance was measured at 620nm in a spectrophotometer using a blank containing 5ml 0.09N NaOH, 1ml acetic acid and 2ml iodine solution and made up to 100ml volume using distilled water. The amylose content was determined based on the standard curve prepared using potato amylose. Amylopectin was calculated by difference stated by Juan, et al. [13] shown in Equation 2:

$$Amylopectin\ (\%) = 100 - Amylose\ (\%) \quad (2)$$

2.2.3. Evaluation of Resistant Starch

Resistant starch was evaluated by the method described by Goñi, et al. [14]. 100mg of the sample was dispensed into centrifuge tube and 10ml KCl-HCl buffer (pH1.5) was added and the mixture homogenized. 0.2ml pepsin was added to the homogenized sample mixture and incubated at 40ºC for 60min with constant shaking in a water bath. After which the sample was cooled to room temperature, 9ml Tris -maleate buffer (pH 6.9) was added alongside 1ml α-amylase was added to the mixture, shaken well and incubated for 16h at 37ºC in a water bath with constant shaking. Subsequently the sample was centrifuged for 15min at 3000rpm and the supernatant was discarded leaving the sediment. The sediment was washed once with 10ml distilled water, centrifuged and the supernatant discarded before adding 3ml distilled water and 3ml 4M KOH. The contents were mixed thoroughly and left to stand at room temperature for 30min with constant shaking before 5ml buffer (pH 4.75) and 0.08ml amyloglucosidase were added and mixed. The sample mixture was incubated for 45min at 60ºC in a water bath with constant shaking. The mixture was clarified by centrifuging at 3000rpm for 15min and the supernatant siphoned into a volumetric flask. The residue was washed twice with 10ml distilled water and clarified by centrifuging each time and the supernatant recovered and combined with was put into the volumetric flask previously. The recovered supernatant solution was made up to 100ml using distilled water. A standard curve containing 10-60ppm glucose was generated. 0.5ml water, sample and standard glucose solutions were dispensed into test tubes. 1ml GOD-PAP was added to each to each test tube and incubation was done for 30min at 37ºC in a water bath. Absorbance of test and standards were read at 500nm against reagent blank. The standard curve was used to calculated glucose concentration of the sample. Resistant starch was calculated as shown in Equation 3:

$$Resistant\ starch\ (\%) = mg\ of\ glucose\ X\ 0.9 \quad (3)$$

2.3. Pasting Properties Determination

Pasting properties of *Pleurotustuberregium*sclerotia flour was evaluated using Rapid ViscoAnalyser (Dingling RVU 232015, USA) by methods described by AACC [15]. A 3g sample was dispersed in an aluminium canister containing 25ml of distilled water. The sample mixture underwent a controlled heating and cooling cycle under constant shear where it was held at 50ºC for 1min, heated from 50 to 95ºC at 6 ºC/min and held at 95ºC for 5min. Finally each sample was cooled to 50ºC and held for another 2min. The starch viscosity parameters measured were peak viscosity(PV), trough viscosity~viscosity at the end of holding time at 95ºC (HPV), breakdown viscosity (PV-HPV), cool paste viscosity (CPU)~final viscosity-viscosity at the end of the hold time at 50ºC; setback viscosity (SBV)~(CPU-HPV), pasting time= time from onset of pasting to peak viscosity, pasting temperature= temperature from onset of pasting to peak viscosity. Stability ratio (SR) = $\frac{HPV}{PV}$ and setback ratio (SBR) = $\frac{CPV}{HPV}$ were calculated prescribed by Julianti, et al. [16].

2.4. Functional Properties Determination

2.4.1 Bulk Density

Bulk density was determined by the method described by Onabanjo and Ighere [17]. A 50g weight of *Pleurotustuberregium*sclerotia flour was put into 100ml measuring cylinder. The cylinder was tapped several times on a laboratory bench to a constant volume. The volume of sample was calculated as shown in Equation 4:

$$Bulk\ density\ (g/cm^3) = \frac{Weight\ of\ sample}{Volume\ of\ sample\ after\ tapping} \quad (4)$$

