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Research Paper :

Tray drying of button mushroom (*Agricus bisporus*)

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ABSTRACT

Dehydration of button mushrooms (*Agricus bisporus*) were carried out with various pretreatments like blanching, socking in different combination of sodium metabisulphite, potassium metabisulphite, citric acid, sugar and sodium chloride in tray dryer. The dehydration experiments were carried out at different temperature of 40, 45, 50 and 55^{0}C. The moisture loss data and drying characteristics such as drying rate, diffusivity, moisture ratio, during the drying process were determined. The qualities of dehydrated mushroom slices were evaluated on the basis of colour, appearance, rehydration ratio and veil opening by sensory evolution. The diffusion coefficient evaluated were 1.01 x 10^8 m^2/s to 9.82 x 10^{-9} m^2/s in tray dryer. The sample treated with combination of potassium metabisuphate, citric acid, sugar and NaCl at 55^{0}C temperature were better accepted by consumer panel. The minimum and maximum rehydration ratio found 1.84 to 2.1, respectively.

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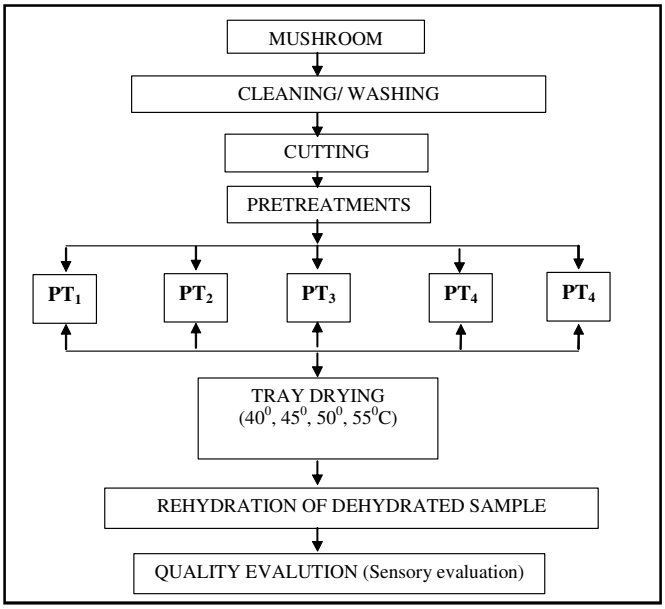
Key words : Drying, Mushroom, Pretreatments, Tray dryer, Diffusivity

India is primarily an agriculture-based country. It offers vast potential for mushroom cultivation due to varied climate suited for the cultivation of different mushrooms. Mushrooms are appreciated for their characteristic flavour and texture. However, due to short shelf-life, the produce remains acceptable for few hours only. Like all fleshy fruits and vegetables, mushrooms are highly perishable because of their high moisture content, delicate texture and unique physiology. They cannot be stored for more than 24 hours at ambient temperature or for 1 to 2 weeks in refrigerated conditions. Once the fruiting body matures, degradation process starts and it becomes inconsumable after some time. Development of brown colour is the first sign of deterioration and is a major factor contributing to quality losses (Arumugnathan *et al.*,2003).The enzyme, polyphenol oxidize, in presence of oxygen (O_2) combine with amino acid derivatives to form highly coloured complexes thus making them highly unacceptable. Further on storage, the fruiting bodies shrivel, lose weight with the opening of veil, the stalks grow longer and at last they open, exposing the gills. Toughening of texture and loss of whiteness are also observed during prolonged storage. Therefore, it becomes very important to evolve a better method of preservation for increasing the shelf life and maintaining the quality of mushroom and this can be achieved by dehydration. Dehydration is a major food processing operation in the food industry for the removal of water (responsible for many deteriorative reactions) from a product (Madamba *et al.,* 1994).

METHODOLOGY



Procedure for the experiment:

Pretreatments:

The following pretreatments (PT) were applied to 0.5 cm mushroom slices.

PT-1: Blanching in boiling water for 3 min and steeping in solution of 0.5% sodium metabisulphite ($NaHso_3$) + 0.25%Citric acid (CA)at room temperature for 15 min.

PT-2 Blanching in boiling water for 3 min and steeping in solution of 1.0% potassium metabisulphite (KMS) ($KHSO_3$) +0.25% CA at RT for 15 min.

PT-3 Blanching in boiling water for 3 min and steeping in solution of 0.1% $KHSO_3$ +0.2% CA+ 6%sugar+ 3% NaCl at RT for 15 min.

PT-4 Steeping in solution of 0.5% $KHSO_3$ at RT for 15 min; no blanching

PT-5 Steeping in solution of 0.1% $KHSO_3$ +0.2% CA+ 6%sugar+ 3% Nacl at RT for 15 min; no blanching.

