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Assessment of Nutritional Profile of the Edible Mushrooms

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ABSTRACT

Background: With the increasing awareness in public on health and nutrition, mushrooms have gained more popularity in recent times for its nutritional, health benefits and culinary value. These are excellent source of vitamins and minerals. Hence, often called as “White Vegetable” They are regarded as one of the superfoods due to their high nutrient content as well as their healing properties.

Methods: The present study was carried with the objective of analysing the macronutrients and mineral composition of three edible mushroom varieties *i.e.,* Oyster mushroom-*Hypsizygus ulmarius* (Elm oyster mushroom); Milky mushrooms- *Calocybe indica* and APK2.

Result: Study results revealed that the high protein content was found high in Oyster mushroom -*Hypsizygus ulmarius* (39±0.08%) followed by *Calocybe indica* (34.22±0.15%) and APK2 (33.23±0.08%). While, the crude fibre and carbohydrate content among the three mushrooms ranged from 17.24% to 36.14% and 7.66 to 29.09% respectively. Minerals content among the mushroom varieties, with findings ranging from Na-30 mg to 41 mg, K-989 mg to 1258 mg and P-622 mg to 766 mg Per 100 g dry weight.

Key words: Functional quality characteristics, Minerals, Mushrooms, Protein, Proximates.

INTRODUCTION

Mycophagy is the practise of consuming fungi. Mushroom is a fungus with a fleshy spore bearing fruiting body that typically belongs to the phylum Basidiomycota, order Agaricales (Britannica, 2020). Typically, the term mushroom refers to an edible sporophore, a highly nutritious natural vegetable rich in protein, vitamins and fibre. Since ancient times, mushrooms have provided a natural way to good health. It is an excellent source of vitamins and minerals. Hence, often called as “white vegetable” or “vegetarian meat” (Devi, 2018). Mushrooms are becoming increasingly popular and are widely consumed by people of all ages all over the world. They are regarded as one of the superfoods due to their high nutrient content as well as their healing properties (Ma *et al.,* 2018). Mushroom is a complete food suitable for all age groups, considering the health benefits, mushrooms are being considered as a future vegetable owing to their medicinal and nutritional properties and the mushroom consumption has significantly increased in recent years. On account of their high digestibility, mushrooms are considered to be a potential substitute for muscle protein (Pavel, 2009).

Mushrooms could be an alternative source of new antimicrobial compounds, mainly secondary metabolites such as terpenes, steroids, anthraquinones, benzoic acid derivatives, quinolones and some primary metabolites like oxalic acid, peptides and proteins (Maria *et al.,* 2015). They have a great nutritional value since they are rich in protein, with an important content of essential amino acids, fiber and low-fat content (Chelladurai, 2021). Moreover, edible mushrooms provide a nutritionally significant content of vitamins (B_1, B_2, B_{12}, D and E) (Mattila *et al*., 2001). Thus, they could be an excellent source of formulating different nutraceuticals and might be used directly in human diet and to promote health for the synergistic effects of all the bioactive compounds present (Barros *et al.,* 2007 and Ferreira *et al*., 2009). The present study was carried with the objective of analysing the macronutrients and mineral composition of three edible mushroom varieties *i.e.,* Oyster mushroom-*Hypsizygus ulmarius*; Milky mushrooms- *Calocybe indica* and APK2 along with the functional quality characteristics.

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MATERIALS AND METHODS

The current study was carried out in the Department of Foods and Nutrition, Post Graduate and Research Centre, PJTSAU, Rajendranagar, Hyderabad. All the three mushroom varieties- (Oyster mushroom-*Hypsizygus ulmarius*; Milky mushrooms- *Calocybe indica* and APK2) used in this study were collected from the Department of Plant Pathology, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad. Flow chart for preparation of powder from fresh mushroom is shown in Fig 1.

Proximate analysis

The standard procedures of AOAC were used to determine the proximate composition *i.e.,* moisture, protein, fat, crude

fiber, ash, carbohydrates and energy among the three mushroom varieties (oyster mushroom-*Hypsizygus ulmarius*; milky mushrooms- *Calocybe indica* and APK2).

Mineral analysis

Minerals like Na, K, P, Cu, Fe, Zn and Mn were analysed using (AOAC. 2000) standard procedure. The aliquot for mineral estimation was prepared by wet digestion using diacid (HNO_3 and $HClO_4$ in 9:4 ratio respectively) procedure as given in the Fig 2. Minerals like Na, K were analysed using flame photometer, P content was analysed using double beam UV- Visible spectrophotometer, trace minerals like copper (Cu), zinc (Zn), iron (Fe) and manganese (Mn) were analysed by using ICP- OES.

