

# Nutritional-Medicinal Profile and Quality Categorization of Fresh White Button Mushroom

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**Abstract:** Due to susceptible change era for the world, limited land resources; vast encounter to meet the food demand and medicine for the growing populations make the necessity to discover any alternative food which has good nutritional and medicinal value. Hence, the quality categorization of Fresh White Button Mushroom has been necessitated by the need for harmonizing requirements governing the quality of products. The contents and categorizations were formulated in accordance with the procedures established by standards physicochemical and sensory determination methods. The chemical composition (moisture, ash, protein, carbohydrate, total fat) and minerals composition (Se, Ni, Mn, Cu, Zn, Na, N, Fe, P, Ca, Mg, S, and K) of white button mushroom were determined. Results show that edible mushrooms are rich sources of protein ( $3.27\pm 0.12$ ), fiber ( $1.87\pm 0.08$ ), carbohydrates ( $2.66\pm 0.61$ ), fats ( $0.22\pm 0.05$ ) and energy ( $28.50\pm 1.22$  Kcal) g/100g fresh weight basis respectively. In addition to these, white button mushrooms also contain the highest content of potassium ( $3560\pm 153.33$ ) and sulfur ( $2195.59\pm 1405.60$ ) mg/kg fresh weight basis mineral elements. The quality categorization was monitored under a controlled environmental condition (Temp.  $5-6\pm 1^{\circ}\text{C}$ ) and packed in a 30 $\mu\text{m}$  thickness polyethylene bag. The data were categorized by organoleptic, physicochemical, and bacterial count (CFU/g) basis. The grades SSQM: size < 33.44mm, whiteness (Hunter) > 80 number of pieces: 19/200g, open veils; Nil, Veiled: Nil; lactic acid: > 0.7%, *Lactococcus lactis*: >  $9.5 \times 10^5$ , SQM: Size range of 33.57-38.55, whiteness (Hunter): 70-80, Veiled 1, open veiled 1, open veiled 6.25%, lactic acid: 0.4-0.7 % and *Lactococcus lactis*: >  $8.4 \times 10^5$ , AQM: size > 38.62, Whiteness (Hunter): 60-70, Veiled 1, open veiled 2, open veiled 16.6%, lactic acid: 0.3-0.4 % and *Lactococcus lactis*: >  $3.4 \times 10^5$ . The overall fruiting body has a significantly high level of nutrient and mineral composition, Lactic acid, and probiotic bacteria, thus WBM can be used as a good source of food as well as medicine.

**Keywords:** White Button Mushroom; Nutritional; Medicinal Profile; Lactic acid; *Lactococcus lactis*; Immunomodulation.

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## 1. Introduction

The complete nutrition and diet are increasing very significantly, not just in the regular everyday life of human beings, but similarly in the treatment of chronic diseases and incessant infections. Worldwide specialists are identifying that mushrooms are restorative foods rich in nutrition. The therapeutic properties of WBM are effectively clinical trials conducting throughout the world by the National Institute of Health (NIH) and WHO. Mushrooms are an important natural source of food and medicine; in this way, FDA has formally chosen mushrooms as “healthy foods. Due to insufficient studies on the nutritional properties of wide-ranging mushrooms have been stated in the reports [22, 26].

Mushrooms are a good source of vitamin B complex riboflavin (B2, niacin (B3), Pantothenic acid (B5), ergo sterols (provitamin D2) and minerals such as (selenium, potassium, and copper). Mushrooms additionally, also contains a wide range of therapeutic compounds such as triterpenoids, glycoproteins, natural antibiotics, enzymes, and enzyme inhibitors that strengthen the human health system [12]. Mushrooms contain nine fundamental amino acids like arginine, histidine, lysine, leucine, isoleucine, methionine, phenylalanine, threonine, and valine. Mushrooms are accepted everywhere throughout the world as valuable health foods since they are poor in calories, fat, and fundamental fatty acids and rich in protein, vitamins, and minerals [55]. WBM is considered to be next-generation health food supplements as they are low in fat, have no cholesterol, high in protein with good biological value, and identified as a food source to fight starvation in developing countries [27]. In addition, WBM contained a natural source of carbohydrates, unsaturated fatty acids, dietary fibers, vitamins and minerals, and low in heavy metals [24, 39, 53, 59, 61, 58, 68]. The post-harvest losses can make the quality and safety improvement by quality standards categorization of the WBM [50]. The quality categorization on the basis of sensory properties such as taste, texture, and flavor is distinctive properties of this fleshy and edible mushroom with regard to the consumer's point of view for sustaining a healthy life [20,21,53]. In WBM, biologically active phytochemicals residing in this species are also significant interest from the pharmaceutical and nutraceutical aspects [17].

Mushroom used as a fresh ingredient in soup, sauces, salads, stuffing's and meat dishes [6, 10, 14, 15, 19, 48,76]. The quality of WBM was also affected by various factors like transportation, processing, packaging, and storage. The classification method of quality of WBM, seems to be very real, easy to practice, and low-slung value, but not always a feasible approach for all mushroom species [1, 2]. The basic nutritional profile of White button mushroom (WBM) on dry weight basis available in the previous study, but there are no such reports that are dealing with fresh white button mushroom with nutritional, therapeutic minerals elements and categorization with specific factors like size, whiteness (color) and bacteria. Therefore, the main aim of this study was to assess quantitative data on the basis of fresh WBM nutritional values; minerals content, bacterial load, and organoleptic changes occur during storage were analyzed and categorized for acceptance in dietary use.

