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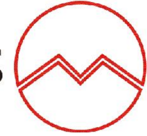

Effects of Some Preservation Methods on the Nutrient and Mineral Compositions of Three Selected Edible Mushrooms

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Abstract: The global commercial mushroom production today is increasing yearly. To enhance the supply, many food processing industries normally provide a wide range of canned and processed edible mushroom products such as frozen, sterilized, dried, pickled, marinated and salted mushrooms in forms of mushroom powder, paste, concentrates and extracts. This study was therefore aimed at investigating the effects of popular preservation methods on the nutrient and mineral compositions of three selected oyster mushrooms of economic importance (*Pleurotus ostreatus*, *Pleurotus florida* and *Pleurotus sajor*-caju). Fresh mushroom samples were purchased from mushroom farms; each mushroom was shared into five different groups and processed as fresh, refrigerated, sundried, oven dried and micro-wave dried groups, they were thereafter analyzed for nutrient and mineral compositions. The results obtained revealed that the preservation method had significant effects on the nutrient and mineral compositions of the mushroom samples. Notably, the lowest weight values were obtained from the sundried mushroom samples while the highest value was obtained from the fresh samples. The microwave mushroom samples were richer in nutrient and mineral compositions as compared to the other three preservation methods but in all lower than the fresh samples. It is therefore concluded that the preservation methods had effects on the nutrient and mineral contents of mushrooms. However, if there is need for preservation of excess mushrooms, preservation through micro-wave drying is recommended best among the four processing methods for mushrooms preservation since it was able to retain the highest value of protein in all the studied mushrooms.

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1. Introduction

Mushrooms are the fruit bodies of fungi generally known as macrofungi (Cheung, 2008). They include members of Basidiomycota and some members of Ascomycota. Fleshy fruit bodies and hymenia are usually borne on gills with ephemeral structures (Ramsbottom, 1989), edible fruit bodies are commonly called mushrooms while the poisonous species are referred to as toadstools. The two groups are morphologically not distinguishable but they often differ in chemical composition (Adedayo, 2011). The number of recognized mushroom species has been reported to be 14,000, which is about 10 % of the total estimated mushroom species on earth ((Ramsbottom *et al*., 1989; Cheung, 2008; Koushki *et al*., 2011). The most cultivated mushrooms worldwide are *Agaricus bisporus*, *Lentinus edodes, Pleurotus spp, Auricula auricular, Flamulina velutipes* and *Volvariella volvacea* (Aida *et al*., 2009), they are source of nutrient and mineral salts according to Zoberi (1972 and 1973) and Jonathan *et al* (2016a-c and 2012). These authors reported various edible mushrooms which are rich in ascorbic acid, amino acids, protein, minerals (Ca, P, Fe, K, Na) and glycogen.

Mushrooms are free of cholesterol, contains low fat and small amount of B vitamins. They are one of the few natural sources of vitamin D, which is essential for healthy bones and teeth. Mushrooms are a good source of B vitamins for people who don’t eat meat, riboflavin (B_2), niacin (B_3) and pantothenic acid (B_5). These vitamins help break down proteins, fats, carbohydrate so they can be used for energy (Duyff, 2006). Owing to their attractive taste, aroma and nutritional values, edible mushrooms are valuable

components of the diet (Czapski, 2003; Vetter, 2003). Mushrooms have good quality proteins with lysine and tryptophan. The carbohydrates in the mushrooms are at a level of 4.5 to 5.0% but are in the form of glycogen, chitin and hemicelluloses instead of starch (Duyff, 2006). Mushrooms have also been used not only as a source of food but medicinal value as well (Aida *et al*., 2009; Jonathan *et al*., 2016a-c).

