THINK INDIA JOURNAL

ISSN:0971-1260
Vol-22-Issue-37-December -2019

Effect of Ultraviolet irradiation on the nutritional composition of post-harvest Button mushrooms

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ABSTRACT

Vitamin D deficiency can cause severe pre medical conditions, neurodegenerative, autoimmune diseases etc. Mushroom called as queen of vegetables, is a super food with abundance of nutrients when exposed to Ultra violet radiation generate vitamin D_2 as a pro vitamin from ergosterol. It is perishable in nature considered as an amazing small miracle with huge benefits. The purpose of this study was to determine the effect of UV rays on nutritional composition and shelf life of button mushroom powder. Post-harvest Button mushroom was treated with different UV-rays (UV-A, UV-B, UV-C) at different distance for varied time durations followed by freeze drying. Sample with maximum vitamin D content was selected for further nutritional analysis. Vitamin D_2 content significantly ($p<0.0001$) increased over control in button mushroom when exposed for 30 minute to UV-A, UV-B and UV-C at distance of 60cm. No significant effect was observed on protein, crude fat and crude fibre content of button mushroom, while a significant ($p<0.005$) increase in ash was seen because use of UV radiation increases the mineral content. The in vitro protein digestibility was significantly ($p<0.01$) increased over control in button mushroom by UV treatment along with significant ($p<0.0001$) increase in total phenols. The results of this study showed that the UV exposure led to a substantial increase in the nutritional value of button mushroom.

Keywords
Button mushroom, UV irradiation, Vitamin D_2, In-vitro protein digestibility, Total phenols

Introduction

Vitamin D is an essential nutrient required to boost immune system and plays vital roles in human metabolism. Vitamin D also makes cathelicidin to kill pathogens like mycobacterium tuberculosis in body and herpes in brain (Onusic, 2019). Many physicians have seen low level of vitamin D as a serious pre medical condition. Vitamin D deficiency can cause diabetes, autism, psoriasis, multiple sclerosis, Alzheimer's, Parkinson's, rickets, osteoporosis, osteomalacia, insidious diseases like cancer and autoimmune diseases (Stamets,2012). Vitamin D deficiency

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becomes epidemic due to sun-phobic nature of helicopter moms who slathering their children with sunscreen loaded with parabens, titanium, other carcinogenic substances (Onusic, 2019). Vitamin D is found in two main forms i.e. vitamin D_2 (ergocalciferol) and vitamin D_3 (cholecalciferol) (Phillips et al., 2012).Mushroom are rich in vitamin D precursor ergosterol which on exposure to UV rays converts to ergocalceferol (pro vitamin D_2) (Stamets, 2012). Mushrooms are known as queen of vegetables and nature's hidden treasure of nutrition. Mushrooms are good vegetarian source of protein but inferior to non-vegan sources as meat, fish etc (Aremu et al., 2009). The nutritional value of mushrooms is higher than one may think. It is one of the healthier foods more than just a condiment for salads that's why it is recognized as a qualitative healthy food. Mushrooms are low in calories but contain lots of fibre content along with abundant amount of vitamins and mineral content. Increasing consumption of whole unprocessed foods like mushrooms appears to decrease the risk of obesity and overall mortality. So, it is a superfood which considered as an amazing small miracle with huge benefits (Brouns, 2018). On another hand, the physiological conditions of mushroom make them perishable in nature. Thus the need of the hour is value addition in various products at commercial level. Processing of mushrooms will not only help them to be available in whole year but the same the nutrient loaded food will add more taste, texture and flavor which will attract people to consume more mushrooms and will help to increase the demand as well as play the vital role to achieve the nutritional security not at the household level but including the National level by which the nutritional status of the people will be improved and get better (Harsh and Joshi, 2008). Thus the present research concentrates on the production of mushroom powder as a value added product to increase its shelf life and for better revenue generation.

Materials and methods

Sample collection

Untreated freshly harvest Button mushroom (Agaricusbisporus) was procured from the Department of Microbiology, College of Basic Sciences, PAU, Ludhiana during November 2016 to March 2017.