## **2. Materials and Methods**

### *2.1. Study area.*

This research was carried out at Dr. Analytical laboratories, which is located in Navi Mumbai, Maharashtra-India. White button mushroom (*A.bisporus*) was collected from the mushroom cultivated farm, Pune, India. Dr. Analytical Laboratories, Navi Mumbai provides the entire chemicals and reagents of an analytical grade for the testing of samples.

### *2.2. Experimental design.*

The WBM was collected for the study; as they can be reared easily and successfully in the existing climatic conditions and their importance as edible species, they have wider distribution. WBM cultivated under controlled conditions temperature ranging from 14-18<sup>0</sup>C. The 2kg fresh mushrooms were collected and analyzed for nutritional and medicinal value and quality categorization.

### 2.3. *Methods for nutritional and mineral content.*

#### 2.3.1. Moisture Content.

The quantum of moisture percentage of WBM was determined by drying the fresh wet mushroom. They were kept at  $105 \pm 2^\circ\text{C}$  in an oven for 2 hours to dry. The sample was weighed about 5 gm and placed in the formerly dried and tared moisture dish (about 75 mm wide and 25 mm deep). The dish was then transferred in an air oven and cooled in a desiccator and weigh. The process was repeated until the change between two consecutive weighings is less than 1 mg, and finally, the lowest weight was recorded [29].

#### 2.3.2. Mineral Content.

The carbon content in WBM was determined by the titration method. 0.05g of the sample placed into 250 ml volumetric flask and 25ml of potassium dichromate-sulphuric acid solution added, and the mixture was boiled at  $200^\circ\text{C}$  for 60 minutes, thereafter cooled at room temperature. The total volume of about 100 ml was made with distilled water. After that 0.2 mol/l ammonium Iron II sulfate solution was added until the brown color disappeared. 0.25ml of N-phenylanthranilic acid solution was added and titrated with 0.2 mol/l ammonium iron II sulfate solution until the solution becomes blue-green [28]. Nitrogen estimation was carried out by a standard method [8]. The Selenium (Se), Nickel (Ni), Manganese (Mn), Copper (Cu), Zinc (Zn), Sodium (Na), Iron (Fe), Phosphorus (P), Calcium (Ca), Magnesium (Mg), Sulphur (S) and Potassium (K) were determined by standard methods [44].

#### 2.3.3. Protein Content.

The nutritive value of protein content in the WBM was analyzed by the digestion method. In brief, 2.2 g samples were placed into digestion flask, and 0.7g mercury oxide, 15g powdered potassium sulfate, and 25ml sulphuric acid were added in a sequential manner. The flask was placed on a heater in an inclined position and warmed gently until foaming ceases. A small amount of paraffin added to reduce foaming, and the solution was boiled vigorously until the solution became clear for almost 2 hours. After cool down the solution, 200 ml of distilled water was added, and mercury was precipitated by adding 25ml of the thiosulphate solution. Zn granules were added to avoid jerking, and 25 g of NaOH (solid pellet) was added to make the solution strongly alkaline. The flask was then connected to the distillation bulb on the condenser, and the flask was rotated to mix the content thoroughly and heated immediately until the ammonia has distilled over (150 ml). Excess acid was titrated with standard (0.1N NaOH) using methyl red as an indicator. Blank was also determined using all reagents and calculated protein value [32].

#### 2.3.4. Total fat and carbohydrate content.

The total fat content in WBM (white button mushroom) was determined by Soxhlet Extraction technique. 109 g of the sample precisely weighed into the thimble and separated with the solvent in a Soxhlet extraction apparatus for approximately 16 hours. The concentrate was dried contained in the Soxhlet flask, whose vacant mass has been earlier determined at  $95\text{-}100^\circ\text{C}$  for 30 minutes. Continued drying and weighing were done alternately at 30-minute intervals until the loss in mass between two consecutive weighings is not more than one milligram, and the lowest quantity was recorded and calculated [31].

The quantum of carbohydrate was determined after the percentage of moisture, protein, fat, and ash. Total carbohydrate calculated as:

=  $100 - (A + B + C + D)$ , where: A = percent by mass of moisture, B = percent by mass of total protein, C = percent by mass of fat, and D = total ash, percent by mass [34].

#### 2.3.5. Ash content and energy estimation.

The content of ash in mushroom was determined by using Muffle Furnace. Weighed 3 g of the sample in the dish was weighed, which was previously dried in an air-oven and weighed. The plate was heated gently on a flame at first and then strongly in a muffle furnace till grey ash results, in the desiccator plate, cooled and further weighed. Inside the muffle furnace, the plate heated for 30 minutes. Thereafter, the plate kept in a desiccator, cooled, and weighed. The heating process repeated for 30 minutes, cooling and weighing were performed until the difference between two successive weighings is less than 1 milligram. Finally, the lowest quantity was recorded [29]. The energy value from the white button mushroom was calculated by the conversion method [33].

#### 2.4. White button mushroom categorization and storage.

The white button mushroom was collected from mushroom houses at the Weikfield, Pune, and then segregated according to size, color, and veil opening. Thereafter, WBM samples were categorized into four groups; super quality Mushroom (SSQM), super quality Mushroom (SQM), A-grade, and B-grade. All categorized WBM placed into the polyethylene bags (thickness 30 $\mu$ m) and stored under 5-6 $\pm$ 1 $^{\circ}$ C for eight days. All the experiments were performed at 0, 2, 4, 6, and 8 days.