Dehydration characteristics:

Initial moister content :

Initial moisture content of sample was determine by hot air over drying method as recommended by Association of Analytical Chemist (AOAC). The moister content in per cent was calculated using equation,

$$Mw(\%) = \frac{W_1 - W_2}{W_1} \times 100$$

Overall drying rate:

The overall drying rate was computed by using following equation.

$$(\Delta m/\Delta t) = \frac{Mi - Mf}{Dt}$$

Diffusivity:

In drying diffusivity is used to indicate the flow of moisture or moisture out of material. In falling rate of drying, moisture is transfer mainly by molecular diffusion.

$$\frac{\partial M}{\partial t} = D\frac{\partial^2 M}{\partial X^2}$$

where, D = Diffusion coefficient, m^2 /s, M is the moisture content, X is the distance from the centre line and t is the time elapse during the drying. Assuming uniform initial moisture distribution and negligible external resistance, the solution of above mentioned equation as proposed by Crank (1975) is

$$\frac{M - M_e}{M_O - M_e} = \frac{8}{\pi^2}\sum_{n=0}^{\infty}\frac{1}{(2n+1)}\exp\left[-(2n+1)^2\pi^2\frac{Dt}{L^2}\right]$$

Rehydration ratio:

The rehydration ratio (Ranganna, 1986) was computed by using following equation

$$RR = \frac{WR}{WD}$$

where, WR - Drained weight of reconstitute slice g

WD - Weight of dried sample taken for reconstitute g

RR - Rehydration ratio

Sensory evaluation and veil opening:

The evaluation was done on the basis of 9-point Hedonic scale recommended by the Bureau of Indian standard (IS 1971). A panel of 10 judges evaluated for colour, appearance and overall acceptability of dehydrated mushroom.

Statistical analysis:

The experimental drying data were statistically analyzed in terms of reduction in moisture content and moisture ratio with drying time for drying data using analysis of variance (ANOVA).

RESULTS AND DISCUSSION

The results obtained from the present investigation are summarized below :

Tray drying of mushroom slices:

The primarily processed button mushrooms slices were pretreated with chemicals. The slices were dehydrated in the cabinet dryer. The drying experiment was carried out with drying air temperature of 40, 45, 50 and 55^0C ($\pm 1^0$C). The velocity of the drying air was kept constant as 2.8 (± 0.1) m/s. The initial weight of the samples and the weight after every 15 minutes interval were recorded for initial two and half hours. Subsequently the weights were recorded after every 30 minutes interval till the constant weight was observed. It was found that final moisture contents in the range of 11-12 per cent (wb) for various drying experiments.It can be seen that maximum moisture removal took place in initial period of drying for all the pretreatments samples. It can be seen that in all the experiments more than 40 per cent reduction in moisture took place in the initial period of 2h of drying (Fig. 1). It can be observed from the curves that as the time of drying increased the moisture content of the same samples also decreased. It can also be seen that maximum moisture removal took place in initial period of drying for all the pretreatments samples. It can be seen that in all

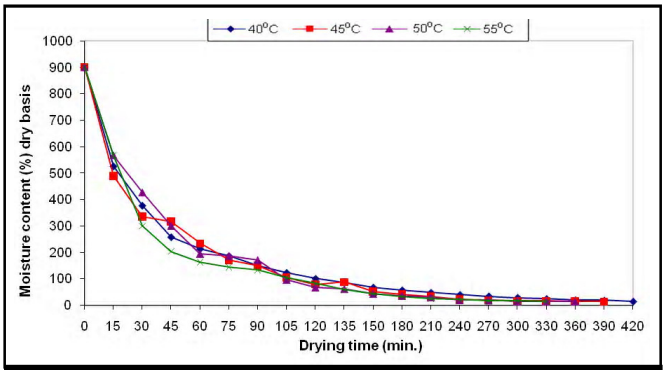


Fig. 1 : Variation in moisture content of mushroom slices treated with PT_3 at different temperatures of drying air

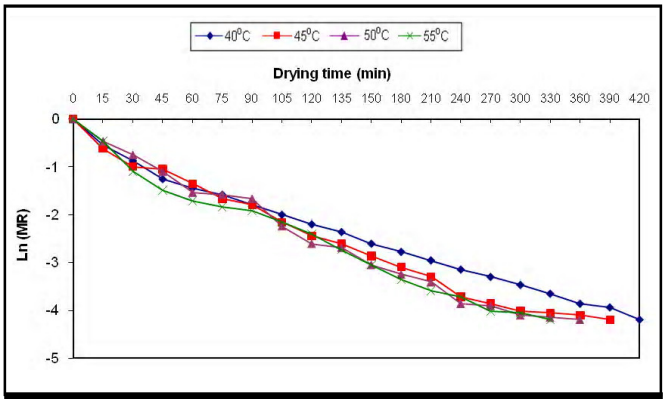


Fig. 3 : Variation in ln of MR of mushroom slices treated with PT3 at different temperatures of drying air

the experiments more than 40 per cent reduction in moisture took place in the initial period of 2h of drying.

Drying rate curves for button mushroom slices:

The drying rates curves of mushroom slices were determined by mass balance equation during the tray drying experiments. It can be seen from the various Fig that the complete drying took place in the falling rate period of during for all the pretreatments and at all the drying air temperatures. The constant rate period of drying was completely absent in all the experiment of mushroom dehydration. It can be seen that the initially drying rate was different for different temperatures for a particular treatment, but as the drying continued, the curves followed the similar pattern and overlaped each other. It may be due to very small variation in the value of drying rate (Fig: 2).

