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Effect of vacuum freeze drying on physical quality of button mushroom (*Agaricus bisporus*)

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Abstract

Experiments were conducted to determine the physical quality of vacuum freeze-dried Button Mushrooms. Different treatments without and with blanching, before and after segmenting the mushrooms were taken for study. Three samples of Button Mushrooms (T_1, T_2, and T_3) and the working pressure of 0.75 Torr or 100 Pa and temperature (-28°C) were considered for experimental investigations. Various physical parameters like density, shrinkage, color, and rehydration ratio were determined. The lowest and highest density recorded was 0.119 g cm^{-3} & 0.1568 g cm^{-3} for T_3 and T_1, respectively at 0.75 Torr. In the same way low and high shrinkage was 1.8% and 4.28 % for T_2 and T_1, respectively at 0.75 Torr. The L* value which expresses the color exhibited high at 71.13 and low at 71.96, respectively for T_3 and T_1 at 0.75 Torr. For samples T_1 and T_2, the lowest and maximum rehydration ratios were found as 2.33 and 4.44, respectively at 0.75 Torr. Treatment T_2 was found to have a better rehydration ratio.

Keywords bulk density, button mushroom, rehydration ratio, vacuum freeze drying

Introduction

Button mushroom is considered a highly valued fungus, mostly due to its medicinal and antioxidant properties [1-2], high protein content [3], and general public likeability as a healthy food source. A mushroom is a macro-fungus that can be either hypogynous or epigeous, is large enough to be seen with the unaided eye, and can be manually harvested [4]. Vitamins like the B-complex and vitamin C are both abundant in mushrooms. It has significant amounts of pantothenic acid, biotin, and niacin. On a dry weight basis, mushrooms also contain 3-32 percent fiber, 4.0-8.1 percent carbs, and 1.1 to 8.2 percent lipids [5]. It has a moisture content of roughly 90% [6]. Preservation of mushrooms by drying has been practiced with various heat treatment methods [7-8] but with a compromise to nutritional factors.

Mushrooms have an extremely short shelf life and cannot be transported or stored for more than 24 hours under the ambient conditions found in the majority of the country and the year. Button mushrooms have high moisture content, making them quite perishable. The fruiting body begins to degrade once it reaches maturity, and eventually, it becomes unusable. The majority of the 0.13 MT total production of mushrooms in India in 2016-17 the most recent statistics available until 2020-21 went to the white button mushroom. During the 2016–17 academic year, Punjab produced the most white button mushrooms (0.09 MT) [16]. A mere 0.5 million tonnes (MT) were produced worldwide in 1961, but 34.8 MT were produced in 2013 [10]. As a result, they should be consumed or processed as soon as possible after harvest. Because of this, mushrooms are primarily traded in the processed form on the global market.

Vacuum-freeze drying has received attention recently as a viable technique for producing high-quality dried food items, including fruits, vegetables, and pharmaceuticals. Vacuum's low temperature and quick mass transfer, along with freeze-quick drying's energy transfer, have the potential to increase energy efficiency and product quality. Information on the energy analysis of drying and the quality of button mushrooms dried using vacuum-freeze technology is scarce [1-2]. To ascertain the physical quality of vacuum freeze-dried button mushrooms, the current investigation was undertaken.

Methodology

All the experiments were conducted using standard scientific methods as given in laboratory protocols, by scientists and suggested by earlier researchers. The data obtained from the various experiments were arranged in a suitable form, and statistically analyzed with (CRD) using OPSTAT software. Results are presented in graphical form with interpretation and discussion.

Selection of raw materials

Button mushrooms (*Agaricus bisporus*) with a moisture level of 92–94% (w.b.) were purchased from a reputable mushroom grower company in Varanasi (U.P.). These mushrooms were raised in a controlled environment, harvested on the designated day, brought to the lab shortly thereafter, and kept in a refrigerator kept at a temperature of 4-5°C until further usage. For the T_1, T_2, and T_3 tests, mushrooms with identically sized heads were utilized. Each 50g sample was weighed and handled independently in 3 replications for the experiments, which were set up as follows:

Whole Mushroom Without Blanching, WMWB (T_1),
Segment before Blanching, SBB (T_2),
Segment after Blanching, SAB (T_3)

Sample preparation

To remove clinging pollutants, the chosen white button mushrooms were thoroughly washed under running water. They were then graded according to size, which eliminated any variances in exposed surface area.