Experimental design

Button mushroom was cleaned and sliced longitudinally and exposed to different UV rays using UV lamps such as UV-A (Wave Length 280-315nm, Philips TLD-18 Watt), UV-B

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(Wave Length 315-400nm, Philips TL-20 Watt/01), UV-C (Wave Length 100-280nm, G18T8) at varied distance (30cm, 45cm, 60cm) for different time durations (10min, 20min, 30min) whereas Sun rays treated group of Button mushroom was exposed for 10min, 20min and 30min and stored at -20^{0}C for 24 hrs.Non-irradiated mushrooms used as a control. Mushroom samples were freeze dried at -40^{0}C for 36-48hrs and pulverization into fine powder and stored in tight sealed aluminum coated poly bags. Sample with maximum vitamin D_2 content i.e. UV-B treated button mushroom treated at maximum distance (60cm) and maximum time(30min) was further used for nutritional analysis and storage stability.

Nutritional evaluation

Proximate Analysis

Moisture (water) Content, Crude Protein, Crude Fat, Crude Ash and Crude Fibre were all estimated by standard procedure as per AOAC, 2000.

Total Energy was computed by factorial method using formula

Energy (Kcal) = (4 x protein) + (9 x fat) + (4 x carbohydrates)

In-vitro protein digestibility was determined by the method of (Akeson and Stachman, 1964) modified by (Singh et al.,1989).

Procedure

sample (0.5g) was taken in 250ml conical flask and added 50ml of pepsin solution Incubation at 37°C for 24 hrs was done. The solution was neutralized with 30ml of 0.2N Sodium hydroxide. Then 50ml of pancreatin solution was added and again incubated at 37°C for 24 hrs. Run an enzyme blank under prescribed conditions omitting protein sample. A few drops of toluene should be added to maintain aseptic environment in the system. The contents of the flask were centrifuged at high speed and filtered through Whatman No.44 filter paper. The residue was analyzed for N_2 content by macro- kjeldahl method. The digestibility coefficient was determined by subtracting the residue protein from the initial protein on the basis of 100g of sample.

Total phenols was estimated by the method of (Singleton et al.,1999).

Extraction of Bioactive compound- Phenolic compounds

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Procedure

The sample weighed as known quantity was taken in 100ml of the conical flask. Then add 15ml of 80% methanol acidified to pH 2.0 with 6N HCl (Hydrochloric acid) by vortex at room temperature for 30 minutes. The filtrate was decanted and re-extracted the residue for complete removal of phenolic compounds. This procedure was repeated for two times. The three supernatants were pooled, centrifuge at 6000rpm for 15min and filtered with the help of Whatman No.1 filter paper. Then the volume was made by solvent to 50ml. The sample was shifted to micro centrifuge tubes and stored at -20°C for total phenolic content (TPC) for which the known quantity of aliquot of sample was taken and volume up to 1.5ml with D/W was made. Then 0.5ml of FC reagent was added followed by adding 10ml of 7.5% Na_2CO_3 and incubated at 37°C for 60 minutes. Resulting blue colour complex was read at 750nm.

Standard

Standard of series of known concentration of Gallic acid (5µg to 20µg) was made. For that 0.1, 0.2, 0.3, 0.4ml filtrate was taken and treated in the same way as sample.

Blank

0.5ml of distilled water was taken and treated in the same way as sample.

Calculation

Total phenol (mg GAE/100 g) = Std. Concentration/Std. O.D × Sample O.D/Aliquot taken × Vol made up/Sample taken × 100/1000 × Dilution factor

Proximate composition of Button mushroom powder

Table 1 Proximate composition of treated Button mushroom powder (on dry weight basis)

Treatment	Protein (%)	Fat (%)	Ash (%)	Fibre (%)	Carbohydrate (%)	Energy (Kcal)
CBMP	25.22± 0.25	1.23±0.26	9.37± 0.31	8.21± 0.10	48.29± 0.31	305.16±1.06
TBMP	25.40± 2.06	1.33± 0.06	10.86±0.34	8.70± 0.79	45.35± 1.49	294.96±2.18
| t | - Value	**0.149**	**0.621**	**5.540**	**1.072**	**3.349**	**7.296**

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p-Value	**0.889**	**0.568**	**0.005**	**0.344**	**0.029**	**0.002**

