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# Nutritional value and antioxidants in fruiting bodies of *Pleurotus ostreatus* mushroom

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## ABSTRACT

The fresh and dried fruiting bodies of cultivated *P. ostreatus* are accomplished by using different chemical analytical methods. The results are showing that the nutritional value is including: energy 236.624 & 56.05 kcal/100g; moisture content 86.33 & 5.155%; also the following constitutes by g/100g DW in fresh and dry samples: dry matters 13.667 & 94.844; total proteins 22.6 & 9.6; amino acids 3.43 & 0.68; total carbohydrates 35.1 & 2.83 and total lipids 0.91 & 0.77. Each of K, Mg, Zn, Na and Cu are determined by mg/100g DW. Antioxidant metabolites are detected and included ascorbic acid 2.395 & 0.6204 g/100g DW in fresh & dry samples, respectively; free phenols are 23.99 & 163.515 and bounded phenols are 2.85 &1.96 µg/100g in fresh & dry samples, respectively. Comparison between the fresh and dry *P. ostreatus* samples appeared that the fresh sample has high nutritional value with highest values in all tested parameters. Also the dry samples had the higher contents of four minerals (1696.25 K, 90.25 Mg, 21 Zn, and 4.5 Cu mg/100g DW comparing to the fresh sample (1402.5 K, 74.25 Mg, 18.25 Zn, and4.0 Cu). On the other side, the levels of each of Fe were 179.75 & 78 and Na 417.7 & 204.25 mg/100g DW, respectively).

**keywords:** *Pleurotus ostreatus*; nutritional value; energy; dry maters; moisture; proteins; carbohydrates; lipids and antioxidant compounds

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## 1. INTRODUCTION

Since human civilization, fruiting bodies of mushrooms (*Agaricus bisporus, Pleurotus sp. and Lentinula edodes*) are appreciated for texture and flavor as well as widely accepted as food flavoring material in soups for centuries. Global production of the cultivated mushroom around the world are 6.2 million tonnes with approximate value at least 14 billion $US in 1997, with a more than 12% increase annually from 1997 to 1981. Paul Stamets is a mycologist who used the tree oyster mushroom names *Pleurotus ostreatus* (Jacq. ex Fr.). *Pleurotus ostreatus* takes the second ranks in the mushroom production around the world. It also represents 70% from the total global mushrooms production [1].

*Pleurotus ostreatus* is very popular wild and cultivated edible mushroom around the world and having a high rank in the market because of low cost, production technology as well as high biological efficiency, nutritional, flavoring and medicinal values. It often has the scent of anise with delicious, texture and high productivity/unit area and has been recognized as an exceptional food source to alleviate malnutrition in developing countries. It is used as a healthy as a nutritive manufacturing. *Pleurotus* has a high biological activity, low toxicity and is used in folk classical medicine, flavor of food industry, perfume, cosmetics and pharmaceutical industries, as defoaming agents and to improve shelf life and safety of minimally processed fruits. Wild *P. ostreatus* favorite for co-customer due to its flavor and texture [2–6].

The highest nutritional value of *P. ostreatus* depend on the presence of high level of protein 25-50%, essential amino acids (arginine, alanine, glutamine, & glutamic acid), carbohydrates 17–47% (no starch, but found the glucans, mannitol, trehalose and it also contains small amounts of arabitol, which may cause gastrointestinal upset for some people [4]), many of vitamins as "thiamine (B1), riboflavin (B2), niacin (B3), folic acid (B9), C, D and K", fibers (7–38%) and ash (8–12%). It has a high contents of minerals such as Ca, P, Fe, K, Mn, Cu, Zn, Mg and Se. *Pleurotus ostreatus* has higher content of iron and acts as a very good iron source for treatment the anemia, it is also very poor in lipid content and have high contents of lovastatin as anticholesterol agents and essentials unsaturated fatty acids including oleic, linoleic, α-linolenic and palmitic. On the other side *P. ostreatus* contains few digestible carbohydrates and very low (calories "each 100 g have 28 k/Cal", 2-5% fats and Na). *Pleurotus* contains high potassium to sodium ratio, which makes it is an ideal food for patients suffering from hypertension and heart diseases [3–10]. *Pleurotus ostreatus* has high nutritional value which reassigns their medicinal value and riches by numerous bioactive antioxidant metabolites. It was used as a traditional oriental medicine and has beneficial health effects without any negative side-effects. It used as a source of powerful new pharmaceutical products and has many bioactive metabolites, specially it possess antioxidant metabolites which used in prevention of many dangerous disease such as anticancer, immunomodulatory, hepatoprotective, antidiabites, antimicrobial, antiinflammatory, support human health agents, anticholesterol and anti-cardiovascular diseases [7–10].