##### 2.4.1. Assessment of WBM quality.

A total of 20 packets of WBM contained, each bag carrying 200g WBM were selected and assessed for quality categorization. The quality categorization was divided into three categories, i.e., Sensory Evaluation, Physiochemical and bacteriological determination. All the test experiment was followed by standard methods.

##### 2.4.2. Whiteness.

The colorimeter (L, a\*, b\*) Model CR-400, Chroma Meter made by Konica Minolta company, Japan), was used for whiteness measurement. The chroma meter was standardized with a white plate before use. L\*(lightness), a\*(+red-green), and b\*(+yellow-blue) parameters were measured on the side of the mushroom cap. A total of 10 samples from three replicate packages were measured. The hunter whiteness was calculated using the following formula: Hunter Whiteness =  $L - 3b^*$ [47].

##### 2.4.3. Size and grades.

The harvested white button mushroom was segregated on the basis of the size of the cap. The size of the cap was measured by slide caliper and recorded in millimeters (mm).

#### 2.4.4. Open veil.

The below-mentioned formula was used to analyze the open the veil of WBM percentage [37].

$$\% \text{ Open Veils} = N_{ov} / N_{tx} \times 100$$

Where  $N_t$  defines the total number of white button mushrooms, and  $N_{ov}$  defines the number of open caps mushrooms.

#### 2.4.5. Texture, aroma (odour) and overall acceptance.

The organoleptic evaluation was conducted by a trained panel for texture, aroma, and overall acceptability. 1-3 point hedonic rating test was used to evaluate the degree of acceptability of FWBM slice 5mm from the sample. One slice from each sample of 5mm thickness was provided to 10 panelists as randomly coded samples. The taste panelists were requested to rate the mushroom sample for their aroma, texture, and overall acceptability on a scale of 1-3 (where 3 represents the highest point; 2 represents a medium point, and 1 represents the lowest point) [18].

#### 2.4.6. Temperature.

The samples of White Button Mushroom were kept under controlled temperature  $6 \pm 1^\circ\text{C}$  for days-0, 2, 4, 6, and 8. All test was conducted at room temperature.

#### 2.4.7. Moisture.

The quantum of moisture percentage of the white button mushroom was determined by drying the fresh wet mushroom. They were kept at  $105 \pm 2^\circ\text{C}$  in an oven for 2 hours to dry. The weight of the sample was 5 gm and place in the formerly dried and tared dish (dimensions 25 mm deep and 75 mm wide) and then transferred in an air oven. The dish was cooled in a desiccator, and weigh, and the process was repeated until the change between two consecutive weighings less than 1 mg. Finally, the lowest weight was recorded [29].

#### 2.4.8. Lactic acid.

The quantum of lactic acid of white button mushroom was determined by the procedure described previously [29] and calculated as given below:

$$\frac{[(M_2 - M_0) \times 100] + 0.1 \alpha}{M_1 - M_0}$$

Where,

“ $M_0$ ” denotes mass (g) of the dish (with zinc oxide), lid and stirring rod.

“ $M_1$ ” denotes the mass (g) of the dish (with zinc oxide), lid, stirring rod, and test portion.

“ $M_2$ ” denotes the mass (g) of the dish, lid stirring rod and dried test portion (including zinc oxide)

“ $\alpha$ ” denotes the mass (g) of lactic acid as achieved in Step I, and it is equal to 0.1 g/g of lactic acid content.

#### 2.4.9. Estimation of *Lactococcus lactis*.

Initially, dilution of each sample was done by weighing the 10 g WBM in a sterile environment and then placed into a sterile mortar and pestle with 90 ml of the sterile buffer. The sample was homogenized and then serially diluted up to  $10^5$  using the same diluent. Then, 0.1 ml from each dilution was transferred into the MRS agar plate [23] ( $30^{\circ}\text{C}/72\text{h}$ ) for *Lactococcus lactis* counts, and the colony counts were recorded.

#### 2.5. Statistical analysis.

The quantum of nutrients and minerals contents of white button mushroom was presumed to be normal, and mean $\pm$ SD were evaluated as representative parameters of the distribution. Statistical analysis was performed by SPSS [64] software by using two way ANOVA, and the  $R^2$  value was calculated.