Functional quality characteristics

All the three mushroom varieties (oyster mushroom-*Hypsizygus ulmarius*; milky mushrooms- *Calocybe indica* and APK2) were analysed for the functional characteristics *viz*.,

A. water activity

(Abramovie *et al*. 2008) using digital water activity meter (Freund EZ-200) where 2.0 gm of sample is weighed, placed in the instrument and readings were noted. Each sample was analyzed in triplicates and the average values was calculated.

B. Water absorption index and Water solubility index (Yagci and Gogus, 2008)

Where adding a known weight of sample powder to distilled water. The sample is then stirred and the suspension is poured into a tare centrifuge tube. After centrifugation, the supernatant is dried and the weight of solids in the supernatant is used to calculate the water-soluble index as a percentage of dry weight of the extrudate. The weight of the sediment in the centrifuge tube is used to calculate the Water absorption index as a percentage of the water bound per 100 gms of sample powder.

$$WAI = \frac{\text{Weight of the suspension}}{\text{Weight of dry solids}}$$

$$WSI = \frac{\text{Weight of dissolved solids in the supernatant}}{\text{Weight of dry solids}}$$

C. Oil retention capacity

Oil retention capacity also known as fat absorption capacity was expressed as g/g. ORC was determined by the method described by Beugre *et al.* (2014). Where known weight of the sample is placed in a centrifuge tube of known weight to which refined oil is added, centrifuged at 3000 rpm for 20 min later, the supernatant was decanted and the weight of the oily residue in the centrifuge tube was noted. ORC was calculated using the equation given below.

$$ORC = \frac{\text{Weight of oil residue with centrifuge tube - Weight of empty centrifuge tube}}{\text{Weight of sample}}$$

E. Hydrophilic-Lipophilic index

According to Njintang *et al*. (2001) hydrophilic-lipophilic index can be determined as the ratio of WAI to that of ORC. This HLI is used to determine the relative affinity of flour for water and oil.

$$HLI = \frac{\text{Water absorption index}}{\text{Oil retention capacity}}$$

RESULTS AND DISCUSSION

Proximate composition

The proximate composition of the three mushroom varieties on dry weight basis were summarized in Table 1.

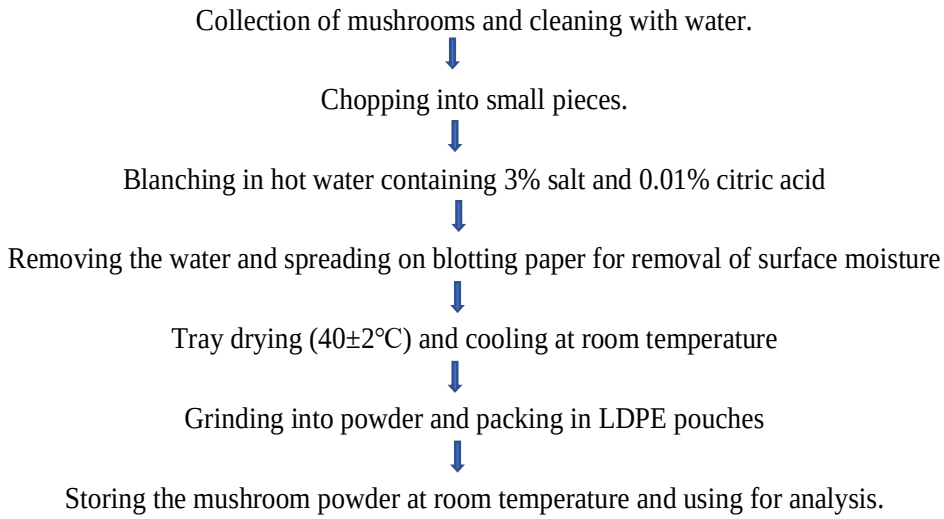

Fig 1: Flow chart for preparation of mushroom powder.

Moisture

Moisture content among the three mushroom varieties were ranged from 9.33% to12.26% with a significant difference ($p \leq 0.01$). Highest moisture content was reported in APK2 milky mushroom and lowest moisture content was observed in *Calocybe indica*. The results were in comparable with the sheikh *et al*. (2010), who reported 10.13% of moisture in oyster mushroom variety *(Pleurotus ostreatus)*. The difference observed in the moisture content may be due to size of the mushroom slices, drying extent and difference in the mushroom varieties.