*Pleurotus ostreatus* is efficient lignin cellulosic degraders and can grow on wide variety of agricultural wastes. It has the ability to produce many enzymes such as amylases, pectinases, xylanases, cellulases, chitinases, proteases, lipases, β-galactosidases, inulinase, phytase, protease and laccase with broad adaptability. It is also used in bioremediation industries [9]. *Pleurotus ostreatus* is riches in fatty acid including, myristic, stearic, eleostearic, palmitic, olic, margaric, heptadsenoic, arachidic and icosenoic acids. Fatty acids are important sources of fuel for brain cells, heart and skeletal muscle because when metabolized its yield large quantities of ATP [11]. *Pleurotus ostreatus* could be very useful for vegetarians and helpful to overcome the deficiency in protein and amino acid. It contains the most essential amino acids [5,6].

This investigation has been designed to determine the nutritional value of *P. ostreatus* including energy, total proteins, free amino acids, total carbohydrates, total lipids and mineral analysis. Some antioxidant contents especially ascorbic acid and phenolic compounds were also detected. A comparison between the fresh and dried *P. ostreatus* samples for selecting the highest nutritional value for being consumed as a healthy food and medicinal diet in international medicinal centers for prevention or treatment numerous human diseases which formed from the nutritional deficiency were also aimed.

## 2. MATERIALS AND METHODS

### *2.1. Collection of P. ostreatus samples*

Fresh and air dried samples of *P. ostreatus* were obtained from Agricultural Mushroom Centre, Fac. Agric., Assiut University, Egypt. The spores of *P. ostreatus* were originated and obtained from the Egyptian National Center for Agricultural Ihuth.

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## 2.2. Determination of P. ostreatus nutritional value

Nutritional value of the *P. ostreatus* samples involved total carbohydrates, total lipids, total proteins, ash content. Fresh and dry weight and moisture contents were recorded. Minerals content includes Fe, K, Na, Cu, Zn and Mg was also determined.

### 2.2.1. Determination of the moisture content, fresh and dry matters

Moisture content of the fresh and air dry samples were determined by weighting a portion of the sample and dried in an oven for 24 h at 70°C, then cooled in desiccators and reweighted and the process was continued for up to two successive constant weights. The moisture content was expressed as a percentage of the wet weight by method of Sharma et al [3] and Abeer et al [6].

### 2.2.2. Determination of total carbohydrates

Anthrone-sulphuric acid reagent was used to determine the total carbohydrates according to method of Fales [13]. A calibration curve using pure glucose was made. Anthrone 0.2 g, 30 ml distilled water, 8 ml absolute ethyl alcohol, and 100 ml concentrated $H_2SO4$ (D=1.84) were respectively mixed in a conical flask under continuous cooling in an ice bath. This reagent should be always freshly prepared. Fruiting bodies of the *Pleurotus* samples (200 mg) were mixed with 10 ml 2N HCl in test tubes, heated in boiling water bath for 1 hour. Finally, this solution was cooled, filtered and completed to 10 ml by distilled water. Sample extract (0.1 ml) and 4.5 ml anthrone reagent were thoroughly mixed and boiled in water bath for 7 min., after which it was directly cooled under tap water. The absorbance of the developed blue green color was determined at 620 nm against a blank containing only water and anthrone reagent.