### 3. Results and Discussion

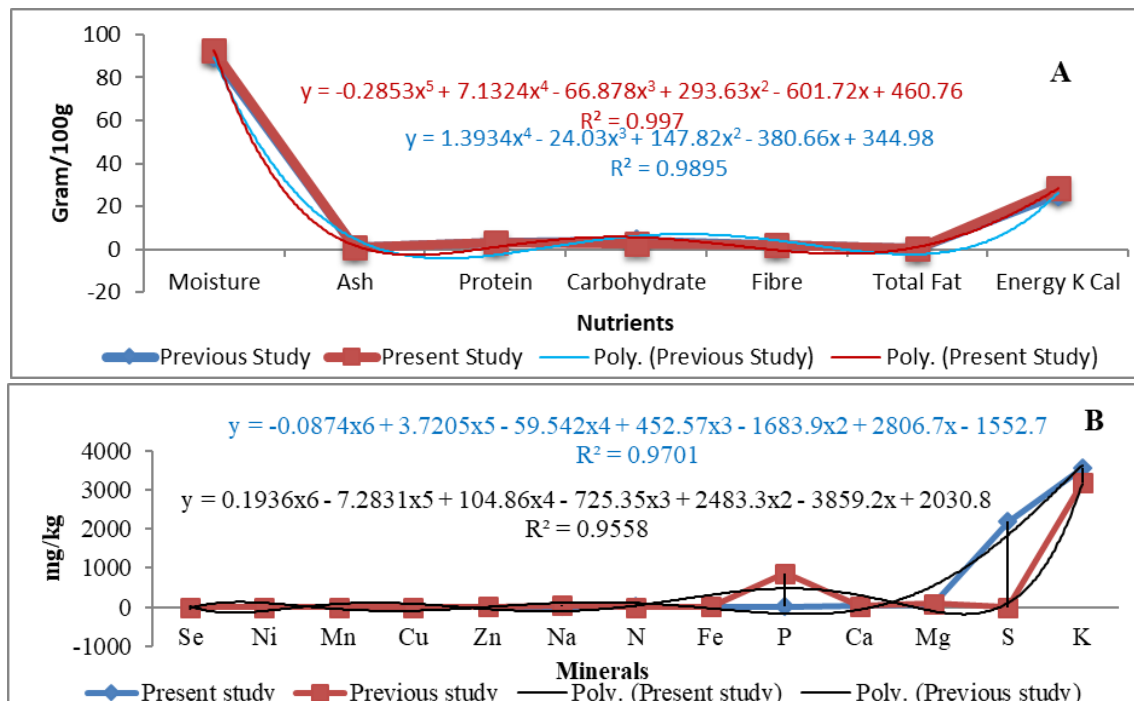
Mushrooms are a noble source of vitamin B complexes such as riboflavin (B2), niacin (B3), Pantothenic acid (B5), ergosterols (provitamin D2) and minerals, *i.e.*, selenium, potassium, and copper. Mushrooms additionally possess several therapeutic substances like triterpenoids, natural antibiotics, glycoproteins, enzymes, and enzyme inhibitors that strengthen the health system [12]. Zinc is a constituent of several enzyme systems that regulate various metabolic reactions. Mushrooms are considered a good source of zinc *via* a property of biological accumulator in nature [9].

This study is the first report for assessment of nutritional, medicinal, and quality categorization of FWBM (*A. bisporus*). In this study, nutrients, minerals elements, physicochemical factors evaluated for deterioration of the quality of white button mushroom. Our study showed that the various properties like whiteness, lactic acid, and *Lactococcus lactis* bacterial content in fresh white button mushroom dependent on various physicochemical factors. During the storage of WBM, the changes in these properties occur due to natural metabolic activity mushrooms. The nutrients and minerals contents of WBM is directly related compost on which they grow. The previous study also reported that heavy metals in white button mushrooms and compost were very significant and suitable for WBM cultivation and human consumption [61,62].

Normally the WBM were contains a very high natural source of protein, less in fats, carbohydrate, and no cholesterol. The high content of Fe, P, Ca, Mg, S, lactic acids, and *Lactococcus lactis* are very important components in FWBM, which controlled the biological activity. Consequently, designing standard methods by selecting discs from representative parts of the fruiting body, as well as discrimination between firmness and toughness, is important [46]. In order to find out the precise nutritional composition and minerals content in white button mushrooms, were tested in Dr. Analytical laboratory, Navi Mumbai, India. The nutrients and minerals content indicated that composition in the fresh wet basis of a white button mushroom. The moisture, protein, fiber, and Energy (Kcal) contents of white button mushrooms were higher compare to previous study and lower ash, carbohydrate, and fat. The  $R^2$  value was found 0.997, which is highly significant. The composition of this nutrient may be considered as potential nutraceuticals, and it can be beneficial for health-related issues and treatment of various kinds of diseases [3].

### 3.1. Moisture.

The moisture content in the fresh white button mushroom (FWBM) plays a very significant role in the quality of mushroom. In the present study, moisture ranged from 92.40-93.30 %. The average moisture content was  $92.80 \pm 0.37$  % (Table 1), and the relationship between other nutrients found  $R^2 = 0.997$ , which showed very significant (Fig. 1a).



**Figure 1.** (A) Correlation of nutrients composition, Moisture, Ash, Protein, Carbohydrate, Fat, and Energy (KCal) (B) Correlation of minerals Se, Ni, Mn, Cu, Zn, Na, N, Fe, P, Ca, Mg, S, and K of Fresh White Button Mushroom. Each value represented as arithmetic mean  $\pm$  SD and statistically analyzed by SPSS 17 two way ANOVA and nutrients composition value  $R^2 = 0.997$  found more significant with respect to previous studies  $R^2=0.9895$ . For minerals value,  $R^2=0.9701$  also more significant compare to previous results  $R^2=0.9558$ .

### 3.2. Proteins.

The mushroom considered a good source of proteins that contained essential amino acids and substantial quantities of non-essential amino acids. The protein contents in mushrooms are varied due to the availability of nitrogen, geographical location, and also affected by environmental factors [13]. The results showed that protein content in FWBM was  $3.27 \pm 0.12$  g/100g [Table 1].

### 3.3. Carbohydrate and fat.

The mushrooms are an important natural source of carbohydrates. The Carbohydrate content was found to be lower than the quantum of protein in the mushrooms. The low carbohydrate content may be considered as a suitable food source for diabetic patients [42]. The mean quantum of carbohydrate in the fresh white button mushroom was  $2.66 \pm 0.61$  (Table 1). The fats content in cultivated mushrooms had a lower amount compared to a wild variety [51]—The fat content in fresh white button mushroom was found to be  $0.22 \pm 0.059$  (Table 1).