Figure 1. Fresh white whole button mushrooms T_1 (*Agaricus bisporus)*

Experiments were performed at pressure of 0.75 Torr with three types of mushroom samples i.e. T_1, T_2, and T_3. Button mushrooms were cut manually into segments as shown in Figures 1 and 2. The flow chart of the process of experiments is given in Figure 3.

Figure 2. Button mushroom segments (after and before blanching) T_2 and T_3

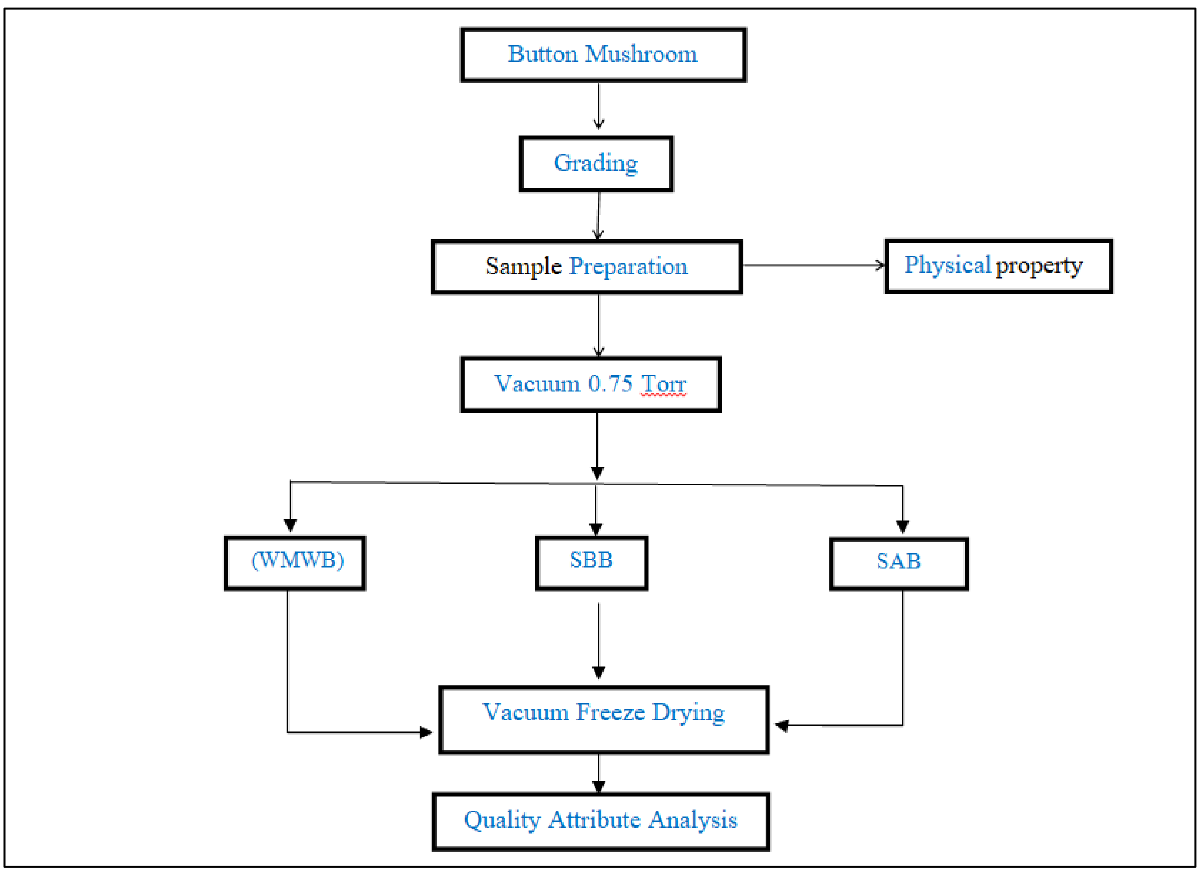

Figure 3. Flow chart of physical quality analysis of vacuum freeze-dried mushroom sample

Vacuum freeze drier

A vacuum freeze drier as shown in Figure 4 (Make: NSW-275, Model: Lyophilizer -40°C) was used for the experiments. It has a heating system, condenser, vacuum pump, and drying chamber. The vacuum pump draws steam from the chamber, which a condenser then condenses into ice. Three hot plates are used in the freeze dryer heating system, and they are supported by a support platform. The material was directly heated to provide the energy needed for the phase shift. At a condenser temperature of 40 °C and a vacuum of less than 0.150 m bar, the drying process was conducted.