2.4.2. Water Absorption Capacity (WAC) and Oil Absorption Capacity (OAC)

These were determined by the methods described by Onabanjo and Ighere [17]. For WAC, 1g of *Pleurotustuberregium*sclerotia flour was dispensed into 25ml centrifuge tube and 15ml distilled water was added to it and the tube was agitated on a vortex mixer for 2min. The suspension was centrifuged at 1000rpm for 20min and after which, the clear supernatant was decanted and discarded. The wet flour residue was reweighed and water absorption was expressed as weight of water bound by 100g dried flour. The same procedure was used for oil absorption capacity except that water was replaced with vegetable oil of specific gravity of 0.98g/ml. Water absorption capacity and oil absorption capacity were expressed as shown in Equation 5:

$$WAC/OAC\ (g/g) = \frac{Weight\ of\ sediment}{Initial\ weight\ of\ flour} \quad (5)$$

2.4.3. Emulsion Activity

This was determined by the method described by Yasumatsu, et al. [18]. A mixture of 1g flour sample, 10ml distilled water and 10ml soybean oil was prepared in a calibrated centrifuge tube. The emulsion was centrifuged at 2000rpm for 5min. The ratio of the height of emulsion layer to the total height of the mixture was calculated as emulsion activity in percentage shown in Equation 6:

$$Emulsion\ activity\ (\%) = \frac{Height\ of\ emulsion\ layer\ before\ centrifugation}{Total\ height\ of\ the\ mixture\ after\ centrifugation}\ X\ \frac{100}{1} \quad (6)$$

2.4.4. Emulsion Stability

This was determined by the method of Yasumatsu, et al. [18]. Emulsion stability was estimated after heating the emulsion in the calibrated centrifuge tube which was obtained from the determination of emulsion activity at 80°C for 30min in a water bath. This was followed up by cooling for 15mins under running tap water and centrifuged at 2000rpm for 15min. Emulsion stability was expressed as shown in Equation 7:

$$\text{Emulsion stability (\%)}=\frac{\text{Height of emulsified layer}}{\text{Totsl height of the mixture}} \text{ X } \frac{100}{1} \qquad (7)$$

2.4.5 Foam Capacity and Foam Stability

Foam capacity and foam stability were determined by the methods described by Narayana and Narasinga Rao [19]. Foam capacity was evaluated by dispensing 1g flour sample into a blender and 10ml deionized water (pH adjusted to 7.4 using 1N NaOH and 1N HCl) was added. The mixture was blended for 5min before turning into a 250ml graduated cylinder and the foam volume was recorded immediately. Foam capacity was calculated as shown in Equation 8:

$$\text{Foam capacity (\%)} = \frac{\text{Volume of foam after whipping}}{\text{Volume of foam before whipping}} \text{ X } \frac{100}{1} \qquad (8)$$

Foam stability: Foam stability was evaluated by recording foam volume in the cylinder 1h after whipping as percent of initial foam volume, shown in Equation 9.

$$\text{Foam stability (\%)}=\frac{\text{Volume of foam 1h after whipping}}{\text{Volume of foam immediately after whipping}} \text{ X } \frac{100}{1} \qquad (9)$$

2.4.6.Swelling Index and Swelling Capacity

These were analysed by the methods described by Ukpabi and Ndimele [20]. Swelling index was determined by dispensing 25g of flour sample into 250ml measuring cylinder. 150ml deionized water was added and the mixture was shaken and allowed to stand for 4h before observing the extent of swelling. Swelling index was calculated as shown in Equation 10:

$$\text{Swelling index (g/g)}=\frac{\text{Volume after soaking} - \text{Volume before soaking}}{\text{Weight before soaking}} \qquad (10)$$

Swelling capacity: The gel obtained after determining swelling index was used in calculating swelling capacity as shown in Equation 11:

$$\text{Swelling capacity (g/g)} =\frac{\text{Weight of gel after soaking}}{\text{Weight of sample before soaking}} \qquad (11)$$

2.4.7. Dispersibility

This was determined by the methods described by Kulkarni, et al. [21]. 10g of flour sample was weighed into a graduated cylinder and 100ml distilled water was added to it. The mixture was shaken vigorously and allowed to stand for 3h before the volume of settled particles was recorded.

2.4.8. Gelatinization Temperature

It was determined by the method described by Shinde [22]. 1g flour sample was weighed into a 20ml screw capped tube and 10ml water was added to it and shaken vigorously before it was heated slowly in a water bath until a solid gel was formed. The temperature at which a gel was formed was recorded in °C.