3.4. Energy and ash content.

In natural mushrooms, which grow in forest contained an average of 1571.9 kJ/100 of dry weight basis compared to cultivated mushroom 1763.02 kJ found in a previous study [41]. The quantum of energy in the fresh white button mushroom was 28.50±1.22 (Table 1). In this study, the Ash content in the fresh white button mushroom was found to be 0.93±0.01 g/100g (Table 1). Previous researchers reported ash content in mushroom 9.74g/100g on a dry weight basis [11].

**Table 1.** Nutrients composition in fresh white button mushroom - gm/100gm.

S.No	Moisture	Ash	Protein	Carbohydrate	Fiber	Total Fat	Energy K Cal	References
1	89.5	1.25	3.94	-	1.09	0.19	-	[7]
2	91.02	0.78	3.26	6.46	-	0.19	29.55	[65]
3	91.39	1.074	2.75	2.36	3.36	0.448	-	[49]
4	87.77	0.85	3.14	3.23	-	0.17	-	[52]
5	92.45	-	3.09	3.26	1	0.34	22	[16]
Average	<b>90.43</b>	<b>0.99</b>	<b>3.24</b>	<b>3.83</b>	<b>1.82</b>	<b>0.27</b>	<b>25.78</b>	Previous study
SD±	1.63	0.19	0.39	1.56	1.09	0.11	3.78	
Sample1	92.40	0.92	3.12	3.41	1.95	0.16	27.00	Present study
Sample2	93.30	0.94	3.26	1.92	1.75	0.28	30.00	
Sample3	92.70	0.94	3.42	2.64	1.90	0.23	28.50	
Average	<b>92.80</b>	<b>0.93</b>	<b>3.27</b>	<b>2.66</b>	<b>1.87</b>	<b>0.22</b>	<b>28.50</b>	
SD±	0.37	0.01	0.12	0.61	0.08	0.05	1.22	

3.5. Estimation of mineral content in Fresh white mushroom.

3.5.1. Carbon.

The carbon content in WBM (*Agaricus bisporus*) is considered an important factor in terms of its fruit body. The mean value of carbon content in FWBM was found to be 3.04±0.02%. Still, the exact role of carbon content in fresh mushrooms is not yet reported.

**Table 2.** Minerals content in fresh white button mushroom-mg/kg.

S.No	Se	Ni	Mn	Cu	Zn	Na	N	Fe	P	Ca	Mg	S	K
Sample 1	0.05	0.05	0.47	2.67	3.85	2.6	4.9	13.61	19.8	20.61	64.36	87.78	3390
Sample 2	0.065	0.65	1.41	1.86	3.55	4.7	5.7	13.6	20	38.5	93.6	4304	3500
Sample 3	0.05	0.35	0.94	2.261	3.56	3.65	5.3	13.61	10.9	20.62	78.92	2195	3790
Average	<b>0.06</b>	<b>0.35</b>	<b>0.94</b>	<b>2.26</b>	<b>3.65</b>	<b>3.65</b>	<b>5.30</b>	<b>13.61</b>	<b>16.90</b>	<b>26.58</b>	<b>78.96</b>	2195.59	<b>3560.00</b>
SD±	0.01	0.20	0.31	0.27	0.13	0.70	0.27	0.00	4.00	7.95	9.76	1405.60	153.33

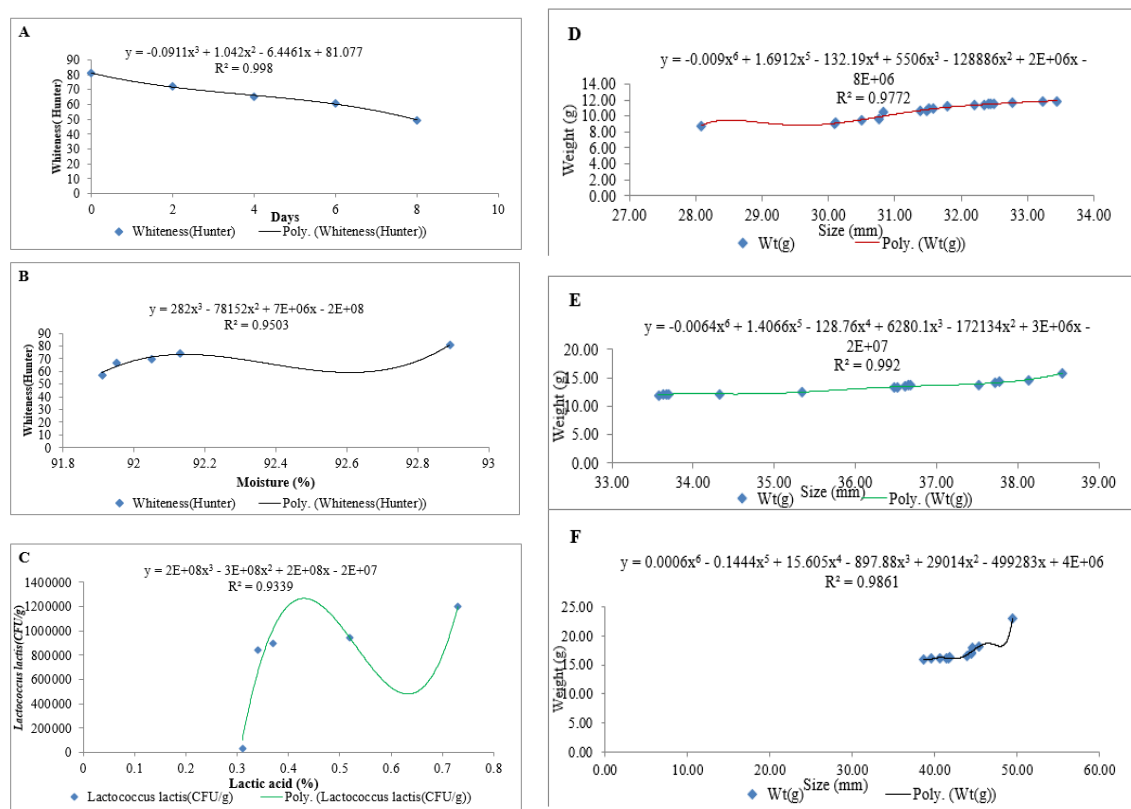
**Table 3.** Organoleptic test results of fresh white button mushroom.