Figure 4. Vacuum freeze drier

Vacuum freeze drying

To achieve steady-state conditions before each drying run, the dryer was turned on 30 minutes before to drying trials. After that, 50 g of button mushrooms were added to the drying pan and spread out in a single layer. At T_1, T_2, and T_3, where the condenser temperature ranged from 28 to 40 °C and the vacuum level was 0.75 Torr, the drying process was conducted. The weight loss was measured every 60 minutes for the first 4 hours, then every 2 and 4 hours thereafter until equilibrium moisture content was reached (change in weight less than 0.01 g).

Quality attributes of vacuum freeze dried Button Mushroom

Bulk Density

T_1, T_2, and T_3's bulk densities were weighed using a digital scale after being carefully filled into a container (Essae-Teraoka Pvt. Ltd., Bangalore, AJ-220E). The bulk density of the samples was calculated by dividing the weight of the filled samples by the volume of the container [17]. The sample's bulk density was determined using equation (1).

$$\text{Bulk density (Kg/m}^3\text{)} = \frac{\boldsymbol{Mass}}{\boldsymbol{Volume}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{(1)}$$

Measurements of volume and shrinkage

The quality, appearance, and consumer acceptance of dried button mushrooms are significantly influenced by shrinkage values. Equation (2) was used to determine the shrinkage of button mushrooms after the drying procedure [11].

$$\%\ \text{Shrinkage} = \mathbf{1} - \frac{\boldsymbol{V}}{\boldsymbol{V0}} \times \mathbf{100} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{(2)}$$

Where,

The initial and dried volumes of the button mushroom are designated as V_0 and V, respectively.

Rehydration Ratio (RR)

Rehydration tests were used to evaluate the vacuum freeze-dried button mushroom's ability to reconstitute. It is the weight of the dehydrated sample (g) divided by the weight of the drained rehydration sample (g), as indicated in equation (3).

$$\text{Rehydration ratio, (RR)} = \frac{Wr}{Wd} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where,
The weight of the rehydrated sample, in g, is Wr.
Wd is the Weight of the dried sample, in g, used for rehydration

Analysis of color

One of the most crucial factors in consumer acceptability of a product is its color, which to the human eye reflects sensation. Too much darkness could indicate that the goods have been overdried. In the current experiment, a Hunter Lab Colorimeter (Made: M/S Hunter Lab, Reston, VA, USA, Model: CFLX-45) was used to ascertain the color of button mushrooms. The surface's color was measured in terms of the color space's L*, a*, and b* values. The color space is arranged in a cube shape, with the L* axis running from top to bottom and having a minimum value of 0 for black and a maximum value of 100 for white. The axes -a*, +a* and -b*, +b* alternate between green and red and blue and yellow, respectively. To represent the color value of the sample, the Hunter L* value, which indicates the degree of whiteness, was selected [12-13].

Analytical statistics

Complete randomization was used in the experiment design (CRD). Data that had been recorded was analyzed using STATPAC (OPSTAT) software. Analysis of variance was used to compare the significant difference between the means to the crucial difference at the 5% and 1% levels of significance (ANOVA).

Results and Discussion

Physical Attribute of Vacuum Freeze Drying for Button mushroom

Bulk Density

The bulk density of dried T_1, T_2, and T_3 decreased considerably as compared to fresh button mushrooms as shown in Figure 5. Pressure significantly ($P<0.01$) influenced the bulk density of the Button mushroom. During vacuum freeze drying, product mass decreased as the water was removed. Change in bulk volume leads to a considerable decrease in bulk density. The lowest density of 0.119 g $cm^{¬¬-3}$ was observed for the sample dried T_3 at 0.75 Torr. The highest density of 0.1568 g $cm^{¬¬-3}$ was recorded of the sample T_1 at 0.75 Torr. Bulk density increased with increased the thickness of the button mushroom. Similar results were reported by [14] shea kernel.