CBMP- control button mushroom powder
TBMP- treated button mushroom powder at the distance of 60cm for 30min t-values are absolute values

The data of Table 1 represents the comparison of proximate composition among UV treated button mushroom powder and control (untreated) button mushroom powder which revealed the effect of UV treatment along with freeze drying on proximate composition of button mushroom powder on dry matter basis. The protein content of treated button mushroom powder was observed slightly higher at 25.40% as compared to control at 25.22% but statistically non-significant. Sulieman et al.(2017) reported the protein content of button mushroom powder fortified with inulin and reported 27.91% of protein content which was significantly higher than the inulin fortified sweet potato flour at 3.33% and inulin fortified glutinous rice flour at 8.03%. In contrast, Enas et al.(2016) had analyzed the proximate composition of five edible mushrooms, where the protein content of button mushroom (Agaricusbisporus) was found at 36.55% which was higher than the other mushroom such as Lentinusedodus had 28.55%, Boletus sp at 35.84% and Flammulinaventutipes contained the similar amount of protein at 36.55%. Pleurotuseryngii contained 42.23% protein content which was higher among the other varieties of mushroom.

In case of fat content, 1.33% in treated button mushroom powder and 1.23% in control Button mushroom powder was observed with no statistical difference. Rahi and Malik, (2016) compiled data of various cultivated species of mushrooms which explained the range of crude fat from 1.7%-8 % presents in button mushroom (Agaricusbisporus).

The ash content of treated button mushroom powder was significantly higher at 10.86% than the control button mushroom powder at 9.37%. The use of UV radiation on the substrate also increases the mineral content (Adejumoet al., 2017). The exact mechanism of increase in ash content is not known but use of UV rays on mushroom or the substrate increases the ash is well supported in the literature. Similarly, Rahi and Malik, (2016) reported that the ash content of cultivated Button mushroom (Agaricusbisporus)ranged from 7.7% to 12%. Kaur et al.(2013) recorded nutritional composition of button mushroom (Agaricusbisporus)powder which revealed the presence of 6.7% of ash content.

Statistically no significant difference was observed in fibre content of button mushroom powder treated with UV-B rays. Fibre content of treated button mushroom powder was observed

ISSN:0971-1260
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at 8.70% as compared to control Button mushroom powder at 8.21%. OECD, (2007) reported the range of dietary fibre content present in various varieties of button mushroom (Agaricusbisporus) at 7.8%-32.8%. On the contrary low values were reported by Ishara et al.(2018) i.e. content of crude fibre at 5.63% in button mushroom (Agaricusbisporus).

The calculated carbohydrate content of treated button mushroom powder was estimated at 45.35% which was lower than control button mushroom powder at 48.29%. The variation in carbohydrate content could be probably due to the relative variation in the nutrients among treated button mushroom powder and control button mushroom powder. The energy content of treated button mushroom powder was at 294.96Kcals which was significantly lower as compare to control button mushroom powder at 305.16Kcals. OECD (2007) had given range of carbohydrate content in various varieties of button mushroom from 43.3%-61.3%. According to Ishara et al (2018) the carbohydrate content was analyzed at 43.51% whereas energy content was observed 320.5Kcals in button mushroom (Agaricusbisporus).

In-vitro protein digestibility and Total phenols of Button mushroom powder

Fresh mushroom contains high protein content as compare to other vegetables with the exception of green peas and pulses. Due to high protein content of mushroom it can substitute the meat protein. In-vitro protein digestibility is the method to assess the protein quality based on enzymatic hydrolysis. Similarly, Mushroom is considered as the rich source of antioxidants as well as antiradical activities. However, phenolic acids are the main phenolic compound present in mushroom. The effect of UV-B rays on in-vitro protein digestibility and total phenols of Button mushroom powder has been discussed in Figure1.

The data revealed that in-vitro digestibility of protein was found at 84.25% in button mushroom powder when treated with UV-B at the distance of 60cm for 30min which was significantly higher than control button mushroom powder at 74.33%.It could be due to the effect of UV-treatment. As per the previous studies the polyphenols are not only potential antioxidants but they bind the pepsin enzyme and make it more active by changing its 3D conformation. Increase in polyphenols directly affects the protein digestibility. The freeze drying is efficient processing method which retained the nutrients with lesser losses.