Grade	Size (mm)	Size of Tray (cm)	Net Wt. (g)/ Packet	Average Wt.(g)/ Pcs	No.of Pcs/Pac ket	Closed (No of Pcs)	Veiled (No of Pcs)	Open (No of Pcs)	% of Open Veils	Whiteness (Hunter)	Lactic Acid (%)	<i>Lactococcus lactis</i> (CFU/g)
SSQM	<33.44	16.2 X 12.2	200	10.7± 0.99	19	NIL	NIL	NIL	NIL	>80	>0.7	>9.5x10 <sup>5</sup>
SQM	33.57-38.55		200	13.31± 1.08	16	14	1	1	6.25	70-80	0.4-0.7	>8.4x10 <sup>5</sup>
AQM	>38.62		200	17.19± 1.89	12	9	1	2	16.6	60-70	0.3-0.4	>3.4 x10 <sup>5</sup>



### 3.5.2 Selenium.

The selenium incorporated as a natural source into amino acids, such as selenocysteine and selenomethionine. The selenium content in the present study of FWBM was found to be  $0.06 \pm 0.01$  mg/kg (Table 2). Dietary consumption of selenium ranges from 7-4990  $\mu$ g per day, with mean standards of 40  $\mu$ g every day in Europe and 93  $\mu$ g (in Ladies) to 134  $\mu$ g per day (in men) in the USA [54]. The WBMs is adequate to provide a sufficient amount in terms of everyday intake of selenium. The correlation coefficient of selenium with other minerals was very significant, and the  $R^2$  value of Se with other minerals was 0.9701 (Figure 2).



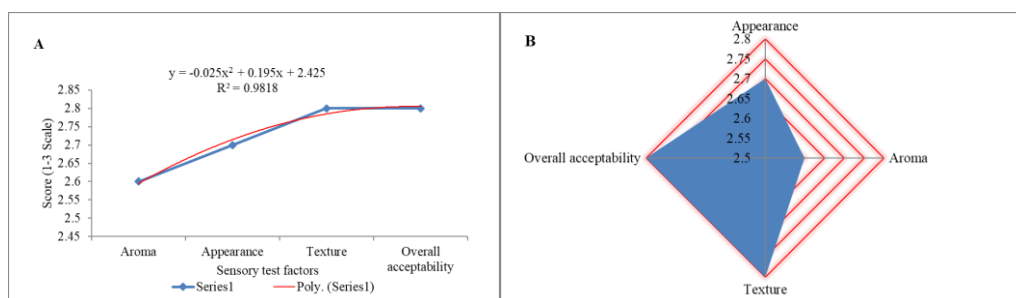
**Figure 2.** (A) Relationship between Whiteness (Hunter) and storage day of a white button mushroom. (B) Relationship between moisture content and whitenss of White button mushroom. (C) Relationship between Lactic acid and *Lactococcus lactis* bacteria in white button mushroom (D) Relationship between Length and Weight of White button mushroom Grade SSQM. (E) Relationship between Length and Weight of White Button Mushroom Grade SQM. (F) Relationship between length and weight of White Button Mushroom Grade AQM. Each value represented as arithmetic mean $\pm$ SD and statistically analyzed by SPSS 17 One way ANOVA. Whitenss and Storage day value  $R^2=0.998$ , Moisture and Whitenss value of  $R^2=0.9503$ , Lactic acid and *Lactococcus lactis* value  $R^2=0.9339$ , Length-weight grade SSQM value  $R^2=0.9772$ , Length-weight grade SQM value  $R^2=0.992$  and Length-weight grade AQM value  $R^2=0.9861$  found to be significant.

### 3.5.3 Nickel.

Nickel may be considered as a stimulator of some enzyme systems, but at a higher level, its toxicity is also reported. It deposited in the lungs at high concentrations and may lead to bronchial hemorrhages or collapse [25]. Present study results showed that in FWBM, nickel content was found to be  $0.35 \pm 0.20$  mg/kg and varied between 0.05-0.65 mg/kg (Table 2).

### 3.5.4. Manganese.

Manganese is a vital component of the mitochondrial oxidant scavenging enzyme, manganese superoxide dismutase. Manganese is also present in metalloproteins, such as pyruvate carboxylase, and in the cytoplasmic enzyme, glutamine synthetase. A deficiency of magnesium was shown to affect the humoral immune system. The average manganese content in fresh white button mushroom samples was  $0.94 \pm 0.31 \text{ mg/kg}$  (Table 2). The value for these mushroom species is in accordance with previously reported studies [35]. In plants, toxicity limits of manganese are high and range between  $400\text{-}1000 \text{ mg/kg}$  [75].