Shrinkage

Pressure influenced the shrinkage of T_1, T_2, and T_3. The lowest shrinkage of 1.8 % was observed for the sample dried T_2 at 0.75 Torr. The highest shrinkage value of 4.28 % was recorded of the sample T_1 at 0.75 Torr as shown in Figure 6. From the statistical analysis of data, it is explicit that the effect of different treatments was significant ($P<0.01$) on shrinkage. The shrinkage percentage of samples was significantly increased with increased the thickness of the button mushroom. It increased from 1.8 to 4.28 % by increasing the T_1, T_2 and T_3 [13] Reported the similar results for freeze dried strawberries.

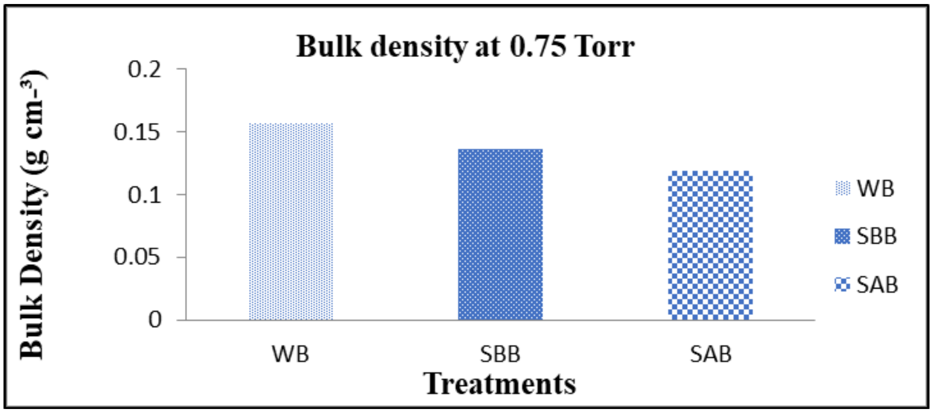

Figure 5. Bulk Density at 0.75 Torr

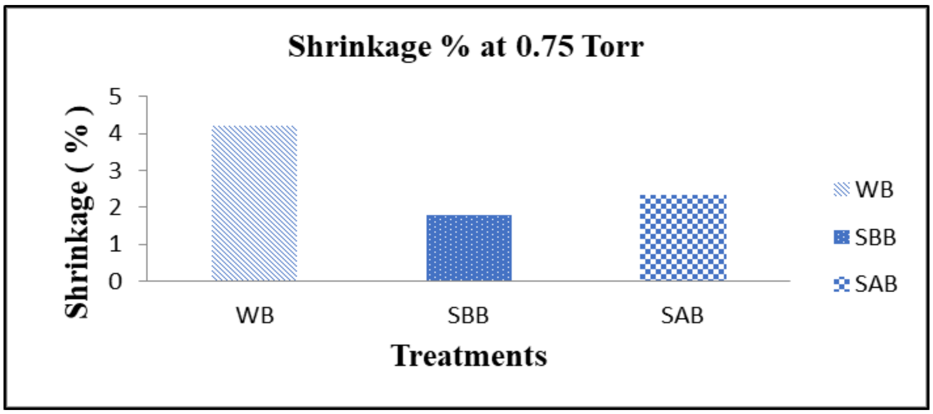

Figure 6. Shrinkage % at 0.75 Torr

Colour

The fresh button mushroom sample was found to have an L* value of 78.56. The L* values of fresh and dehydrated button mushrooms were compared. The L* value of dried mushrooms was found to be much lower than that of the fresh sample, indicating that the browning reaction occurred during drying, as shown in Figure 7. Enzymatic reaction, which is influenced by temperature, pressure, and treatment time, is the primary factor in color change during drying. The button mushroom's L* value was affected by pressure. The samples dried T_3 at 0.75 Torr had the lowest L* value, which was 71.13. The sample dried T_1 at 0.75 Torr recorded the highest L* value of 71.96. The L* values of dried button mushrooms with thickness did not differ significantly (P 0.01). [12-13] noted that freeze-drying strawberries and mushrooms produced comparable results.