3. Results and Discussion

3.1. Starch Components

Resultson starch components of *Pleurotus tuberregium* flour from air dried sclerotia is shown in Table 1. Its total starch content of 73.63% was comparable to total starch content of *Pleurotus ostreatus* and had a value of 75% [23] but higher than starch from green cadaba banana flour subjected to various drying methods and had values between 29.24 and 40.77% [24].

Its amylose and amylopectin contents were 20.03% and 53.60% respectively. The ratio of amylose and amylopectin in starch influences mechanical property of starch polymer [25]. Its amylose content (20.03%) was comparable to amylose content of *P. ostreatus*(21.7%) [23] but lower than amylose content of native banana and plantain starches which had values of 42.07% and 38.79% respectively [6]. Amylopectin content (52.62%) observed in this work was lower than amylopectin content of *P. ostreatus*(78.30%) [23]. Amylose content is the underlying condition for categorizing starches into waxy, semi-waxy, regular and high amylose types when amylose content is 0-2%, 3-15%, 15-35% and >40% of the total starch respectively [26]. In the current study, starch from air dried *Pleurotustuberregium* flour can be classified as regular starch.

Resistant starch content observed for *P. tuberregium*was 12.37%. This value was lower than resistant starch content of green Cadaba banana flour subjected to different drying methods with values that ranged between 16.83 and 27.53% [22] but higher than resistant starch content of different cassava varieties which ranged between 1.12 and 4.14% reported by Chisenga, et al. [27]. Goñi, et al. [14] classified food materials with resistant starch content of 5-15% as high resistant starch foods. This suggests that flour from air dried sclerotia of *Pleurotustuberregium*can be classified as high resistant starch flour. Resistant starch functions physiologically as fibre in promoting a healthy gastrointestinal environment such as being a prebiotic compound [8]. Therefore, incorporation of *P. tuberregium*flour into food formulations will be of benefit in promoting a healthy gut environment.

Table-1. Starch fractions of *Pleurotus tuberregium* flour from air dried sclerotia

Parameter	Value
Total starch (%)	73.63±0.00
Amylose (%)	20.03±0.00
Amylopecyin (%)	53.62±0.02
Resistant starch (%)	12.37±0.01

Note: Values are means ± standard deviation.

3.2. Pasting Properties

Table 2 shows results on pasting properties of flour from air dried *P. tuberregium* sclerotia. Its pasting temperature was 60.16ºC while its peak time was 5.97mins. Pasting temperature obtained in this work was lower than pasting temperature (86.70 ºC) and peak time (7.90min) reported by Kolawole, et al. [28] for *P. tuberregium* flour obtained from sclerotia oven dried at 40ºC. Subroto, et al. [29] reported an increase in pasting temperature of potato starch oven dried at 40ºC when compared with pasting temperatures of starch obtained by heat moisture treatment. This suggests that pre-treatment such as oven drying affects pasting temperature which causes molecular rearrangement of starch molecules resulting to closed packed structure of amylose and amylopectin molecules hence influencing water absorption within the amorphous and crystalline regions. Pasting temperature indicates the temperature at which viscosity begins to rise [30] and it ensures swelling, gelatinization and subsequent gel formation during processing [31]. Peak time is a measure of cooking time [32]. Low peak time is desirable to save energy required to form gels from starch. Therefore *P. tuberregium* flour obtained from air dried sclerotia has a moderate pasting temperature and peak time hence, will not consume much energy to cook.

Peak viscosity (PV) was 350.55RVU. This was in contrast to peak viscosity reported by Kolawole, et al. [28] for *P. tuberregium* flour which had a value of 101.33RVU. The high PV reported for *P. tuberregium* flour obtained in our work could be due to less interaction between water molecules and amylose-amylopectin granules through hydrogen bonds. Charles, et al. [33] attributed a high peak viscosity to be caused by low levels of amylose and failure to re-associate with amylopectin and strengthen the molecular network. Peak viscosity can be affected by amylose/amylopectin content and ratios, molecular weight, intermolecular conformation and the degree of polymerization of amylose and amylopectin, amount of amylopectin branching and the presence of minor components [34].