Protein

Results revealed that *Hypsizygus ulmarius* contained high amount of protein content (39.34%) compared with other two milky mushroom varieties (Calocybe indica-34.22%; APK2- 33.23%). Alam *et al.* (2008) reported the protein content (g/100 g on dry weight basis) in *P. ostreatus*, *P. sajor-caju*, *P. florida* and *C. indica* was 23.91±2.0, 24.63±1.51, 20.56±1.45 and 21.4±1.86 respectively which was lower than the present study. The difference in the protein content might be because of the substrate used for growing the mushrooms and difference in mushroom varieties. Yan *et al*. (2016) stated that a substrate is important for growing the mushroom. It was observed that protein content among the three mushroom varieties were higher than meat with 19-25% (Rabia *et al*., 2018) and legumes with 21-30% (Islamiyat *et al*., 2019).

Fat

Fat content among the three mushroom varieties ranged from 1.50% to 2.33%. With the higher amount of fat was found in *Hypsizygus ulmarius* (2.33%) which is significant ($p \leq 0.01$) to milky mushroom varieties (*i.e., Calocybe indica* and APK2) with 1.50%. The difference in the fat content among the mushrooms may be due difference in the varieties and species.

Ash

The ash content of the three mushroom varieties ranged from 4.30 to 7% with significant difference ($p \leq 0.01$) indicating that these mushrooms contain a significant amount of minerals. The milky mushroom varieties had a high ash content (7- 6.66%), which was similar to the study conducted by Chelladurai *et al*. (2021) that reported 7.04% of ash in milky mushroom variety *Calocybe indica*. The variation in ash content among mushrooms could be attributed to

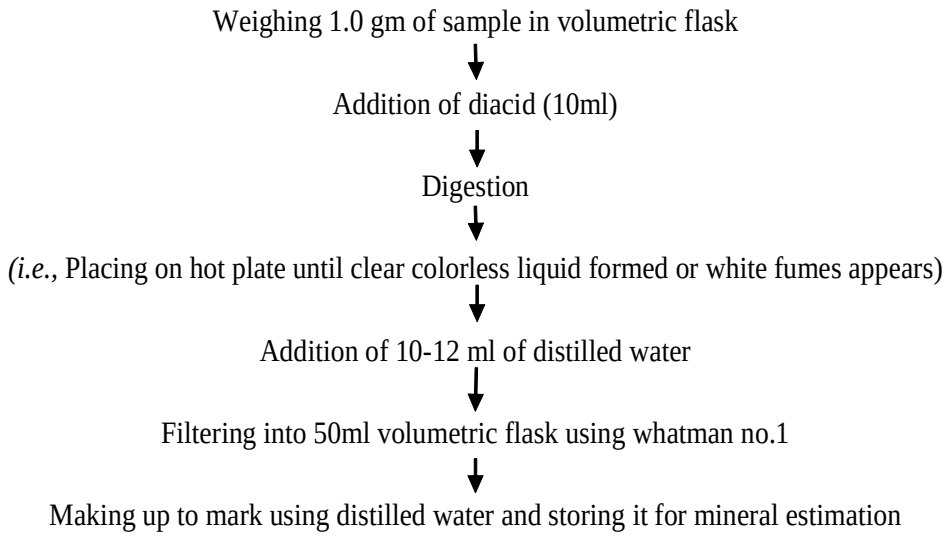

Fig 2: Flow chart for preparation of aliquot for mineral analysis.

Table 1: Proximate composition per 100 g on dry weight basis in three mushroom varieties.

Mushroom varieties	Moisture (g%)	Protein (%)	Fat (%)	Ash 9 (%)	Crude fiber (%)	Carbohydrates (%)	Energy (K. Cal)
HU	10.38^{b}±0.03	39.34^{a}±0.08	2.33^{a}±0.16	4.30^{c}±0.09	36.14^{a}±0.26	7.66^{c}±0.41	207.5^{c}±2.1
Ci	9.33^{c}±0.26	34.22^{b}±0.15	1.50^{b}±0.03	7^{a}±0.07	18.22^{b}±0.64	25.33^{b}±1.66	251.7^{b}±6.1
APK2	12.26^{a}±0.03	33.23^{c}±0.08	1.50^{b}±0.03	6.66^{b}±0.16	17.24^{c}±0.70	29.09^{a}±0.64	262.8^{a}±2.3
P value	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**	0.00**

HU- *Hypsizygus ulmarius*; Ci- *Calocybe indica*; APK2- APK2 milky mushroom.