The consumption of mushrooms throughout the year, particularly of mushroom species harvested in natural habitats is made possible through the use of appropriate processing methods. The food processing industry provides a wide range of canned and processed mushroom products, including frozen, sterilized, dried, pickled, marinated and salted mushrooms, mushroom powder, paste, concentrates and extracts (Bakowski and Michalik, 1982; Vivar-Quitana *et al*., 1999; Kondratowicz and Kowalko, 2000; Czapski, 2003). Edible mushrooms in fresh, cooked or processed forms are nutritionally sound, tasteful food source for most people and can be a significant dietary supplement for vegetarians (Breene, 1990). Unfortunately, freshly harvested mushrooms have short shelf life and are highly perishable, seasonal availability occurs in the case of forest mushrooms.

This chiefly concerns wild mushrooms but also applies to cultivated species (Burton and Noble, 1993; Tseng and Mau, 1999; Czapski, 2000). Hence, in periods when supply exceeds demand, processing is recommended. This study is therefore aimed at investigating the effects of some available preservation methods on the nutrient and mineral compositions of three selected edible mushrooms.

2. Materials And Methods

2.1Sources of mushrooms

Three oyster mushrooms of economic importance were selected for this study; they include *Pleurotus ostreatus*, *Pleurotus florida* and *Pleurotus sajor-caj*. *Pleurotus ostreatus* samples were purchased from a mushroom farmer at Odo-Ona, Ibadan, while *Pleurotus florida* and *Pleurotus sajor caju* were obtained from the Pathology Unit of Forestry Research Institute of Nigeria. They were identified and authenticated at the Forestry Research Institute of Nigeria (FRIN) Pathology Unit. These mushrooms were selected based on their availability at the time of this research. Sawdust of *Milicia excelsa* was used as cultivation substrate for *P. ostreatus* while sawdust of *Gmelina arborea* was used as cultivation substrate for *P. florida* and *P. sajor caju.*

2.2 Experimental location

The samples were prepared at the Pathology Laboratory of the Department Botany, University of Ibadan, Nigeria. Nutrient and mineral analyses of the samples were carried out at SMO consult, Ibadan, Nigeria.

2.3 Sterilization of equipment

All glass wares used in the experiment were washed with detergents, rinsed with sterile distilled water and allowed to dry except the 250ml extraction flask which was dried in the oven at 105-110 ^{0}C. Working benches were sterilized by swabbing them with cotton wool soaked with 70% ethanol.

2.4 Experimental design

The freshly harvested mushroom samples were analyzed at the stage of collection; they were subjected to different processing methods and then re-analyzed after a period of time to observe the effect of processing methods on their mineral contents. Immediately after the procurement of the freshly harvested edible mushrooms, each mushroom was shared into five different groups representing fresh, refrigerated, sundried, oven dried and micro-wave dried groups. The groups for refrigeration were kept in a plastic container and refrigerated at 4^{0}C for 5 days in a refrigerator manufactured by Midea Industries, the sundried groups were left to dry in the open air for 5days, the oven-dried groups were dried in an oven manufactured by Masterchef industries at 50^{0}C for 48 hours while the micro-wave dried groups were dried at 40^{0}C for 48 hours in a micro-wave manufactured by Eurosonic industries.

These mushrooms were mashed each with mortal into flake-form before they were digested and analyzed in the laboratory according to each mushrooms and groups. The freshly harvested groups as controls were mashed with mortal into paste form and analyzed immediately for nutrient analysis and mineral contents. The experiment was done in triplicates in Complete Randomized Design (CRD).

2.5 Nutrient analysis

Determination Crude protein: The crude protein in the samples was determined through the estimation of total nitrogen by Kjeldahl procedure. The amount of crude protein was obtained by multiplying the nitrogen content by 6.25. This factor was based on the assumption that all feed proteins contain 16% nitrogen and nitrogen present in the tissue is presented as protein. The protein content may vary in nitrogen content from 13 to 18%.