### 2.2.3. Determination of total lipids

The method adapted from that of Kaufmann et al [14] and Handel [15] 50 mg of dry *P. ostreatus* fruiting bodies were homogenized (with a polytron homogenizer) with 4mL chloroform /methanol mixture (1:1v/v) in a handheld ground glass homogenizing tube. The homogenate was centrifuged at 3000 rpm for 5 min. An aliquot (0.25ml) of the supernatant was transferred to a glass tube, being careful to deposit the sample directly at the bottom to the tube. Lipid extract was placed in a heating block set at 100°C to allow the solvent evaporate. Once the solvent is gone about 10 min, 0.1ml of concentrated sulfuric acid is added to each tube, vortexed, and then heated at 100°C for 10 min, then removed from the heat block and allowed to be cooled at room temperature before adding 2.4ml of vanillin reagent (600 mg of vanillin, 100ml of hot water, 400ml of 85% phosphoric acid) and vortexed. After 5min. the absorbance of the pink color developed was measured in Unico UV–2100 spectrophotometer at 490 nm Standard curve was prepared by different concentrations of soybean oil. The data calculated as g/100g DW.

### 2.2.4. Determination of free amino acids

Preparation of *P. ostreatus* extract (0.5 g) were ground to a fine powder in liquid nitrogen and then homogenized in 5 ml of 100 mM potassium phosphate buffer (pH 7.8) and used to determine only the free total amino acids. Free amino acids were determined according to the method of Moore and Stein [16].

***Reagents*:-**

1- Ninhydrin reagent: 0.25 g ninhydrin in 100 ml methanol
2- Citrate buffer: 10.5 g citric in 50 ml 2N NaOH (pH= 5.5)
3- Stannous chloride: 10 mg in 10 ml citrate buffer and 10 ml Ninhydrin reagent
4- Diluent solvent: equal amounts of distilled water and ethanol 95%

Sample extract (0.2 ml) and 1 ml stannous chloride were incubated in boiling water bath for 20 min. then after cooling the absorbance was measured at 570 nm using spectrophotometer (Unico UV-2100 spectrophotometer). A calibration curve was constructed using glycine. The free amino acids concentration was calculated as g/100g DW.

### 2.2.5. Determination of total proteins

Fruiting bodies of *P. ostreatus* samples (0.5g) were homogenized in 10 ml 1 N NaOH in water bath for 30 min. then filtered and completed to a definite volume by distilled water, then determined. A calibration curve was constructed using egg albumin and the data were expressed as g protein/100g DW according to Lowery's method [17]. This method consists of the following reagents.

Reagent A: 2 g sodium carbonate in 100 ml 0.1 N sodium hydroxide.

Reagent B: 0.5 g $Cu_2SO_4.5H_2O$ in 100 ml 1% sodium potassium tartarate.

Alkaline reagent solution: this reagent was freshly prepared by mixing 50 ml of reagent A with 1 ml of reagent B. Five ml of the alkaline reagent solution were added to one ml of the test solution, then mixed and allowed to stand at room temperature for 10 min. Then, 0.5 ml of diluted Folin Ciocalteau's reagent (1: 2 v/v) was added and mixed rapidly. After 30 min., the extinction against appropriate blank was read at 750 nm.

### *2.2.6. Calculation of the energy content of the P. ostreatus*

Nielsen [12] is calculated the energy content of the *P. ostreatus* samples by using following equations:

Energy (Kcal/100g) = (protein×4 + carbohydrate×4 + fat×9).

### *2.2.7 Minerals analysis*

The mixed acid digestion procedure as described by Allen [18] was used for preparing the extracts of *P ostreatus*. Perchloric acid (60%), concentrated nitric and sulphuric acids were mixed in ratio 1:3:1 by volumes. Five ml were used for digestion of 0.2 g of dry tissue. After digestion on hot plate is completed as indicated by white fumes and the sample became colorless, the volume was completed to 50 ml with distilled water. Samples of this solution were taken for atomic determination of the following minerals: Na, K, Cu, Zn, Fe, and Mg. The data were expressed as mg/100g DW. This determination in atomic absorption spectrophotometer as Module 210 vGp in Buck Scientific at Assiut University.