Note: Values are expressed as mean±standard deviation of three determinations. Values with similar superscripts within columns are statistically similar at 0.05% level. **($p \leq 0.01$).

differences in the concentration of the substrate used for mushroom cultivation, stage of harvesting, climatic condition as well as differences in the varieties.

Crude fiber

High amount of crude fiber was observed in oyster mushroom- *Hypsizygus ulmarius* (36.14±0.26%) and low in milky mushroom variety- APK2 (17.24±0.70%). The results there was a significant difference (p≤0.00) in the crude fiber content among the mushroom varieties and revealed milky mushroom species contained less amount of crude fiber, which was similar to the study conducted by Alam *et al.* (2008).

Carbohydrates

The carbohydrate content of the three mushroom varieties varied from 7.66 to 29.09% with a significant difference (pd"0.00). Alam *et al*. (2008) found that the carbohydrate content of mushrooms ranged from 37.8 to 48.5% which was higher than the current study. This difference could be due to the substrate used for cultivation or the stage of development.

Energy

The energy content of the three mushroom varieties ranged from 207.5 K. Cal to 262.8 K. Cal per 100g dry weight. It was observed that milky mushroom varieties (*Calocybe indica* and APK2) contained more calories (262.8 to 251.7 K. Cal/100g) than oyster mushroom variety (*Hypsizygus ulmarius*). Mushrooms were regarded as a low-fat energy source. This low energy content is due to the high fibre, low fat, high protein and no cholesterol content (Breene, 1990).

Mineral composition

Minerals are the ash that remains after the mushroom has been completely incinerated. The mineral composition of three mushroom varieties were summarized Table 2.

Major mineral composition

The potassium content of the three mushroom varieties ranged from 989 to 1258 mg/100 g dry weight basis. Potassium concentration of oyster mushroom species in a study conducted by Mallikarjuna *et al*. (2012) ranged from 2472 mg to 3634 mg/100 g dry weight basis which was higher compared to the present study. The variation in potassium concertation could be due to difference in varieties of mushrooms and the substrate used for growing mushroom. Sodium content among the three mushroom varieties ranged from 30.07mg to 41.33 mg. It was observed that both milky mushroom varieties (*Calocybe indica* and APK2) contained similar sodium concertation compared to oyster mushroom variety (*Hypsizygus ulmarius*) which was similar to a study done by Zahid *et al*. (2010). The difference in sodium concentration among the three mushroom varieties may be due to variation in the concentration of substrate used, time of harvest or stage of maturity and change in the species. Phosphorus content among the three mushroom varieties ranged from 622.3 mg to 766 mg/ 100 gm of dry weight which was similar to a study conducted by Mallikarjuna *et al*. (2012) and higher than the study conducted by Zahid *et al*. (2010).

Trace mineral composition

Trace metal accumulations in mushrooms can vary depending on the mushroom species, the part involved, the stage of harvest, the fruiting body and environmental factors (Tuzen, 2003).

Copper content among the three mushroom varieties were ranged from 2.70 mg to 3.80 mg/ 100 g dry weight with a significant difference (p≤0.00) between them which was higher than a study conducted by Mallikarjuna *et al*. (2012). It was also observed that, both milky mushroom varieties (*Calocybe indica* and APK2) contained similar copper concentration compared with oyster mushroom variety (*Hypsizygus ulmarius*). Iron content among the mushroom's ranges from 26.54 mg to 70.07 mg/100 gm dry weight basis which was lower than a study conducted by Salehi. (2019). The variation in the iron content in the same mushroom species might be because of the changes in carbon and nitrogen composition in the substrate used for cultivating the mushrooms and difference in the varieties. Magnesium content among the three mushroom varieties was ranged from 1.70 mg to 2.40 mg/100 g dry weight basis. While higher concentration of magnesium was reported in APK2 milky mushroom variety and lowest in oyster mushroom variety (*Hypsizygus ulmarius*). Mushrooms are said to be good biological accumulators of zinc and it is biologically very important to humans (Bano *et al*., 1981). The zinc concentration among the three mushroom varieties were ranged from 15.53 mg to 16.77 mg/ 100 dry weight which was higher than a study conducted by Mallikarjuna

Table 2: Mineral composition (mg/100 g on dry weight basis) in three mushroom varieties.