**Figure 3.** (A) Relationship of Sensory evaluation of white button mushroom. (B) Sensory evaluation score of a white button mushroom. Each value represented as arithmetic mean  $\pm$  SD and statistically analyzed by SPSS 17 One way ANOVA. Sensory relation of Aroma, Appearance, Texture, and overall acceptability value  $R^2 = 0.9818$  and sensory evaluation test by hedonic method value ranges.

### 3.5.5. Copper.

Copper is found to be the third most abundant trace element in the human body. The accumulation of copper suggests a possibility that the peptide or its digestive products show a vital part in the copper transport to the liver as a copper ligand. A small amount of copper is found in the human body ( $50\text{-}120 \text{ mg}$ ), and it plays a very critical role in various biochemical processes [66,69]. The average copper content in the fresh white button mushroom was  $2.26 \pm 0.27 \text{ mg/kg}$  (Table 2). *A.bisporus* had the highest copper content accumulated in mushroom species, which is not considered as a health risk [40].

### 3.5.6. Zinc.

Related to adults, infants, babies, youngsters, teenagers, pregnant, and lactating ladies require zinc in an increased amount and, therefore, are at expanded risk of zinc reduction. Zinc paucity during the growing period results in growth let down. The deficiency of zinc, particularly in children, could result in appetite loss, weakness, growth retardation, low spirited, and retarded sexual growth [57]. The results of this study showed that the average Zn content present in WBM was  $3.65 \pm 0.13$  and ranged between  $3.55\text{-}3.85 \text{ mg/kg}$  (Table 2).

### 3.5.7. Sodium.

Low sodium content in mushrooms is an ideal food for people having blood pressure. Previous reports in hypertensive patients (non-diabetic) have revealed that dietary modifications may reduce diastolic blood pressure if a low amount of sodium is included in daily diet [45]. Earlier research reported that sodium content in mushroom was  $50 \text{ mg/kg}$ , while the present results showed that sodium content was  $3.65 \pm 0.70 \text{ mg/kg}$  and ranged between  $2.6\text{-}4.7 \text{ mg/kg}$  (Table 2).

#### 3.5.8. Nitrogen.

Nitrogen is a very significant component of protein. The protein content of mushrooms relies on the structure of the substrate, size of the cap, harvesting time, and types of species [73]. Results indicated that a good natural source of nitrogen and revealed average nitrogen in FWBM was  $5.30\pm 0.27$  and range between 4.9-5.7 mg/kg and (Table 2). The correlation coefficient  $R^2$  value of nitrogen with other minerals was 0.97 (Fig. 1b).

#### 3.5.9. Iron.

Nutritional iron deficiency leads to a defect in thermoregulatory capacity in cold stress human as well as in model organisms. Iron deficiency also results in altered thyroid hormone metabolism throughout the estrous cycle [36]. The mean iron content present in the fresh WBM was 13.61mg/kg (Table 2). The iron content in the present study is suitable for the human diet.

#### 3.5.10. Phosphorus and Calcium.

Nutritional phosphorus and calcium consumption are often considered to be the main factors in bone mineralization and metabolism. Other research also has shown the potential for the treatment of osteoporosis by calcium intake and calcium supplementation [72]. The Calcium and Phosphorus were recorded an average phosphorus  $16.90\pm 4.0$ , and calcium content was  $26.58\pm 7.95$  mg/kg in the fresh white button.

#### 3.5.11. Magnesium.

Magnesium helps to retain normal muscle, bone, and nerve function keeps heart rhythm steady, maintains a healthy immune system. In this study, average Magnesium content in fresh white button mushroom was found to be  $78.96\pm 9.76$  mg/kg (Table 2). Magnesium is essential for mushrooms, and its uptake and sequestration are regulated by them [70].

#### 3.5.12. Sulfur.

Mushroom contains L-Ergothioneine between 0.40 to 2.00 mg/g (D/W), which is a type of sulfur-related amino acid. L-Ergothioneine can't be produced by humans inside the body. There was a significant increment in the ergothioneine substance of RBCs (mg/dL) with 16 g of mushroom powder (identical to 2 servings of fresh mushrooms) [74]. Sulfur carries out various functions in enzyme reactions and protein synthesis. It is a part of keratin, which is significant for the hair maintenance, skin, and nails, stimulating and shape to these protein tissues. It is also essential for collagen formation. Quantum of Sulphur in WBM samples was found to be  $2195.59\pm 1405.60$  (Table 2).

#### 3.5.13. Potassium.

The high potassium content and the presence of bioactive compounds in the fruiting bodies could be associated with the neuronal stimulatory function. This may help in treatment options for patients with partially impaired cognitive functions. Prevention is preferred over treatment for this traumatic disease; once the signs of disease are clinically observable, the

reversal is difficult [60]. The reported from the literature content of potassium in white button mushroom was 3180 mg/kg while present results showed  $3560 \pm 153.33$  mg/kg and varied between 3390-3790mg/kg (Table 2). The white button mushroom may be considered as a potential candidate for the development of functional food to decrease/inhibit the intensity of age-related neurodegenerative diseases.