## *2.3. Determination of antioxidant metabolites*

### *2.3.1. Determination of ascorbic acid*

The ascorbic acid was determined according to Jagota et al [19]. *Pleurotus ostreatus* fruiting body's (0.3 g) were ground with liquid nitrogen and suspended in 2 ml of 5% trichloroacetic acid (TCA). The homogenate was centrifuged at 10,000 rpm for 15 min at 4°C. To 0.2 ml of tissue homogenate, 0.8 ml of 10% TCA was added. After vigorous shaking the tubes were kept in an ice bath for 5 min and centrifuged at 3000 rpm for another 5 min. 0.5 ml of the extract was diluted to 2.0 ml using bi-distilled water, and after 0.2 ml of diluted Folin's reagent (commercially prepared Folin–Ciocalteu's reagent of 2 M concentration was diluted 10-fold with bi-distilled water) was added to the extract, the tubes were vigorously shaken. After 10 min. the absorbance of the blue color developed was measured in Unico UV–2100 spectrophotometer at 760 nm. A standard curve was prepared by different concentrations of ascorbic acid.

### *2.3.2 Determination of free and cell wall-bound phenols*

Free and cell wall-bound phenolics were determined according to Kovalvi and Nassuth [20] and Da paz et al [21]. *Pleurotus ostreatus* fruiting body's tissues (0.4 g) were extracted in 50% methanol for 90 min at 80°C. The extract was centrifuged at 14000 rpm for 15 min. and the supernatant was used for free phenolics determination using the Folin-Ciocalteu's phenol reagent. The pellet was mixed with 2 ml of 0.5 N NaOH for 24 h at room temperature to release the bound phenolics, neutralized with 0.5 ml 2 N HCl and centrifuged at 14000 rpm for 15 min. The supernatant was used for bound phenolics estimation using the Folin–Ciocalteu's assay. Two hundred micro-liters of the extracts were diluted to 1 ml with water and mixed with 0.5 ml 2 N Folin–Ciocalteu's reagent and 2.5 ml of 20% Na2CO3. After 20 min. at room temperature, absorbance of samples was measured at 725 nm with a Unico UV–2100 spectrophotometer. Phenolic concentration in the extract was determined from standard curve prepared with gallic acid.

## *2.4. Statistics*

Experiments were performed in three replications. Data have been calculated as means ± standard errors of triplicates (n = 3).

## 3. RESULTS AND DISCUSSION

Nutritional value of the fresh and dried cultivated *P. ostreatus* on rice straw was detected using the different chemical analytical methods and the results were recorded in Table (1) and Figures (1–4). Nutritional value includes total proteins, total carbohydrates, total lipids, fatty acids, ash and energy. Dry matters of the fresh and dry samples were 13.66 and 94.84 g/100g DW, respectively. Kala˘c [22] recorded that the dry matters of the *P. ostreatus* which growing on the different substrates were fluctuated between 88-108.3%. Ahmed et al [23] found

that the dry matters of different strains of *P. ostreatus* cultivated on wheat bran+ sawdust substrate ranged between 10 and 13.8%.

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Moisture contents of the *P. ostreatus* fresh and dry samples were 86.33 and 5.15%, respectively, (Table 1 and Figure 1). Many investigators detected the moisture content of the fresh samples of the growing on different substrates and recorded that the moisture contents were ranged between 86.6 and 90.9% [5,6,23,24].

Energy levels of the fresh and dry samples of *P. ostreatus* were 236.624 and 56.05 Kcal/100g respectively (Figure 1 and Table 1). Energy levels of the *P. ostreatus* samples ranged between 363-416 Kcal/100g are calculated many Authors [3,6,22].

The protein content recorded in fresh and dry of *P. ostreatus* samples were 22.6 and 9.6 g/100g DW (Table 1 and Figure 1). Fresh samples of *P. ostreatus* growing on different substrates had protein content with range between 9.6 and 70.2% [3-6, 10, 22–24]. Total amino acids found in the fresh and dry fruiting bodies of *P. ostreatus* were 3.427 and 0.675g/100g DW, respectively. Twenty kinds of amino acids were detected in *Pleurotus* samples grown on the different substrates by many investigations and includes alanine (18.5–25.1), arginine (20.6–64), asparagine (137), aspartic acid (137), cysteine (3.2–6), glutamic acid (56.8–153), glutamine (4.6–97), glycine (7–11.8), histadine (12.2–56), isoleucine (14.6–29), leucine (26.5–98), lysine (18.9–64), methionine (3.2–8), phenylalanine (16.5–75), proline (0.01–16.8), serine (0.12–18.5), threonine (1.16–32.5), tryptophan (0.11–6.9), tyrosine (0.18–12.8) and valine (0.24–30.1) mg/g [6,7].