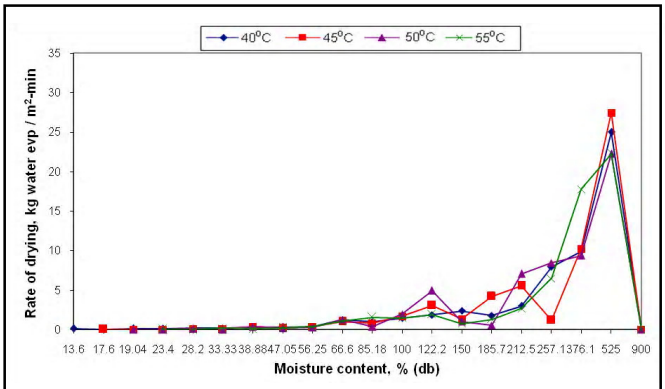


Fig. 2 : Variation in drying rate of mushroom slices treated with PT_3 at different temperatures of drying air

Diffusivity of water in mushroom slices:

The moisture loss data during the air drying were analyzed and moisture ratios at various time interval of drying were determined. Calculated data were statistically analyzed and regression equations were predicted (Table 1). In general, it can be seen from Fig. 3 that ln(MR) versus time follows straight line equation with negative slope. It can also be observed that for a particular treatment the variation in ln(MR) depends on the temperature of drying air. However, the after part of drying the curves did not follow the straight line. The diffusivity during the air drying for various pretreatments temperature of drying air of mushroom slices were calculated by comparing the slope of curves with standard equations. The slope of curves and intercept of straight line were determined, the predicted equations and value of diffusivity with coefficient of determination. It can be seen from the Table 1 the value of diffusivity varied from 5.58 x 10^{-9} to 8.75 x 10^{-9} m^2/s for mushroom slices treated with PT3 and the value of diffusivity increased with drying air temperature.

Rehydration studies:

The 5 g sample of selected dehydrated button mushroom slices was rehydrated by steeping them in water for 10 min. The weight of the sample before and after rehydration was measured. The rehydration ratio and coefficient of rehydration (COR) were determined as explained earlier. The minimum rehydration ratio of 1.842 was obtained for slices treated with PT_1 and the maximum rehydration ratio of 2.108 was obtained for PT_3 treated samples.

Quality analysis of dehydrated button mushroom slices:

Colour appearance and veil opening of dehydrated mushroom slices:

The colour of dehydrated button mushroom slices was tested with the help of consumer panel of 10 judges

Table 1 : Predicted equations, diffusivity value and rehydration ratio of PT_3 mushroom slices

Temperature (^{0}C)	Predicted equations	Diffusivity (m^2/s)	Rehydration ratio	Coefficient of determination
40	Y = (-) 0.0088 x – 0.8494	5.58 x 10^{-9}	0.241	R^2 = 0.92
45	Y = (-) 0.0104 x – 0.8207	6.59 x 10^{-9}	0.250	R^2 = 0.92
50	Y = (-) 0.0117 x – 0.7145	7.42 x 10^{-9}	0.313	R^2 = 0.96
55	Y = (-) 0.0062 x – 0.7844	7.67 x 10^{-9}	0.243	R^2 = 0.89

Table 2 : Consumer panel acceptance of dehydrated mushroom slices

Sr. No.	Treatments	Temp.	Avg. score of panel	Comments
1.	PT_1	55	7	Like moderately
2.	PT_2	55	7	Like moderately
3.	PT_3	55	8	Like very much
4.	PT_4	55	6	Like slightly
5.	PT_5	55	6	Like slightly
6.	PT_1	50	7	Like moderately
7.	PT_2	50	7	Like moderately
8.	PT_3	50	8	Like very much
9.	PT_4	50	6	Like slightly
10.	PT_5	50	6	Like slightly

for all the samples. The 9 point hedonic scale was used which ranges from like extremely (9) to unlike extremely (1). All the samples were presented before the consumer panel. The samples scored more than 6 values were adjudged good the further investigation of the Table 2 showed the result of the consumer panel. The samples treated with PT_3 showed more acceptances when compared to dehydrated mushroom slices treated with other treatments.

The veil opening of dehydrated button mushroom slices were evaluated by the judges. It was observed that most of the de-hydrated samples had no veil opening and full veil opening was in PT_5 samples only.

Conclusion:

– The maximum moisture removal took place in initial period of drying for all the pretreatments including the all pretreated samples and in all the experiments more than 40 per cent reduction in moisture took place in the initial period of 2h.

– The diffusion coefficient varied from 1.01 x 10^{-8} m^2/s to 9.82 x 10^{-9} m^2/s and 1.03 x 10^{-8} x 9.64 x 10^{-9} m^2/s in tray and fluidized dryer, respectively. It also depends on the temperature of drying air.

– The samples pretreated with potassium metabisulphite + citric acid + sugar + NaCl were (PT_3) showed more acceptance on the basis of colour and appearance when veil opening compared to other pretreatments and was recommended.

– The minimum and maximum rehydration ratio of 1.89 and 2.33 was obtained in tray drying.

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