Determination of Total Nitrogen: The total Nitrogen was determined according to the method of Bradstreet (1965). 0.2g of each mushroom sample was weighed carefully into the digestion tubes to ensure that all sample materials got to the bottom of the tubes. Kjeldahl catalyst was added followed by the addition of 5ml of Conc. H_2SO_4, and digested at 350°C until the solution becomes clear. The block was removed from the digester to cool. About 50ml distilled water was added and the content was mixed vigorously. The

mixture was poured into a 100ml flask and made up to mark. The flask was properly shaken and allowed to cool and settle down.

Determination of crude fat: The crude fat in the samples was determined according to the method of AOAC (2003). The fat content in plant tissues is generally extracted with petroleum ether using Soxhlet extraction method. The volatile oils and resins are of little nutritional value. 1gm of each dried sample was weighed into fat free extraction thimble and pug lightly with cotton wool. The thimble was placed in the extractor and fitted up with reflux condenser and a 250ml soxhlet flask, which has been previously dried in the oven at 105-110°C and cooled in the dessicator. The soxhlet flask was then filled to ¾ of volume with petroleum ether (b.pt 40° – 60°C), and the soxhlet flask. Extractor plus condenser set was placed on the heater. The heater was put on for six hours with constant running water from the tap for condensation of ether vapour. The set was constantly watched for ether leaks and the heat source is adjusted appropriately for the ether to boil gently. The ether was left to siphon over several times say over at least 10 – 12 times until it is short of siphoning. It was after this was noticed that any ether content of the extractor was carefully drafted into the ether stock bottle. The thimble containing sample was then placed into the condenser and extracted for about 5-6 hours. The flask containing the fat was detached, its exterior cleaned and dried to a constant weight in the oven.

Calculation

- Weight of empty thimble = W_o
- Weight of thimble + ground sample = W_1
- Weight of ground sample = $W_1 - W_o$
- Weight of empty extraction flask = W_2
- Weight of extraction flask + ether = W_3
- Weight of ether (fat or oil)

$$\% \text{ fat} = \frac{W_3 - W_2}{W_1 - W_0} \times 100$$

Determination of crude fibre: The crude fibre was determined according to the method of Cuniff (1995). 0.50g of the ground sample was weighed into a 1 litre conical flask (W_o). 200ml of boiling 1.25% H_2SO_4 was added and boiled gently for 30 minutes using cooling fingers to maintain a constant volume. The mixture was filtered through muslin cloth stretched over 9cm Buchner funnel and was rinsed well with hot distilled water. The material was scraped back into flask with spatula. 200ml of boiling 1.25% of NaOH was added and allowed to boil gently for another 30 minutes using cooling fingers to maintain a constant volume. The mixture was filtered through muslin cloth and the residue was washed thoroughly with hot distilled water, rinsed once with 10% HCl and again with industrial methylated spirit. The mixture was finally rinsed three times with petroleum ether (BP 40-60°C) and allowed to drain dry. The residue was scraped into a crucible, dried overnight 105°C in the oven and cooled in the desiccator. The sample was weighed (W_1) and dried to ash at 550°C for 90 minutes in muffle furnace, cooled in a desiccator and weighed again (W_2).

Calculation

$$\% \text{ Crude fibre} = \frac{W_1 - W_2}{W_0} \times 100$$

Determination of soluble carbohydrate: The soluble carbohydrate was determined using the nitrogen-free extraction procedure of FAO (2003). The nitrogen-free extractive (NFE) referred to as soluble carbohydrate is not determined directly but obtained as a difference between crude protein and the sum of ash, crude fat and crude fibre.

NFE = 100 – (% ash + crude fibre + % crude fat + crude protein).

Determination of moisture: The moisture in the samples was determined according to the method of AOAC (2003). The moisture in the samples was determined according to the method of AOAC (2003). The weight of the empty crucible was taken W_o, 2g of the sample was added into the crucible and it was weighed (W_1). The sample and crucible was placed in the drying oven and dried at 105-110°C for 24 hours, and cooled in a desiccators. The weight of the crucible with the dried sample was taken W_2 and it was further dried for another 24 hours to make sure the drying was complete and was weighed again.