Rehydration ratio

According to the results of the experimental study, the dehydrated sample absorbed water during rehydration and softened. For vacuum freeze-dried samples, the rehydration ratio is a function of rehydration time. The range of the rehydration ratio for dried button mushroom samples was 4.44 to 2.23, with an average of 3.37. The sample dried T_2 at 0.75 Torr had a maximum rehydration ratio of 4.44. According to Figure 8, the sample of T_1 at 0.75 Torr had a minimum rehydration ratio of 2.33. The results of the present study, which involved rehydrating freeze-dried strawberries under various pressures and temperatures, were supported by the findings of [15]. As a result of the delayed

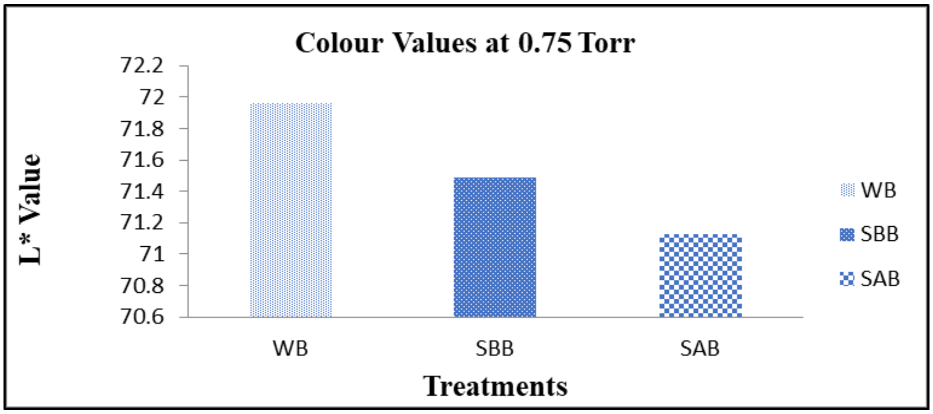

Figure 7. Colour values at 0.75 Torr

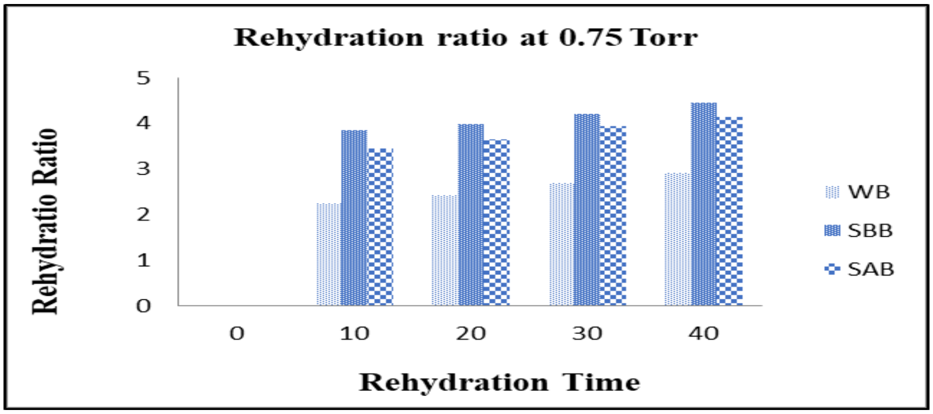

Figure 8. Rehydration ratio at 0.75 Torr

dehydration rate at low drying temperatures, hard, dense products were produced, while porous materials were produced at higher drying temperatures and rehydrated more quickly [16]. The ratio of mushroom rehydration was influenced by mushroom thickness. Significantly ($P<0.01$), the rehydration ratio rose as the thickness decreased.

It was discovered that treatment T_2 (Segment before Blanching) had a greater rehydration ratio. Mushrooms that had been vacuum freeze-dried had a lower bulk density and a higher rehydration ratio than dried mushrooms. The dried button mushrooms had noticeable variations in color, rehydration ratio, shrinkage, and bulk density. We may conclude that the vacuum freeze-drying process can produce dried button mushrooms of high grade.

Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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