Mushroom varieties	Potassium	Sodium	Phosphorus	Copper	Iron	Manganese	Zinc
HU	1258^{a}±0.03	30.07^{c}±0.07	622.3^{c}±0.1	2.70^{b}±0.01	36.47^{b}±0.3	1.70^{c}±0.04	16.77^{a}±0.13
Ci	989^{c}±0.01	41.33^{a}±0.17	766^{a}±0.11	3.80^{a}±0.01	26.54^{c}±0.1	1.803^{b}±0.1	15.63^{b}±0.07
APK2	1014^{b}±0.0	40^{b}±0.04	686.6^{b}±0.1	3.80^{a}±0.01	70.07^{a}±0.3	2.40^{a}±0.09	15.55^{b}±0.4
P value	0.00**	0.00**	1.00^{NS}	0.00**	0.00**	0.00**	0.00**

HU- *Hypsizygus ulmarius*; Ci- *Calocybe indica*; APK2- APK2 milky mushroom. NS- Non-significant.

Note: Values are expressed as mean±standard deviation of three determinations. Values with similar superscripts within columns are statistically similar at 0.05% level. **(p<0.01).

Table 3: Functional properties of the mushroom varieties.

Properties	Mushroom varieties		
	Hypsizygus ulmarius	*Calocybe indica*	APK2
WAC (g/g)	10.602 ±0.28	8.212±0.21	8.625±0.25
WSI (%)	14.715±0.13	16.025±0.11	13.759±0.01
ORC (g)	7.065±0.01	6.999±0.3	6.475±0.09
HLI	1.5± 0.16	1.173±0.12	1.331±0.1
Water activity (a_w)	0.45±0.01	0.46±0.1	0.43±0.11

et al. (2012). Variation of mineral content in the mushrooms analysed could be mainly due to environmental factors, stage of harvest, difference in the species and substrate used for cultivation.

Functional quality characteristics

Functional properties or quality characteristics are critical in determining the level of utilisation in both ingredient formulation and food product development (Adebowale and Lawal, 2004). The functional characteristics of the three mushroom varieties analysed were summarised in Table 3.

Water activity (a_w)

Water activity indicates critical details on microbiological spoilage, chemical and physical stability of newly developed food products. While, the microbial growth was not found in the range of 0.45-0.55. However, in present investigation, water activity among the three mushroom varieties flour was found to be between 0.43 and 0.46, indicating that there was no scope for microbial spoilage and was suitable for consumption even at room temperature.

Water absorption capacity (WAC) and water-soluble index (WSI)

The volume occupied by starch after swelling in excess water to retain starch integrity in aqueous dispersion was assessed by water absorption capacity (Thilagavathi *et al*., 2015). However, the WAC of mushrooms depended on the starch and fiber content. The finding of the study (Table 3) revealed that the milky mushroom varieties (Ci and APK2) contained lesser hydrophilic groups and more starch than HU.

The presence of soluble solids in a dried sample influences the effect of heat treatments such as gelatinization, dextrinization and eventually starch solubilization with other food components such as protein, fat and fiber. When heated in excess water, starch relaxed its crystalline structure, allowing amylose and amylopectin groups to form hydrogen bonds with water molecules. This increased the granules' swelling power and solubility (Hoover, 2001). However, in present study, the WSI of the three mushroom varieties ranged from 13.759±0.01% to 16.025±0.11%.

Oil retention capacity (ORC)

The oil-absorption capacity of mushroom varieties depends on the composition of amino acids, conformation of proteins and surface polarity (Chandra and Samsher, 2013). Table 3 revealed that, the ORC of the HU, Ci and APK2 was found to be 7.065±0.01 gm/gm, 6.999± 0.3 gm/gm and 6.475± 0.09 gm/gm respectively. Results revealed that oyster mushroom variety HU had slightly higher ORC compared to milky mushroom varieties (Ci and APK2).

CONCLUSION

The results of the present study showed that mushrooms were nutritionally rich as they have high nutrient content twice the number of fruits and vegetables in terms of high protein, fiber and they can be used as supplementary food item in Indian diet which is mainly cereal based, helps in bridging the protein gap and improve health of population. From the present study, Mushroom flour can be used in development of various value-added products from improving the nutrient content.

Conflict of interest: None.

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