Calculation:

$$\text{Moisture} = \frac{W_1 - W_2}{W_1 - W_0} \times 100$$

Determination of ash: The determination of ash was carried out according to the method described by AOAC (2003). The empty crucible was weighed W_o and 2g of the sample was added into it and weighed as well (W_1). The sample in the crucible was placed in the muffle furnace to ash at 500-600°C and cooled in the dessicator. The crucible and the ash sample was weighed W_2.

$$\% \text{ Ash} = \frac{W_1 - W_0}{W_1 - W_0} \times 100$$

2.7 Analysis of the Mineral compositions

Mineral analyses of some metal ions were carried out following the procedure of Milner and Whitside (1981). 0.5g of the sample was weighed into the digestion tubes. 10ml of $HNO_3/HClO_4$ acid (2:1) was added to it. It was digested at 150°C for one and a half hours. The temperature was increased to 230°C and 2ml of HCl/Distilled H_2O (1:1) was added and heated for another 30 minutes. The mixture was removed from heat, allowed to cool before been washed into a standard 100ml volumetric flask and made up to the mark with distilled water. Potassium, sodium and calcium were determined by flame photometry from wet digestion. Magnesium, zinc and iron were

determined by Atomic Absorption Spectrophotometry from wet digestion.

2.8 Statistical Data Analysis

The data obtained was analysed using SPSS version 16 and mean was separated by Duncan's multiple range test (DMRT).

3. Results and Discussions

The results of the various analyses of the samples showed that the preservation methods had significant effects on the nutrient and mineral compositions of the mushroom samples (Tables 1 and 2); all the samples had higher moisture content when fresh and refrigerated (Tables 3-5). Mushrooms are generally high in moisture content, which are approximately 90 % of their fresh weight after harvest. This accounts for their short shelf life as they deteriorate easily (Fasidi and Kadiri, 1993, Kim *et al*., 2006, Zahid *et al*., 2010). It was observed that the fresh samples are richer in nutrient and mineral contents as compared to the processed samples. Mushrooms are considered good source of superior quality protein with well distributed essential amino acids (Patil *et al*., 2010). The lowest weight value was obtained from the sundried sample of *P. florida* (Table 5) while the highest value was obtained from the fresh sample of *P. florida*. This agrees with the observation made by James (1995) which indicated that protein content of edible mushroom in dry weight is about 19-40%.

Fresh mushrooms usually contain less fat, the amount being 1-8 % of dry weight (Breene, 1990, Zahid *et al*., 2010). Fat content of *P. sajor caju* in the present study showed different values from the reported value by Chang *et al*. (1981) who reported lower fat content in *P. sajor caju*, that is between 1.7-2 % compared to other mushrooms however, fat content of *P. sajor caju* in this study was higher (2.88 %) compared to *P. florida* which is lower (2.57 %). Available carbohydrate are second major nutrient component of mushrooms.

Table 1: Mean Square Effects of preservation on nutrient composition of the mushroom

Source of variation	DF	Crude Protein	Crude Fat	Crude Fibre	Total Ash	Moisture content	Carbohydrate
Preservation	4	52.79**	0.55**	5.81**	132.00**	18571.79**	125.09**
Mushrooms	2	6.91**	0.19**	1.56**	0.49**	2.28*	4.89 ns
Errors	30	1.27	0.43	0.76	0.004	0.51	12.18

**= highly significant, *= significant, ns= not-significant (p>0.05)

Table 2: Mean Square Effects of preservation on mineral composition of the mushrooms.