Total carbohydrates contents of the fresh and dry samples were 35.098 and 2.839 g/100g DW,b respectively, (Table 1 and Figure 1). The total carbohydrates recorded by several Authors of the fresh samples of *P. ostreatus* growing on different substrates are ranged between 17.5 and 85.86% [4,24]. *Pleurotus ostreatus* fruiting bodies had different kinds of carbohydrates includes β-glucans, chitin, mannitol, glucose, mannose, trehalose, fructose and ribose as recorded by Kala˘c [22].

Low lipids content were detected in fresh and dry samples of *P. ostreatus*: 0.91 and 0.77 g/100g DW, respectively, (Table 1 and Figure 1). The total lipids recorded in this investigation are the lowest level when compared with many other studies on *P. ostreatus* which recorded total lipids ranged between 1.03–5.45% [3-10]. *Pleurotus ostreatus* is becoming more important in our diet for their nutritional, organoleptic, and pharmacological characteristics. Based on their high mineral content, low fat, and low calories, the nutritional values of mushrooms have already been reevaluated. Additionally, *P. ostreatus* is preventing several diseases such as cancer, hypercholesterolemia, and hypertension. Dietary fat is a major constituent of the normal diet and thus a tight feedback regulator, is necessary to ensure balanced lipid homeostasis. Generally, lipid content of mushroom species is low. It is reported that, in fresh mushrooms belonging to different species, the lipid proportion per 100g is 1.7–15.5% in dried mushroom since fresh ones contain high amounts of water [24].

Abeer et al [6] studied the fatty acid profile of fruiting bodies of *P. ostreatus* and found that total saturated fatty acids are 19.0 units. Different kinds of the fatty acids were detected in *P. ostreatus* includes butyric, caproic, caprilic, capric, undecanoic, lauric, tridecanoic, myristic, myristoleic, entadecanoic, pentadesenoic, palmitic, palmitoleic, margaric, heptadesenoic, stearic, trans–oleic, cis–oleic, trans–linoleic, cis–linoleic, linolenic, gamma, arachidic, eicosenoic, eicosadienoic, heneicosanoic, $n$=3*ci*–11,14,17–eicosatrienoic, arachidonic, $n$=6*cis*–8,11,14-eicosatrienoic, behenic, erucic, docosadienoic, tricosanoic, lignoseric-docosa hexaenoic acids [6,22,24].

Eman and Farghaly [7] detected many kinds of free fatty acids in the same fresh and dry samples of the P. ostreatus by GC/MS analysis of the ethanolic extract and recorded the presence of linoleic 29.19, lauric 0.21, myristic 0.32, oleic 0.05, palmitic 6.98 and pelargonic 0.04 mass fractions.

Maximum levels of the different kinds of essential macro- and micro- elements detected in the ash of *P. ostreatus* includes (Cu 4.0, Na 417.75, Zn 18.25, Mg 74.25, Fe 179.75 and K 14025.5) in fresh sample but the dried sample contains (Cu 4.5, Na 204.25, Fe 78, Zn 21, Mg 90.25, K 1696.25) mg/100g DW Table (1) and Figure (2). Many references are studied minerals content of *P. ostreatus* fruiting bodies and recorded that N 49, Mg 37.1, Fe 46.8, P 10.96, Ca 3.4, K 43.4, Cl 1.8, S 6, Cu, Zn, Mn 2.6 and Na mg/100ml [5,22,23].

