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Fatty acid composition, mineral content and storage stability of UV treated Button mushroom powder

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ABSTRACT

The purpose of this study was to determine the effect of UV rays on fatty acid, mineral composition and shelf life of button mushroom powder. Mineral and Vitamin D deficiency are the major cause of abdominal pain, bloating, constipation, diarrhea, loss in appetite, nausea, vomiting, diminished immune system, , irregularity of pulse, muscle cramping, and in extremities cause numbness or tingling etc. Dietary fat is necessary as other nutrients to maintain lipid homeostasis in body and mushroom contains lower fat content but a good source of essential fatty acids. Post-harvest Button mushroom generated vitamin D_2 as a pro vitamin when exposed to 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 and storage stability. 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 palmitic, stearic, oleic acid of button mushroom, while a significant ($p<0.0001$) increase in linoleic acid was seen. In minerals copper, phosphorus, potassium, zinc and selenium were significantly ($p<0.0001$) increased over control in button mushroom after UV treatment except increase in iron. No significant microbial growth (bacterial and fungal growth) was observed in UV treated button mushroom powder upto 5 months of storage period. Storage in air tight glass container was best as compared to other packaging materials.

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KeywordsButton mushroom, UV exposure, fatty acid composition, minerals, shelf life, packaging material

Introduction

Vitamin D is an essential nutrient required to boost immune system and plays vital roles in human metabolism. It is conceivable that UV-B radiation with sunlight and UV lamps on post-harvest fresh button mushroom or post-drying powdered mushroom could become standard commercial practice to raise the vitamin D_2 up to nutritional significance level, Vitamin D deficiency can cause diabetes, psoriasis, multiple type of systemic sclerosis, Alzheimer's, Parkinson's, rickets, osteoporosis, osteomalacia, insidious diseases like cancer and autoimmune diseases in both extremities. In small intestine synthesis of the calcium transport proteins and absorption of calcium gets stimulated in the presence of vitamin D only, which further reduces the risks of diseases caused by deficiency of calcium in body (Jones, 2014; Lips, 2006). Although body is able to produce sufficient amount of Vitamin D while presence of ultraviolet radiation in sunlight(Jones, 2014) even thenvitamin D through dietary sourcesarenecessary to maintain 25-hydroxyvitamin D (25(OH)D) level in circulation of body. There are some foods which naturally contains good amount of vitamin D such as oily fish as animal based dietary source as wellVitamin D as D_2, found in fungi and yeast (Taofiq et al., 2017). Fortification of foods like milk, margarine, cereals etc. with vitamin D (Lamberg-Allardt, 2006) have the potential to provide dietary vitamin D for vegetarians. Mushroomis theonly non-animal based contains quality protein but it is inferior to meat, fish etc. It is more than just a condiment for salads that's why it is recognized as a qualitative healthy food. Mushrooms contain lots of fibre, fatty acids with vitamins and mineral content. Consumption of whole unprocessed foods like mushrooms decreases the risk of obesity. Vitamin D enriched mushrooms having high vitamin D_2 concentration with stability during storage, cooking and get more bioavailable (Aremu et al., 2009).

Mushroom is low energy food provide substantial amounts of vitamins and minerals like iron, selenium, potassium, copper, and zinc (Jo Feeney, 2014).Mushrooms loaded with nutrients, add more taste, texture and flavor which will attract people to consume more mushrooms and will help to achieve nutritional security at national level. Therefore vitamin D enriched mushrooms substantially increase the public health issue of vitamin D deficiency globally. With the increased mushroom production worldwide, the per capita consumption has also increased

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from 0.25kg to 4 kg (Royse, 2014).The research concentrates on production of mushroom powder as a value added product to increase its fatty acid composition, mineral quantity and shelf life which will increase revenue generation also. Thus the need of the hour is value addition in various products at commercial level.