Hot paste viscosity (HPV, i.e Trough) was 101.50RVU. This was higher than 72.62RVU reported Kolawole, et al. [28] for *P. tuberregium* flour. HPV is the minimum viscosity value which measures the ability of paste to withstand breakdown during cooking [16]. Breakdown viscosity (BD) obtained in this work for *P. tuberregium* flour from air dried sclerotia was 149.51RVU while Kolawole, et al. [28] reported a value of 24.52RVU for *P. tuberregium* flour obtained from sclerotia oven dried at 40ºC. Breakdown viscosity is a crucial factor in determining paste stability during heating and mechanical shear stress encountered during processing Arinola, et al. [35]. Adebowale, et al. [32] reported that a higher breakdown viscosity results to a reduced ability of flour to withstand heating and shear stress during cooking. Therefore, in this current study it can be deduced that air dried *P. tuberregium* flour has a low ability to withstand heating and shear stress.

Final viscosity (i.e cold paste viscosity) and set back viscosity were 391.56RVU and 290.06RVU respectively while Kolawole, et al. [28] reported values of 68.64RVU and 41.10RVU for final viscosity and set back viscosity respectively for *P. tuberregium* flour obtained from sclerotia oven dried at 40ºC. The extent to which amylose molecules join to form a strong gel after cooling affects the final viscosity Subroto, et al. [29]. Final viscosity indicates the re-association of starch granules especially amylose during cooling time after gelatinization and the formation of gel network [36]. Set back viscosity represents viscosity of starch after heating to 50ºC. The lower the set back viscosity, the higher the resistance to retrogradation [37]. High set back viscosity obtained in this study suggests that flour produced from air dried *P. tuberregium* sclerotia can easily retrograde while the final viscosity indicated a high re-association of starch granules during cooling time after gelatinization.

Stability ratio and set back ratio were 0.29 and 2.77 respectively. Stability ratio obtained for *P. tuberregium* flour was lower than stability ratio of wheat flour (0.53) reported by Julianti, et al. [16]. Set back ratio of *P. tuberregium* flour was higher than set back ratio of wheat flour (2.02) [16]. Stability ratio provides information on the resistance of a starch paste to viscosity breakdown as shear is applied while set back ratio is an index of starch retrogradation tendency after gelatinization [16]. This confirms that *P. tuberregium*flour obtained from air dried sclerotia has low resistance to viscosity breakdown as shear is applied and a high tendency to retrograde.

Table-2. Pasting properties of *Pluerotus tubberregium* flour from air dried sclerotia

Parameter	Value
Pasting temperature (ºC)	60.16±1.51
Pasting time (min)	5.97±0.0
Peak viscosity (RVU)	350.55±0.77
Hot paste viscosity (RVU)	101.50±2.09
Breakdown viscosity (RVU)	149.51±0.69
Final viscosity (RVU)	391.56±2.17
Setback viscosity (RVU	290.06±0.08
Stability rat	0.29±0.01
Setback ratio	2.77±0.05

Note: Values are means ± standard deviation.

3.3. Functional Properties

Results on functional properties of *Pluerotus tubberregium* flour from air dried sclerotia is shown in Table 3. Its bulk density (BD) was 0.4g/ml. This value was higher than BD of 0.29g/ml reported for *Pluerotus tubberregium* flour by Kolawole, et al. [28]*Agaricusbisporus* (0.22g/ml) and *Pluerotus ostreatus* (0.28g/ml) reported by Ishara, et al. [1] but lower than BD of *Termitomyces heimii* (0.74g/ml) reported by Due, et al. [38]. Bulk density is influenced by

the structure of starch polymers and loose structure of starch polymer could result to low bulk density [39]. A low bulk density is ideal for infant meal [40]. This suggests that the bulk density obtained for flour from air dried *Pluerotus tubberregium* sclerotia could be suitable for the production of infant formula.

Its water absorption capacity (WAC) and oil absorption capacity (OAC) were 4.20g/g and 4.13g/g respectively. WAC observed in this work was lower than WAC reported for *A. bisporus* (5.43g/g) and *P. ostreatus* (7.19g/g) reported by Ishara, et al. [1]. Flour with a water absorption capacity greater than 125ml/100g (ie 1.25g/g) points out good bakery property [41]. Therefore it is an indication that *Pluerotus tuberregium* flour from air dried sclerotia can be good in bakery products. As regards OAC, the value obtained in this research was higher than OAC of *P. tubberregium* flour (0.22ml/g) reported by Kolawole, et al. [28] *T. hemii* (125.25%=1.2525g/g) Due, et al. [38] but lower than OAC *A. bisporus* (548.3%=5.483g/g) and *P. ostreatus* (462.6%=4.626g/g)[1]. Variation in OAC of flour from different food items could be influenced by differences in non- polar side chains of proteins which bind hydrocarbon side chain of the oil through hydrophobic interactions [42]. The fewer the non-polar amino acids, the less the hydrophobic interactions with hydrocarbon chain of oil, hence resulting to low oil absorption capacity.