Source of variation	DF	Calcium	Magnesium	Potassium	Sodium	Iron	Zinc
Preservation	4	2.87**	13.77**	62.94**	28.38**	7.84**	2.57**
Mushrooms	2	43.20**	868.71**	1348.67**	3640.21**	23.48**	11.51**
Errors	30	0.74	1.19	0.19	0.39	0.15	0.05
Total	45						

**= highly significant, *= significant, (p>0.05)

The findings from the result also showed that refrigerated mushroom samples were richer in nutrient and mineral compositions as compared to the other three preservation methods (Table 3, 4 and 5) and this agrees with the report of (Oei, 1991) who observed higher carbohydrate content in refrigerated mushrooms. Furthermore, when comparing dried mushroom to fresh or refrigerated mushrooms, protein content of fresh mushrooms were higher than the refrigerated and the dried mushrooms. From this study, *P. florida* and *P. ostreatus* were both significantly different in crude protein (Table 1), this is in accordance with the finding of Pehrsson *et al* (2003), Zahid *et al* (2010) and Jonnathan et al. (2017). Ash content was found to be highest in the micro-waved sample of *P. sajor-caju* (Table 4) while it was lowest in the fresh sample of *P. ostreatus* (Table 3) is not in agreement with the report of Ayodele *et al* (2011) who observed higher ash content in fresh sample of mushrooms than the preserved sample.

Mushrooms are valuable sources of dietary fibre (chandravadana *et al*., 2005). Dietary fiber content in the four preservation methods were found to be in a comparable range but they differ significantly across the three *Pleurotus* species (Table 1). The highest dietary fibre content was found in fresh sample of *P. ostreatus* (Table 3), while the lowest dietary fibre content was found in *P. florida* after refrigeration

(Table 5), in support of the report made by Breene (1990) who observed the presence of dietary fibre in mushrooms. In this study, we found that the *Pleurotus* species were able to retain almost all their nutrient compositions after preservation, in agreement with the values reported in previous studies of Oei (1991) and Plaza *et al* (1995).

A study of the mineral element content in some edible mushrooms revealed that *Pleurotus* species were good sources of Potassium, Calcium, Sodium, Magnesium, Iron and Zinc (Gupta, 1998). Calcium, Magnesium, Sodium content in the mushrooms were found to have lower values (Table 6,7,8) when compared to the observations made by Plaza *et al* (1995).

Amongst the preservation methods, micro-waved drying retained the highest content of Crude protein in *P. sajor caju* (24.20) and *P. ostreatus* (26.32) as supported by Asemoloye et al. (2017). Total ash and crude fat in all the three species of *Pleurotus* used in this study showed the presence of total ash and crude fat in mushrooms, which agrees with the report made by Zahid *et al* (2009). Micro-waved drying method also retained the highest content of calcium (23.89), sodium (124.89), iron (16.96) and zinc (3.51) in *P. ostreatus*, the highest content of calcium (26.07), sodium (148.92), potassium (952.14) and zinc (2.10) in *P. sajor-caju*. This shows that the minerals were not significantly affected by the heat from the micro-wave, compared to other preservation methods. This is not in agreement with the report of Ayodele *et al* (2011) who observed that sun-drying method of preservation was able to retain more minerals in mushrooms.

However, sun-drying method of preserving mushrooms was found to have retained the highest content of carbohydrate in *P. florida* and *P. ostreatus*. This agrees with the report of Ayodele *et al* (2011).

Table 3: Effect of different preservation methods on nutrient composition of *Pleurotus oestratus*

	Crude Protein	Crude Fat	Crude Fibre	Total Ash	Carbohydrate	Moisture Content	Dry Matter.
Fresh	28.71±0.61[a]	2.87±0.17[a]	8.47±0.24[a]	1.11±0.03[c]	58.48±0.98[b]	90.71±0.03[a]	9.28±0.03[c]
Refrigerated	25.47±0.82[c]	2.10±0.15[c]	6.55±0.18[c]	0.88±0.02[d]	61.74±6.18[a]	92.20±0.02[a]	7.79±0.02[d]
Sundried	23.58±0.09[d]	2.26±0.14[b]	7.00±0.02[b]	7.21±0.03[b]	63.15±5.33[a]	8.81±0.02[b]	91.18±0.02[b]
Oven-dried	23.58±0.09[d]	2.45±0.05[b]	6.81±0.03[b]	9.13±0.02[a]	58.16±0.92[b]	6.05±0.07[c]	93.95±0.07[a]
Micro-waved	26.32±0.22[b]	2.68±0.03[a]	6.88±0.04[b]	9.18±0.02[a]	57.65±0.39[c]	8.02±0.03[b]	91.98±0.03[b]