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 (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

Fatty acid composition(Appleqvist,1968)

Fatty acid composition was determined by using Gas Liquid Chromatography (GLC) in Department of Plant Breeding and Genetics, College of Agriculture, PAU, Ludhiana. A sample of mushroom powder was taken and mixed with the quantity of 1.5ml of petroleum ether (60^0-80^{0}C). Addition of 1.5ml of 0.02M Sodium ethoxide (C_2H_5ONa) was done in the solution. The test tubes filled with solution was vortexed and retained at room temperature for 30-40mins. Then add 1.5ml of 8% Sodium chloride in the solution followed by vortex and again keep it for another 30 minutes. Two layers were established from where the top layer with petroleum ether

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was collected and shifted into the GC vials of 1.5ml quantity. The 1µl sample was taken from this aliquot and injected into GC by utilizing auto sampler on Agilent technologies Gas Chromatography model 7820A series outfitted with flame ionization detector`` fitted with CP-Silica 88 25m x 0.25mm x 0.20mm with FAME column.

Mineral estimation

Minerals namely iron, copper, phosphorus, potassium, zinc and selenium were estimated by Inductively Coupled Plasma Optical Emission Spectrometry (ICP- OES) method using ICP optical emission spectrophotometer (ICP-OES Optima 2100 DV).

Method

For the mineral estimations of dried samples, the wet digestion method is used in which 0.5g sample was taken in a 150ml conical flask and addition of nitric acid: perchloric acid in 5:1v/v (diacid) was done in every sample. The samples were kept for 24 hours. All the samples were digested over hot plate till it remained 1ml and colourless. Then the 25ml volume was made with the use of double distilled water and filled in reagent bottles. The samples were subjected into ICP- OES and the minerals were estimated at a specific wavelength.

Calculation

Mineral concentration (mg/L) = Sample concentration (ppm) – Blank concentration (ppm) x dilution factor.

Storage stability

Button mushroom powder was further evaluated for shelf life using various packaging materials such as ziplock polyethylene bags, glass container and plastic container (Miles and Misra, 1938 and modified by Thatcher and clark, 1968). We have investigated the presence of bacterial and yeast/ mold growth.

Fatty acid composition of Button mushroom powder

Dietary fat is the major constituent of diet like other nutrients which is important to maintain lipid homeostasis in body. Although mushroom contains lower fat content but it is a good source of essential fatty acids. It contains good amount of Oleic Acid and Linoleic Acid

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(Goyal et al.,2015). In the present study we observed the effect of UV-B rays on the fatty acid composition of button mushroom powder.

Table 1 Fatty acid composition of Button mushroom powder (on dry weight basis)

Treatment	Palmitic Acid (C16:0)	Stearic Acid (C18:0)	Oleic Acid (C18:1)	Linoleic Acid (C18:2,ω-6)
CBMP	14.73 ±0.03	5.80 ±0.06	4.66 ±0.19	74.78 ±0.10
TBMP	14.55 ±0.11	5.68 ±0.06	3.90 ±0.35	76.00 ±0.14
|t|-Value	**2.602**	**2.376**	**3.372**	**12.414**
p-Value	**0.060**	**0.076**	**0.028**	**(<0.0001)**

CBMP- control button mushroom powder

TBMP-treated button mushroom powder at the distance of 60cm for 30min

t-values are absolute values

Data of Table 1 showed the fatty acid composition of button mushroom powder when treated with UV-B rays at the distance of 60cm for 30min and that of control button mushroom powder. Among fatty acid composition Saturated (C16:0, 18:0), monounsaturated (C18:1) and polyunsaturated (C18:2) have been analyzed. It was seen that the Palmitic acid (C16:0) was found to be 14.55% in treated button mushroom powder which was statistically non-significant than that in control button mushroom powder at 14.73%. Stearic acid (C18:0) was observed 5.68% in treated button mushroom powder as compared to control button mushroom powder at 5.80%. Oleic acid (C18:1) was evaluated at 3.90%, significantly lower at 5% significance level than the control button mushroom powder at 4.66%. In case of Linoleic acid (C18:2) significantly higher content at 76% was observed in treated button mushroom powder at 0.01% significance level as compared to control button mushroom powder at 74.78%. The results showed button mushroom powder contains good amount of polyunsaturated fatty acid as Linoleic acid. The reason of variation in the Fatty acid composition of treated button mushroom powder might depend on the cellular mechanism of lipid metabolism. Acetyl-CoA Carboxylase is an enzyme plays a key role in fatty acid synthesis which depends on availability of ATP's

