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# Nutritional analysis of cultivated mushrooms of India

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Mushrooms are the fleshy fruiting bodies of filamentous macrofungi and the earliest form of fungi known to man throughout the world (Okhuoya *et al*. 2010). The worldwide production of cultivated mushrooms was 43 million tonnes in 2018–19 in which India's share was 2.25 lac tonnes (Singh *et al*. 2021). In India, mainly 5 mushroom species are cultivated *Agaricus bisporus* (73%), *Pleurotus* spp. (16%), *Volvariella volvacea* (7%), *Calocybe indica* (3%) and other mushrooms (1%) including *Lentinula edodes* (Sharma *et al*. 2017). Mushrooms are rich in proteins, dietary fibers, minerals, vitamins and bioactive compounds and low in fats and energy contents. (Stamets 2005, Barros *et al*. 2007, Rajeshbabu *et al*. 2012).

Mushrooms are also known as functional food or nutraceuticals due to the presence of bioactive compounds, which accounts for many medicinal properties such as antifungal, antibacterial, antiviral, antidiabetic, anticancer, immunomodulation, hepatoprotective, hypolipidemic and hyposensitive activities (Barros *et al*. 2007, Okhuoya *et al.* 2010). Generally, people in India are still not much familiar with the nutritional and medicinal importance of mushrooms. Also production of mushrooms is very low in our country as compared to other parts of the world. Proximate analysis of mushrooms has been investigated thoroughly in different parts of the world but there is not enough information available regarding the nutritional constituents of cultivated mushrooms in India. The objective of the present study was to evaluate the nutritional values of 5 cultivated mushrooms with a view to increase awareness regarding beneficial effects of mushrooms among the peoples in India.

The studies were carried out at ICAR-Directorate of Mushroom Research, Solan, Himachal Pradesh, during 2020–21. The fruiting bodies of the latest strains of edible mushrooms *Agaricus bisporus* (J.E. Lange) Imbach (NBS-5), *Calocybe indica* Purkay. & A. Chandra (DMRO-302), *Flammulina velutipes* (Curtis) Singer (DMRO-253), *Pleurotus florida* (Mont.) Singer (DMRP-136) and *Volvariella volvacea* (Bull.) Singer (DMRO-484) were obtained from the ICAR-DMR, Solan.

Fresh fruiting bodies of average size from the first flush of all 5 mushroom species were procured and dried at ambient temperature (40–45°C) for 3 days in a mushroom dryer. The dried fruiting bodies were ground in a mixer grinder and sealed. Three samples of each mushroom were analyzed for different parameters, viz. carbohydrates, proteins, fats, energy, reducing and non reducing sugars, and dietary fibers, from Punjab Biotechnology Incubator, Mohali, India. Standard procedures of AOAC were used to determine proteins, fat, carbohydrates, sugars, dietary fibre and energy content (AOAC 2002) as per the protocol standardized at PBTI, Mohali. Carbohydrate: PBTI/SOP/18/TP-11; Sugar: PBTI/SOP/16/TP-09; Protein: IS 7219:1973; Fat: PBTI/SOP/18/TP-11; Dietary fiber: AOAC 2003: 985.29; Energy: PBTI/SOP/18/TP-11. The moisture and ash contents of fruiting bodies were determined at DMR laboratory, Solan according to AOAC (2003).

The results of nutritional analysis of 5 cultivated mushrooms are given in Table 1. The protein content of cultivated mushrooms ranged from 15.27±0.67% to 38.75±0.90% on a dry weight basis (Table 1). The protein content of *A. bisporus* (30.64±1.18%) observed in the present study was also supported by the earlier reports of 33.48 to 34.44% (Stamets 2005) and 29.14% (Ahlawat *et al*. 2016). The protein content of *A. bisporus* earlier reported 18.4% (Roy and Isaac 2019) and 20.4% (Khan and Chandra 2022) were lower than the present results but Pushpa and Purushothama (2010) reported a much higher (41.06%) protein content. *C. indica* (16.85±0.54%) showed similar protein component as earlier reported 15.4% (Roy and Isaac 2019) but some other studies reported higher protein component 21.60% (Pushpa and Purushothama 2010) and 28.73% (Karuppuraj *et al*. 2012) than the present results. Rajeshbabu *et al*. (2012) reported only 11.65% protein in *C. indica*. The protein content of *F. velutipes* (15.27±0.67%) in the present study was lower than 21.33% reported by Sharma *et al*. (2020). The protein content of *P. florida* (23.61±0.44%) observed in the present investigation agreed