Values with the same letter in each column are not significantly different at ($P<0.05$).

Table 4: Effect of different preservation methods on nutrient composition of *Pleurotus sajor caju*

	Crude Protein	Crude Fat	Crude Fibre	Total Ash	Carbohydrate	Moisture Content	Dry Matter.
Fresh	26.25±1.11[a]	2.88±0.26[a]	7.15±0.67[a]	1.96±0.08[c]	61.74±1.48[b]	89.11±0.70[a]	10.89±0.70[c]
Refrigerated	23.16±0.43[c]	2.25±0.34[c]	6.35±0.27[b]	1.82±0.04[c]	66.42±0.98[a]	90.98±0.15[a]	9.01±0.15[c]
Sundried	22.67±1.15[d]	2.61±0.33[b]	6.54±0.03[b]	7.21±0.04[b]	60.95±0.48[b]	7.75±1.16[b]	91.25±0.11[b]
Oven-dried	24.14±0.10[b]	2.77±0.14[b]	6.84±0.08[a]	8.96±0.15[a]	57.28±0.31[c]	6.55±1.13[c]	94.09±0.09[a]
Micro-waved	24.20±0.23[b]	2.94±0.04[a]	6.82±0.06[a]	9.21±0.05[a]	56.82±0.32[c]	7.79±0.15[b]	92.22±0.13[b]

Values with the same letter in each column are not significantly different at ($P<0.05$)

Table 5: Effect of different preservation methods on nutrient composition of *Pleurotus florida*

	Crude Protein	Crude Fat	Crude Fibre	Total Ash	Carbohydrate	Moisture Content	Dry Matter.
Fresh	28.77±4.02[a]	2.57±0.46[b]	6.52±0.65[a]	1.92±0.04[c]	62.74±0.78[b]	88.62±1.76[b]	11.35±1.76[b]
Refrigerated	24.97±0.16[c]	2.39±0.14[c]	5.81±0.24[b]	1.86±0.04[c]	61.69±8.97[b]	91.13±0.06[a]	8.86±0.06[c]
Sundried	21.97±0.13[c]	2.24±0.08[c]	6.56±0.04[a]	7.32±0.04[b]	64.56±4.81[a]	8.97±0.04[c]	91.02±0.04[a]
Oven-dried	23.75±0.07[b]	2.69±0.07[a]	6.88±0.03[a]	8.73±0.07[a]	59.33±2.40[c]	6.05±0.07[d]	93.94±0.07[a]
Micro-waved	23.77±0.25[b]	2.78±0.03[a]	6.77±0.08[a]	9.18±0.02[a]	57.65±0.39[c]	7.93±0.08[c]	92.22±0.13[a]

Values with the same letter in each column are not significantly different at ($P<0.05$).

Mineral content of *Pleurotus* species varied considerably in all the preservation methods, the values were significantly close to the values of the fresh mushroom samples, indicating that the preservation methods were effective in retaining the mineral content of the mushrooms.

The results indicated that the micro-wave method of preservation was the best in retaining the nutrient and mineral content of the *Pleurotus* species followed by the refrigeration method.