Table (1) and Figure (3&4) clearing that the antioxidant compounds in *P. ostreatus* includes ascorbic acid (2.395 and 0.6204 g/100g DW in fresh and dry samples, respectively) and free phenolic compounds (23.99 and 163.515 µg/100g FW in fresh and dry samples, respectively) and bound phenolic compounds (2.85 and 1.965 µg/100g FW in fresh and dry samples, respectively). Many Authors proved that *P. ostreatus* has many antioxidant metabolites which include ascorbic acid, $\beta$–carotene, lycopene, and $\gamma$–tocopherol and polyphenols includes flavan–3–ols, flavonols, and tannins. Antioxidant metabolites act as scavenger the free radicals, metal chelating properties, capability of inhibiting or reducing different enzymes. Antioxidant metabolites act as a defense against microbes and biotic stress (pollutants and UV radiation) and it have numerous pharmacological properties including

anticancer, antiinflammatory, antihypertensive, antidiabetes, anticholesterols, immunomodulatory, antimicrobial, antioxidant, antimutagenic, antiallergenic, haematological, cardiovascular diseases, atherosclerosis, Alzheimer disease and also used in nutritive manufacturing as a preservatives [25-28].

## 4. CONCLUSION

*Pleurotus ostreatus* has high content of essential fatty and amino acids, proteins, carbohydrates and some minerals content (K, Mg, Fe and Zn). According to this study, fruiting bodies of *P. ostreatus* has high nutritional, flavoring and medicinal value and it can be regarded as popular healthy foods for prevention and treatment numerous human diseases. Also, it has lower amount of Cu, Na, calories, fat and Na. So, it can be recommended for people suffering from high cholesterol and cardiovascular diseases. Increasing the content of antioxidant compounds in this mushroom increasing their medicinal value, Fresh sample has the highest nutritional value and riches by iron as compared with dry sample.

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**Table1. Nutritional value of the fresh and dry fruiting bodies of *P. ostreatus* samples. Presented data are means of three replicates ±SE (n = 3).**

| Tested Parameters | | | Fresh | Dry |
|---|---|---|---|---|
| % | | Moisture content | 86.33±2.605 | 5.155±0.0706 |
| Nutritional value | g/100gDW | Dry matter | 13.667 ±2.605 | 94.84 ±0.122 |
| | | Total carbohydrates | 35.098±3.464 | 2.839 ±0.2530 |
| | | Total proteins | 22.6 ±0.33 | 9.602 ±0.64 |
| | | Free amino acids | 3.427±.602 | 0.675±0.046 |
| | | Total lipids | 0.91 ±0.092 | 0.77 ±0.152 |
| | kcal/100g | Energy | 236.624 ± 21.9278 | 56.05±6.55 |
| Minerals | mg/100g | K | 1402.5 | 1696.25 |
| | | Mg | 74.25 | 90.25 |
| | | Fe | 179.75 | 78 |
| | | Zn | 18.25 | 21 |
| | | Na | 417.75 | 204.25 |
| | | Cu | 4.0 | 4.5 |
| Antioxidants | g/100g DW | Ascorbic acid | 2.395 ± 0.28 | 0.6204 ±0.1867 |
| | µg/100g FW | Free phenolic comp. | 23.99 ±1.73 | 163.515 ±1.0157 |
| | µg/100g FW | Bound phenolic comp. | 2.85 ±0.47 | 1.9656±1.65 |