Velickovic and Stanic-Vucinic, (2017) reviewed that after the digestion most of the polyphenols remains in gastrointestinal tract due to its low absorption where they affect the

ISSN:0971-1260
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activities of enzymes during the digestion of saccharides, lipids and proteins. The polyphenols have inhibitory effect on the digestion of energy rich components such as saccharides and lipids may be regarded as beneficial effect in weigh control diets. In context of proteins they increase the activity of pepsin which can increase the digestibility of proteins.

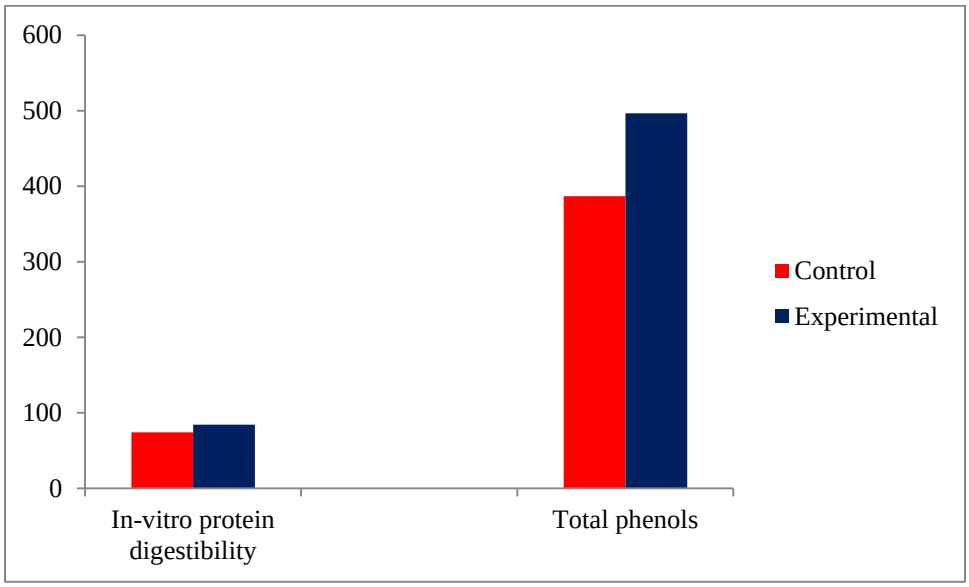

Figure 1 Comparison of In-vitro protein digestibility and Total phenols of UV treated button mushroom powder

Similarly, the content of total phenols in mushroom got increased significantly after the treatment with UV rays (Figure 1).It had been seen that the total phenols of treated button mushroom powder was observed at 496.67mg/100gm in comparison with control button mushroom powder at 386.67mg/100g. The increase in phenol content of treated button mushroom powder was due to UV-B treatment. UV-B exposure causes the abiotic stress in plants. Due to abiotic stress natural reaction takes in plants which produce two natural enzymes, polyphenylalanine ammonia-lyase and chalcone synthase as a mechanism to adapt the stress conditions which further synthesize the phenolics and chemical compounds. So the growth of phenolic compounds increases.

Mitchell, (2011) studied the beneficial effects of UV light on fresh carrots after exposing to UV-B. The results showed that after exposure of 14 seconds to UV-B significantly enhanced the antioxidant activity of carrots by three folds without following the heating and drying process. (Wua et al.,2016) reported that the phenolic content of button mushroom was increased with the UV-C treatment and after treatment the effect was seen at 4.17g/kg. The study showed

ISSN:0971-1260
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that the positive effect of UV-C on total phenols of button mushroom which improved the nutritional quality of button mushroom.

On the basis of results it was found that UV-B potentially improved the total phenols content of button mushroom powder.

Conclusion

The results of the present study showed that the exposure to UV rays led to substantial increase of nutritional composition of Button mushroom powder in terms of in- vitro protein digestibility, total phenols, mineral content and fatty acid composition therefore it could be used as food based approach to combat vitamin D deficiency among the vegetarian population. Further the processing of button mushroom in powder form as a value added product to increase its shelf life and for better revenue generation.

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ISSN:0971-1260
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