Table 6: Effect of different preservation methods on mineral composition of *Pleurotus sajor caju*

	Calcium	Magnesium	Sodium	Potassium	Iron	Zinc
Fresh	26.48±0.04[a]	128.77±0.27[a]	150.96±0.13[a]	953.60±0.54[a]	20.57±0.54[a]	2.98±0.07[a]
Refrigerated	26.08±0.10[b]	127.07±0.09[b]	148.02±0.10[c]	951.93±0.16[b]	18.01±0.13[c]	1.96±0.19[c]
Sundried	25.01±0.09[c]	125.50±0.15[d]	145.20±0.75[c]	950.69±0.68[c]	18.51±0.51[c]	1.48±0.17[c]
Oven-dried	25.52±0.02[c]	126.95±0.24[b]	148.61±0.17[b]	950.89±0.96[c]	18.64±0.95[c]	1.98±0.11[c]
Micro-waved	26.07±0.11[b]	126.28±0.40[c]	148.92±0.40[b]	952.14±2.24[b]	19.64±0.41[b]	2.10±0.40[b]

Values with the same letter in each column are not significantly different at (P<0.05).

Table 7: Effect of different preservation methods on mineral composition of *Pleurotus ostreatus*

	Calcium	Magnesium	Sodium	Potassium	Iron	Zinc
Fresh	24.57±0.09[a]	137.45±0.37[a]	129.05±0.07[a]	974.27±0.25[a]	18.03±0.06[a]	3.60±0.24[a]
Refrigerated	23.09±0.07[b]	135.80±0.23[c]	125.04±0.10[b]	972.20±0.33[b]	16.00±0.07[c]	2.31±0.32[c]
Sundried	21.07±0.07[d]	135.32±0.22[c]	123.01±0.13[c]	963.23±0.89[d]	16.77±0.04[b]	3.38±0.03[b]
Oven-dried	21.01±0.03[d]	128.86±0.13[d]	122.13±0.63[d]	964.39±0.51[d]	15.93±0.32[d]	3.49±0.10[a]
Micro-waved	23.89±0.01[c]	136.04±0.07[b]	124.89±0.15[b]	968.79±1.18[c]	16.96±0.05[b]	3.51±0.06[a]

Values with the same letter in each column are not significantly different at (P<0.05).

Table 8: Effect of different preservation methods on mineral composition of *Pleurotus florida*

	Calcium	Magnesium	Sodium	Potassium	Iron	Zinc
Fresh	23.27±0.11[a]	121.01±0.98[a]	120.64±0.56[a]	970.90±0.24[a]	18.13±0.10[a]	2.17±0.11[a]
Refrigerated	22.00±0.05[c]	120.28±0.29[b]	118.01±0.07[c]	965.90±0.15[c]	17.03±0.05[b]	1.95±0.08[b]
Sundried	22.87±0.04[b]	118.38±0.57[c]	116.46±0.27[d]	966.75±1.91[b]	16.51±0.58[d]	1.87±0.25[c]
Oven-dried	22.57±0.02[b]	115.17±1.75[d]	118.27±1.49[c]	964.18±1.27[d]	16.84±0.19[d]	1.98±0.45[b]
Micro-waved	22.99±0.12[a]	120.19±0.30[b]	119.47±1.84[b]	966.30±0.89[b]	17.59±1.93[c]	2.04±0.12[a]

Values with the same letter in each column are not significantly different at (P<0.05).

4. Conclusion

The preservation methods had effects on the nutrients and mineral content of the mushrooms with irrespective of the species as they showed lower reduced nutrient and mineral compositions as compared to the fresh samples. However, among the preserved mushroom samples, the refrigerated samples had higher carbohydrate, moisture content, magnesium, sodium and potassium contents while micro-wave preserved mushrooms had higher in crude protein, ash, fat, calcium, sodium, zinc, and potassium. Therefore, it is concluded that the fresh mushrooms are better than preserved mushrooms. However, if there is need for preservation for excess mushrooms, preservation through micro-wave drying is the best since it was able to retain the highest value of protein and this is recommended for mushrooms preservations.

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