Emulsion activity (EA) and emulsion stability (ES) obtained in this study were 30.22% and 45.12% respectively. EA of *P. tuberregium* flour was lower than EA of wheat flour (43.88)[33] while its ES (45.12%) was higher than ES of wheat flour (38.38%) [33]. Foam capacity (FC) obtained in this study (7.27%) was lower than FC of *T. heimii* flour (16.67%) Due, et al. [38] pearl millet (11.30%), quinoa flour (9%)[43] as well as wheat flour (12.92%) [33]. The foam stability (FS) obtained in this study (31.55%) was lower than FS of species of *P. ostreatus* flour which ranged between 45.7% and 66.8%[44] but higher than FS reported for wheat flour (1.94%)[33]. An inverse relationship exists between foam capacity and foam stability[33]. Flours with low foam capacity could form small air bubbles enclosed by a dense and more stiff protein film as such may not collapse easily hence, resulting to a higher foam stability.

Swelling capacity and swelling index for *P. tuberregium* flour in this study were 4.17% and 1.61% respectively. Mushroom flour has been reported to have low swelling capacity [45]. Similarly, Ojo, et al. [46] reported a significant decrease in swelling properties of cassava-mushroom flour blends with increased substitution of mushroom flour. The ability of starch particles to retain water and swell is based on the extent of water retention through hydrogen bonding and is controlled by its amylose content as well as its amylopectin side chains [47].

Dispersibilty index for *P. tubberregium* flour was 53%. Dispersibilty is an index that measures how well a flour/flour blends can be rehydrated with water[21]. A high dispersibilty enhances better reconstitution of starch in water to give fine and functional paste[31]. This suggests that *P. tuberregium* flour from air dried sclerotia will rehydrate moderately in water to give a fine paste. Gelatinization temperature obtained for *P. tubberregium* flour in this study was 94ºC. This was quite higher than gelatinization temperatures of *S. citritum* (70 ºC) and *P. ostreatus* (80 ºC) reported byAniekemabasi, et al. [23]. Gelatinization temperature of starch is affected by botanical origin, amylose content and the structure of the amylopectin in the molecules Aniekemabasi, et al. [23]. High gelatinization temperature is associated with low amylose content and suggests thermal stability Aniekemabasi, et al. [23]. It was observed that *P. tubberregium* flour from air dried sclerotia had a regular amylose content which could be categorized as low Table 1 and this suggests its high gelatinization temperature.

Table-3. Functional properties of *Pluerotus tubberregium* flour from air dried sclerotia.

Parameter	Value
Bulk density (g/cm^3)	0.40±0.00
Water absorption capacity (g/g)	4.20± 0.12
Oil absorption capacity (g/g)	4.13±0.12
Emulsion capacity (%)	30.22±1.62
Emulsion stability (%)	45.12±1.82
Foam capacity (%)	7.27±0.10
Foam stability (%)	31.55±1.58
Swelling capacity (g/g)	4.17±0.88
Swelling index (g/g)	1.61±0.07
Dispersibility index (%)	53.00±1.00
Gelatinization temperature (ºC)	94.00±0.00

Note: Values are means ± standard deviation.

4. Conclusion

It is concluded that flour from air dried *Pluerotus tubberregium* sclerotia has a regular (ie low) and high resistant starch based on values for its amylose and resistant starch contents. Therefore, it can be incorporated in food formulations for nutritional purposes where its resistant starch can function as a prebiotic. The pasting properties indicated that the flour can retrograde based on its set back viscosity and set back ratios and a low tendency to withstand shear stress based on its breakdown viscosity and stability ratio. Its functional properties indicated that it can be used in food formulations where low bulk density is desirable such as in weaning foods and will be useful as a good thickener and in low fat foods based on its water and oil absorption capacities. However, there is need for technological modification to improve its pasting properties so as to generate flour with a high stability ratio and a low set back ratio and so withstand retrogradation and with improved resistance to shear stress.

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