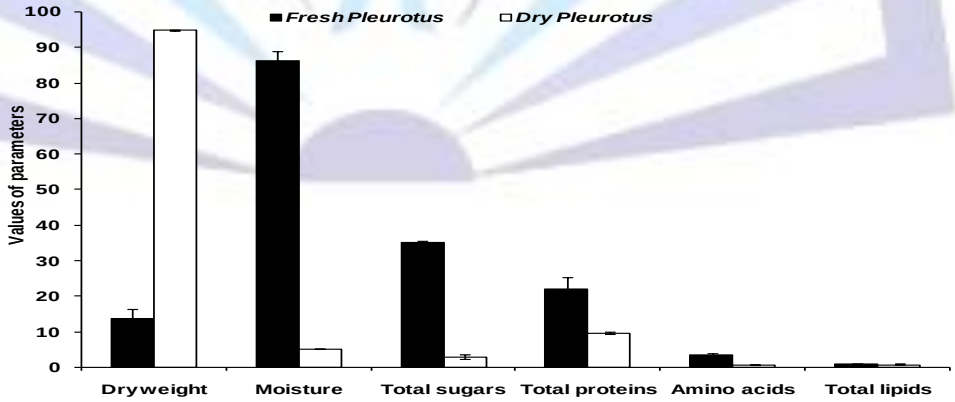


**Fig1: Values of analytical parameters determined in the fresh and dry fruiting bodies of *P. ostreatus* samples (moisture % of fresh weight, all the tested parameters calculated as g/100gDW). Presented data are means of three replicates± standard error.**

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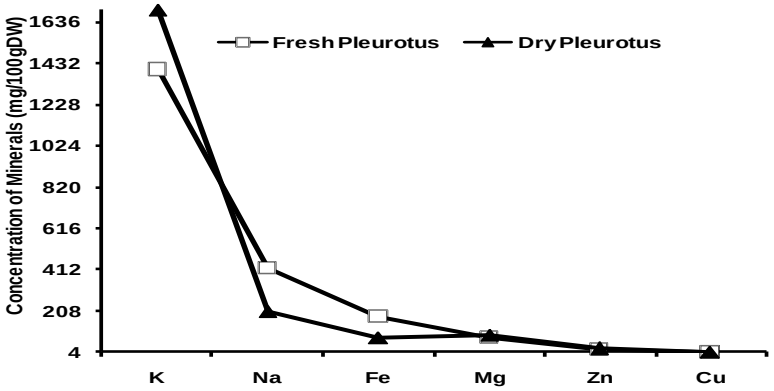


**Fig 2: Minerals content (mg/100g DW) in the fresh and dry fruiting bodies of *P. ostreatus* samples.**

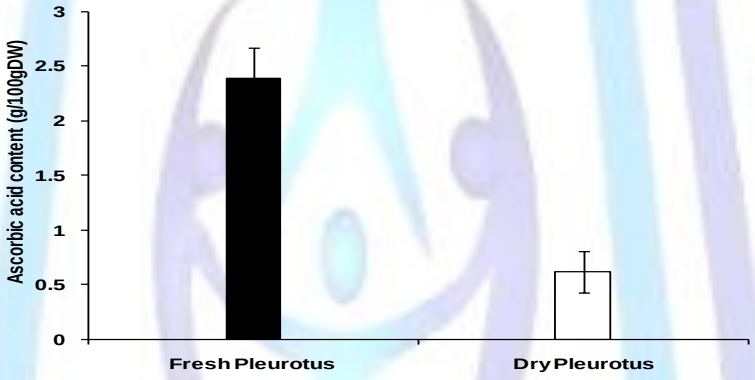


**Fig3: Ascorbic acid content (mg /100g DW) in the fresh and dry fruiting bodies of *P. ostreatus* samples. Presented data are means of three replicates± standard error.**

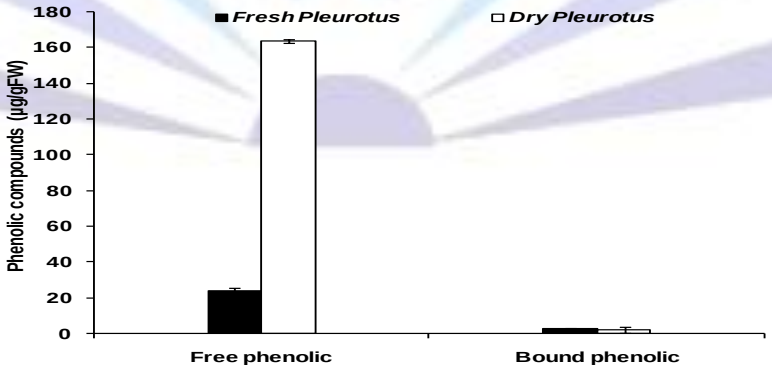


**Fig 4: Free and bound phenolic compounds (µg/100g FW) in the fresh and dry fruiting bodies of *P. ostreatus* samples. Presented data are means of three replicates± standard error.**