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Table 1 Nutrient composition of cultivated species of mushrooms

| Parameter | *Agaricus bisporus* | *Calocybe indica* | *Flammulina velutipes* | *Pleurotus florida* | *Volvariella volvacea* |
|---|---|---|---|---|---|
| Proteins (%) | 30.64±1.18 | 16.85±0.54 | 15.27±0.67 | 23.61±0.44 | 38.75±0.90 |
| Fat (%) | 0.97±0.06 | 3.88±0.11 | 0.91±0.07 | 1.05±0.06 | 0.84±0.04 |
| Carbohydrates (%) | 52.26±1.35 | 65.17±0.99 | 69.60±1.24 | 53.37±1.14 | 39.33±0.35 |
| Reducing sugars (%) | 3.56±0.17 | 13.73±0.22 | 7.50±0.33 | 9.45±0.78 | 1.97±0.13 |
| Non reducing Sugars (%) | 3.40±0.14 | 5.58±0.39 | 4.61±0.18 | 5.55±0.21 | 1.83±0.10 |
| Dietary Fiber (%) | 30.51±0.61 | 34.68±1.50 | 37.88±1.60 | 40.48±0.75 | 30.22±0.81 |
| Energy (Kcal/100 g) | 340.40±3.41 | 363.10±2.60 | 347.60±1.48 | 346.40±2.49 | 319.90±1.79 |
| Moisture (%) | 92.44±0.52 | 87.02±0.18 | 88.52±0.40 | 90.79±0.22 | 90.39±0.62 |
| Ash (%) | 9.5±0.45 | 7.15±0.81 | 6.75±0.34 | 6.95±0.43 | 8.15±0.11 |

All components were analyzed on dry weight basis except moisture.

with the earlier reported 22.16% (Jose and Geetha 2018) and 22.06% (Bashir *et al*. 2020). However, previously reported value of 27.83% (Pushpa and Purushothama 2010) was much higher than present results. The results of the present study regarding the protein content of *V. volvacea* (38.75±0.90%) were supported by the earlier report of 38.10% (Ahlawat *et al*. 2016). Ahlawat and Kaur (2020) reported 30.1% protein content in *V. volvacea* (DMRO-484).

The lipid content of cultivated mushrooms was observed very low and ranged from 0.84±0.04 to 3.88±0.11% (Table 1). The lipid content of *A. bisporus* (0.97±0.06%) was agreed with 1.56% as reported by Ahlawat *et al*. (2016) but lower than the previously reported 2.12% (Pushpa and Purushothama 2010), 4.7% (Roy and Isaac 2019) and 3.93% (Khan and Chandra 2022). Results regarding the lipid content of *C. indica* (3.88±0.11%) were comparable with 2.90% (Rajeshbabu *et al*. 2012), 4.96% (Pushpa and Purushothama 2010) and 3.1% (Roy and Isaac 2019). The lipid content of *F. velutipes* (0.91±0.07%) was observed lower than 2.18% reported by Sharma *et al*. (2020). In *P. florida* (1.05±0.06%), the results of the present investigations were supported by 1.54% (Pushpa and Purushothama 2010) but differed from 2.28% (Jose and Geetha 2018) and 3.73% (Bashir *et al*. 2020). The lipid content of *V. volvacea* (0.84±0.04%) observed in the present study was comparable to 0.97% reported by Ahlawat *et al*. (2016) but lower than 2.77% (Punitha and Rajasekaran 2015) and 2.59% (Ahlawat and Kaur 2020).

All five mushroom species analyzed in the present study showed the largest amount of carbohydrates (39.33±0.35 to 69.60±1.24%) per 100 g of dry matter (Table 1). The carbohydrate content of *A. bisporus* (52.26±1.35%) was comparable with the previously reported 51.05% (Ahlawat *et al*. 2016) and 53.10% (Roy and Isaac 2019). Pushpa and Purushothama (2010) and Khan and Chandra (2022) reported 28.38% and 17.05% carbohydrates respectively, which were much below the results of the present study. The carbohydrate content of *C. indica* (65.17±0.99%) was comparable with 57.27% (Karuppuraj *et al*. 2012) and 67.80% (Roy and Isaac 2019) but higher than 46.49% (Rajeshbabu *et al*. 2012) on similar works. *F. velutipes* (69.60±1.24%) showed similar carbohydrate content as already reported 64.61% (Sharma *et al*. 2020). The carbohydrate content of *P. florida* (53.37±1.14%) agreed with 49.12-52.35% (Prasad *et al*. 2018) but higher than the previously reported 32.08% (Pushpa and Purushothama 2010) and 26.88% (Jose and Geetha 2018). The carbohydrate content of *V. volvacea* (39.33± 0.35%) agreed with 42.30% reported by Ahlawat *et al*. (2016) but was much below than 52% reported by Punitha and Rajasekaran (2015) and 66% reported by Salamat *et al*. (2017). The reducing sugar content of mushrooms was observed between 1.97±0.13 to 13.73±0.22% and non-reducing sugar content was 1.83±0.10 to 5.58±0.39%.