### 3.6. Whiteness.

Whiteness is one of the important quality parameters for white button mushroom, which has been evaluated by using the L\*lightness color value within the following range; SSQM>80; SQM>70 and AQM-grade->60 (Table 3). It has also been observed that when the L value is less than 60, it was unacceptable for a supermarket. As shown in Fig.3 whiteness values of 0 to 6days were reasonable range and acceptable for supermarket sale for eight days at  $5-6 \pm 1^{\circ}\text{C}$ . The regression coefficient relationship between whiteness and storage day  $R^2=0.998$  (Fig. 2a) as well as moisture and whiteness  $R^2 = 0.9503$  (Fig. 2b). After harvest, the white button mushroom color slowly changes from white color to brown, and this disapproving browning causes enzyme oxidation and bacterial growth, which results in damage to the nutritive value and shelf life of the mushroom [2, 5,38, 43].

### 3.7. Size and grades.

The size of the button mushroom is categorized according to the diameter of and weight. The WBM categorically divided into three grades as per organoleptic, lactic acid, and *Lactococcus lactis* (Table 3). To make the accuracy of the grade length-weight relationship regression coefficient analyzed and found significant. The relationship regression coefficient was for SSQM grade  $R^2=0.9773$  (Fig. 2d), SQM grade  $R^2=0.992$  (Fig. 2e) and AQM grade  $R^2=0.9861$  (Fig. 2f).

### 3.8. Open veil.

The veil opening is unique of the utmost destructive post-harvest alteration in the white button mushrooms, which markedly influence the supermarket acceptability. The Veil opening percentage of the white button mushroom is interrelated with aging and water loss during the storage of the mushroom [33]. It was observed that increases in the veil opening of the white button mushroom up to 16.6% (Table 3). Veiled opening indicated that the white button mushroom becomes matured.

### 3.9. Texture, aroma (odour), and overall acceptance.

The supreme essential quality parameters with regards to consumer preferences are texture. After harvesting the loss of texture in white button mushroom is primarily accredited to the cell growth, lack of cuticle on the surface, moisture content, and water movement [1, 4, 37]. The sensory evaluation was analyzed by 10 members of the panel, as shown in (Table 4). The mouthfeel attributes toughness (texture), appearance, aroma, and overall acceptability were correlated and found significant ( $R^2=0.981$ , Fig. 3a). Since the texture is a significant feature of keeping the quality of the mushroom, still, texture measurements during mushroom maturation, as well as during post-harvest storage, have been hindered by morphological/anatomical differences in the mushroom tissue occurring during development.

The sensory evaluation also plotted by radar diagram and found overall acceptability of white button mushroom (Fig. 3b). Perishable fruiting bodies darken and change their taste and odor [71].

**Table 4.** Sensory evaluation of white button mushroom (*Agaricus bisporus*).

Assessor	A	B	C	D	E	F	G	H	I	J	Total	Average	S.D±
Appearance	3	2	3	3	3	2	3	3	3	2	27	2.7	0.46
Aroma(Odour)	3	3	2	2	3	3	3	2	2	3	26	2.6	0.49
Texture	3	3	3	3	2	2	3	3	3	3	28	2.8	0.40
Overall acceptability	3	2	2	3	3	3	3	3	3	3	28	2.8	0.40

### 3.10. Temperature.

The rate of spoilage of mushrooms depends on the temperature. The storage temperature of mushroom was kept at controlled conditions  $5-6\pm 1^{\circ}\text{C}$  for eight days to minimize the metabolic activity [22, 50].

### 3.11. Lactic acid and *Lactococcus lactis*.

The content of lactic acid decreased with *Lactococcus lactis* bacteria. The average quantum of lactic acid was  $0.454\pm 0.156$  and *Lactococcus lactis* ( $7.8\times 10^5\pm 3.9\times 10^5$ ). The relationship between Lactic acid and *Lactococcus lactis*  $R^2=0.9339$  (Fig. 2c) was obtained and found significant. Lactic acid renders food unaffected to bacteriological spoilage, thus food with unique sensory qualities, and augments the health-improving properties of the product via enrichment of lactic acid bacteria and the presence of the viable, useful microflora. The essential component for the lactic fermentation procedure has mushroomed as the main ingredient [30, 56, 67].

## 4. Conclusions

The present study on FWBM's nutritional, medicinal profile, and quality categorization has been made to utilize as nutraceuticals and therapeutic purposes. Our results indicated that FWBM has very high biological properties and contains nutrients and minerals components with good taste. This study also proposed that the consumption of white button mushrooms has important health benefits for the human body.

The order of minerals content for therapeutic and dietary values was in the order of (Se>Ni>Mn>Cu>Zn>Na>N>Fe>P>Ca>Mg>S>K). This study could be beneficial in analyzing the quality parameters of fresh white button mushrooms within a temperature range of  $5-6\pm 1^{\circ}\text{C}$ , which is acquired for conventional supply chains and, more precisely, during the commercial storage. This study results concluded that to harmonize the white button mushroom distribution and storage average temperature  $5-6\pm 1^{\circ}\text{C}$ , Moisture (%)  $92\pm 0.36$ , Whiteness (Hunter)  $69.7\pm 7.83$ , Lactic acid (%)  $0.454\pm 0.156$  and *Lactococcus lactis*  $7.8\times 10^5\pm 3.94\times 10^5$  (CFU/g) was suitable for good quality of mushroom. The beneficial health value of mushrooms due to the presence of lactic acid bacteria viable cells [63].

Future research is also required on chronic diseases and intake quantum of FWBM, especially with the rise of new proof of their medical advantage impacts. However, FWBM can be recommended for a daily diet to keep a sustainable life.

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## Conflicts of Interest

The authors declare no potential conflict of interest.

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