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(Adenosine Triphosphate). Biosynthesis of PUFA requires large amount of ATP's than SFA's and MUFA's production. UV exposure may decrease the availability of ATP's for the synthesis of fatty acids which can cause decrease in fatty acid composition of UV treated button mushroom powder.

Guihéneuf et al.,(2010) studied the effect of UV stress on fatty acid composition in two marine microalgae Pavlova lutheri (Pavlovophyceae) and Odontellaaurita (Bacillariophyceae). It was reported that UV-R treatment led to reduction in PUFAs such as 20% in EPA and 16% in DHA, in P. lutheri species whereas no change of fatty acid composition was observed in O. aurita species. Shaoet al., (2010) studied fatty acid composition of button mushroom (Agaricusbisporus) in cap and stem, separately. It was seen that the Palmitic acid (C16:0) present in cap was 14.1% whereas it was 14.93% in stem part. Stearic acid (C18:0) was recorded at 3.82% and 4.56% among cap and stem part which was followed by monounsaturated fatty acid as Oleic acid (C18:1) contained in the cap at 3.28% and in stem part at 1.96%. Linoleic acid (C18:2), the polyunsaturated fatty acid was recorded at 68.59% in cap portion and 67.49% in stem portion.

Goyal et al., (2015) compared the fatty acid composition of Button mushroom (Agaricusbisporus) with Oyster mushroom (Pleurotussajor-caju). The analysis has shown the content of Palmitic acid (C16:0) at 12.27% in button mushroom and 13.50% in oyster mushroom. Stearic acid (C18:0) was found to be at 4.58% and 2.92% in button mushroom and oyster mushroom respectively. The presence of Oleic acid (C18:1) was reported 8.69% in button mushroom as compared to oyster mushroom at 9.46%. In case of Linoleic acid (C18:2) Button mushroom have contained 70.36% whereas 65.67% was evaluated in Oyster mushroom.

Mineral content of UV-B treated Button mushroom powder

Mushroom is considered as rich source of minerals. It contains very good amount of phosphorus and potassium. Selenium is also present in an adequate amount. The effect of UV-B rays on mineral content of button mushroom powder has been discussed below:

Table 2 Mineral content of UV-B treated Button mushroom powder (on dry weight basis)

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Treatment	Iron (mg/100g)	Copper (mg/100g)	Phosphorus (mg/100g)	Potassium (mg/100g)	Zinc (mg/100g)	Selenium (mg/100g)
CBMP	8.76±0.15	8.33±0.24	635.29±0.84	2163.14±1.82	1.69±0.09	0.33±0.02
TBMP	9.19±0.22	13.04±0.74	916.07±2.52	2470.29±1.48	4.36±0.13	0.87±0.03
|t|-Value	**1.982**	**8.211**	**129.379**	**252.648**	**17.354**	**13.768**
p-Value	**0.119**	**0.001 (<0.0001)**	**0.000 (<0.0001)**	**0.000 (<0.0001)**	**0.000 (<0.0001)**	**0.000 (<0.0001)**