The dietary fiber content of investigated mushrooms ranged from 30.22±0.81 to 40.48±0.75% on a dry weight basis (Table 1). The dietary fiber content of *A. bisporus* (30.51±0.61%) was much higher than 19.10–20.90% (Stamets 2005), 18.23% (Pushpa and Purushothama 2010) and 13.80% (Roy and Isaac 2019). *C. indica* showed 34.68±1.50% dietary fiber, which agreed with the 37.52% reported by Karuppuraj *et al*. (2012), but higher than previously reported 13.20% (Pushpa and Purushothama 2010). The fiber content of *F. velutipes* (37.88±1.60%) was observed much higher than 23.31% reported by Nwe and Zin (2020). The dietary fiber content in *P. florida* (40.48±0.75%) was observed much higher than the previously reported 23.18% by Pushpa and Purushothama (2010) and 24.45% by Bashir *et al*. 2020. Dietary fiber content of *V. volvacea* (30.22±0.81%) was also observed higher in the present study than the earlier report of 7.43% (Salamat *et al*. 2017).

The fruiting bodies of the cultivated mushrooms were also found rich in metabolizable energy content, which ranged from 319.90±1.79 Kcal/100 g to 363.1±2.60 Kcal/100 g dry weights basis (Table 1). Present study results regarding *A. bisporus* (340.4±3.41 Kcal) agreed with 340–355 Kcal (Stamets 2005) and 328 Kcal (Roy and Isaac 2019). The energy content of *C. indica* (363.1±2.60 Kcal) was comparable with 328 Kcal (Roy and Isaac 2019) but differed from 250 Kcal reported by Rajeshbabu *et al*. (2012). Results of the energy analysis of *P. florida* (346.4±2.49 Kcal) were comparable with 329.26 to 344.61 Kcal (Prasad *et al*. 2018). The energy content of *V. volvacea* (319.90±1.79 Kcal) was comparable with 354.80 Kcal reported by Salamat *et al*. (2017).

The moisture content of studied mushrooms ranged from 87.02±0.18 to 92.44±0.52% (Table 1). The moisture content of *A. bisporus* (92.44±0.52%) agreed with the report of 91% (Roy and Isaac 2019). The moisture content of *C. indica* (87.02±0.18%) was comparable with 91% (Roy and Isaac 2019). The present study observed 88.52±0.40% moisture content in *F. velutipes*, which agreed with previous report of 87.50% (Nwe and Zin 2020). *P. florida* showed 90.79±0.22% moisture content which agreed with 89.19–90.04% (Prasad *et al*. 2018) but differed from 84.92% reported by Jose and Geetha (2018). The moisture content of *V. volvacea* (90.39±0.62%) agreed with 89.30% reported by Punitha and Rajasekaran (2015).

In the present study, the ash content was detected 6.75±0.34 to 9.5±0.45% on the dry weight basis of the fruiting bodies of mushrooms (Table 1). The ash content of *A. bisporus* (9.5±0.45%) was comparable with 10.01% (Roy and Isaac 2019) but higher than 7.01% reported by Pushpa and Purushothama (2010). The ash content of *C. indica* (7.15±0.81%) was observed higher than earlier reports of 5.50% (Roy and Isaac 2019) and much less than 12.80% (Pushpa and Purushothama 2010). The ash content of *F. velutipes* (6.75±0.34%) was lower than 9% reported by Nwe and Zin (2020). In the present study the ash content of *P. florida* (6.95±0.43%) was found less than previously reported 9.41% (Pushpa and Purushothama 2010) and 8.57% (Bashir *et al*. 2020). The ash content of *V. volvacea* (8.15±0.11%) agreed with 8.80% reported by Punitha and Rajasekaran (2015) but lower than the 10.08% reported by Ahlawat and Kaur (2020).

Various studies claim that mushrooms are superfoods due to their high nutrient content, especially proteins, dietary fibres, vitamins, and minerals. The findings of the present studies also showed closeness to the results of previous studies and slight variations can be attributed to different strains and substrates used for their cultivation. The results showed that these 5 species of cultivated mushrooms contained high protein and low fat. The inclusion of mushrooms in routine diet may overcome the protein malnutrition problem in human beings.

## SUMMARY

The fruiting bodies of the latest strains of edible mushrooms were obtained from the ICAR-Directorate of Mushroom Research, Solan, Himachal Pradesh during 2020–21. The objective of the study was to evaluate the nutritional values including carbohydrates, proteins, fats, dietary fiber, energy, moisture and ash contents of cultivated mushrooms with the view to increase awareness regarding benefits of mushrooms. The samples were analyzed for different parameters from Punjab Biotechnology Incubator, Mohali, India. The results showed 15.27 to 38.75% proteins, 0.84 to 3.88% lipids, 39.33 to 69.60% carbohydrates, 30.22 to 40.48% dietary fibers, 319.9 Kcal/100 g to 363.1 Kcal/100 g energy, 87.02 to 92.44% moisture and 6.75 to 9.5% ash content. The results of the present study also showed closeness to the results of the previous studies.

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