Values are given in Mean± SE

CBMP- control button mushroom powder

TBMP- treated button mushroom powder at the distance of 60cm for 30min

t-values are absolute values

The mineral content of control button mushroom powder and UV treated button mushroom powder at the distance of 60cm for 30min showed significant variation (Table 2). The iron content of treated button mushroom powder was found at 9.19mg/100g which was slightly higher but statistically non-significant as compare to the control button mushroom powder at 8.76mg/100g. Similarly for copper content of treated button mushroom powder was 13.04mg/100g than the control button mushroom powder with 8.33mg/100g. In treated button mushroom powder phosphorus and potassium content i.e. 916.07mg/100g and 2470.29mg/100g were significantly higher at ($p<0.0001$) than control as 635.29mg/100g and 2163.14mg/100g respectively. Zinc content was observed as 4.36mg/100g in treated button mushroom powder which was significantly higher than the control button mushroom powder i.e. 1.69mg/100g. Similarly, significantly higher selenium content as 0.87mg/100g was reported in treated button mushroom powder than 0.33mg/100g in control button mushroom powder. The metabolism of nutrients is directly or indirectly associated with each other. Although UV treatment directly affects the composition of fatty acids, polyphenols and protein digestibility, indirectly it also affects the mineral composition of mushroom. Adejumoet al., 2017 reported that the UV treatment affects the mineral composition of substrate although the exact mechanism is not known.

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Poongkodi et al., (2015) reported the mineral content in pileus and stripes parts of button mushroom. Phosphorus content was found to be higher in pileus part at 1300mg/kg as compare to 500mg/kg in stripes part of button mushroom. Similarly, copper content was observed at 698.50mg/kg in pileus whereas 637mg/kg in stripes part of button mushroom on dry matter basis. Zinc content of pileus part in button mushroom found to be at 81.60mg/kg which was significantly higher than 89.80mg/kg in stripes part of button mushroom whereas iron content was observed at 350mg/kg in pileus part and 200mg/kg in stripes part of button mushroom. Selenium content of pileus part was found to be significantly lower at 0.496mg/kg and higher at 0.565mg/kg in stripes part of button mushroom.

Masamba and Kazombó-Mwale, (2010) reported the selected mineral content of button mushroom, where the iron content was found to be at 0.2mg/100g, calcium at 2.2mg/100g and 8.4mg/100g of magnesium in button mushroom.

Mattila et al., (2001) compared the mineral content in cultivated button mushroom on the basis of fresh and dry weight basis. Iron content was observed in fresh button mushroom at 3.7mg/kg which was significantly lower than dry button mushroom at 48mg/kg. Similarly, fresh mushroom contained 3.64g/kg potassium as compared to dry button mushroom at 47.3g/kg. The phosphorus content was observed at 0.980g/kg in fresh and 12.7g/kg in dry button mushroom, whereas copper content was found to be 2.2mg/kg in fresh button mushroom in comparison of dry button mushroom at 29mg/kg. Zinc content was estimated at 5.1mg/kg in fresh button mushroom and 66mg/kg in dry button mushroom. The selenium content in fresh button mushroom was observed at 110µg/kg and 1400µg/kg in dry button mushroom.

Storage stability of processed Button mushroom powders during storage for 5 months

Factorial ANOVA was applied on microbial count (bacterial and yeast/mold) (Table 3) for finding out the effect of packaging material and time of storage. There was a significant effect of sample of button mushroom powder and treated button mushroom powder on bacteria count, $F(1,48)=178.087$, $p=<0.0001$ and yeast and mold count, $F(1,48)=27.379$, $p=<0.0001$. There was a significant effect of packaging material on bacteria count of button mushroom powder and treated button mushroom powder, $F(2,48)=3.435$, $p=0.040$ whereas no significant effect was observed on yeast and mold count, $F(2,48)=2.568$, $p= 0.087$. There was a significant effect of time on bacteria count $F(3,48)=14.261$, $p=<0.0001$ and yeast and mold count $F(3,48)=5.344$, $p=0.003$of button mushroom powder and treated button mushroom powder. There was no

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significant effect of interaction between sample and packaging on bacteria count F(2,48)=0.304, p=0.739and yeast and mold count F(2,48)=2.653, p=0.081of button mushroom powder and treated button mushroom powder. There was no significant effect of interaction between sample and time on bacteria count F(3,48)=3.594, p=0.020 and yeast mold count F(3,48)=0.740, p=0.533of button mushroom powder and treated button mushroom powder. There was no significant effect of interaction between packaging and time on bacteria count of button mushroom powder and treated button mushroom powder, F(6,48)=0.304, p=0.932 and yeast and mold count,F(6,48)=0.196, p=0.976. There was no significant effect of interaction between sample, packaging and time on bacteria count of button mushroom powder and treated button mushroom powder, F(6,48)=0.402, p=0.862 and yeast and mold count F(6,48)=0.140, p=0.990.

Table 3 Microbial count (bacterial and yeast/mold) of Button mushroom powder in different packaging materials after storage for 5 months (10^2cfu/g)

Sample	Packaging Material	Bacterial Count				Yeast/mold count		
		105 Days	120 Days	135 Days	150 Days	120 Days	135 Days	150 Days
CBMP	Zip lock Polyethylene Bag	1.67	2.33	2.67	3.67	1.00	2.33	3.00
	Glass container	1.33	2.00	2.33	2.67	0.56	1.15	1.44
	Plastic container	1.33	1.67	2.33	3.33	1.15	2.07	2.37
TBMP	Zip lock Polyethylene Bag	0.33	0.33	1.00	1.00	0.19	0.49	0.85
	Glass container	0	0.33	0.33	0.67	0.11	0.33	0.74
	Plastic container	0.33	0.33	0.67	0.67	0.15	0.37	0.82

CBMP- control button mushroom powder

TBMP- button mushroom powder treated with UV-B at the distance of 60cm for 30minutes

Medium used: Nutrient Agar/ Potato Dextrose Agar

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Incubation Time: 24hrs

Incubation Temperature: 37°C

The results revealed that the initially no microbial growth was observed in stored material till 90^{th} day. With the increase in storage period the microbial growth was increased due to increase in moisture content, but was in permissible limit till 150 days of storage period under good storage conditions. On the basis of results we concluded that the glass container was best packaging material for storage than plastic container and zip lock polyethylene bags which improves the keeping quality of mushroom powder.Qin et al., (2015) studied the effect of PLA/PCL/cinnamaldehyde antimicrobial packaging on physicochemical and microbial quality of Button mushroom (Agaricusbisporus). The results showed that the bacterial count was significantly lower in PLA/PCL/C9 film as compared to the control (LDPE) and PLA/PCL film after 16 days of storage period. The highest weight loss was observed in PLA/PCL/C9 packaging but it was lower than other packaging materials. Its higher permeability for water vapour makes it better packaging material than other packing materials. Kaur, (2017) observed the microbial contamination in raw and roasted pumpkin seed flour stored in glass container during initial period (0^{th} day), 15^{th} day, 30^{th} day, 45^{th} day and 60^{th} day of storage. The results revealed that the bacterial growth in raw pumpkin seed flour was $1.9x10^3$at 0^{th} day, $3x10^3$ at 15^{th} day, $5.2x10^3$at 30^{th} day, $8x10^3$ at 45^{th} day and $10x10^3$at 60^{th} day whereas the bacterial growth of raw pumpkin seed flour was seen lower during the time duration. The bacterial growth was $1.2x10^3$at 0^{th} day, $2.7x10^3$ at 15^{th} day, $5x10^3$at 30^{th} day, $7x10^3$at 45^{th} day, $8.8x10^3$ at 60^{th} day. On the basis of results it can be concluded that the microbial growth of stored pumpkin seed flour was decreased after roasting.

Conclusion

The above study showed that the nutritional composition of Button mushroom powder in terms of mineral content increased significantly on exposure to UV rays therefore it could be used combat micro nutrient deficiencyamong the vegetarian population. Significant increase in linoleic acid content due to UV exposure and presence of low fat content could be increase the consumption of button mushroom among health conscious population as well patients suffering from high cholesterol or heart disease. Due to the high storage stability processed button mushroom powder can be used as a value added product to increase availability in off season and for better revenue generation.

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