**J. Bangladesh Agril. Univ. 13(2): 307–314, 2015** **ISSN 1810-3030**

# Mechanical drying of fresh and osmosed mushroom

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## Abstract

This research was carried out to study the air drying behavior of fresh and osmosed oyster mushroom. Three different temperatures (55, 60 and 65$^0$C) were used to determine the effect of temperature on drying behavior of oyster mushroom in a mechanical dryer and an Arrhenius type relationship was developed from which activation energy value of 13.48 kcal/g-mole for fresh mushroom 16.47, 15.01 and 4.19 Kcal/g mole for mushroom osmosed at 12$^0$C, 27$^0$C and 45$^0$C, respectively were found. Combined osmotic dehydration (in 20% salt solution) and air drying results in significantly higher (4 times) drying throughput compared to fresh mushroom. The values of proximate composition of fresh mushroom are 89.56, 3.83, 0.44, 0.91 and 5.26% moisture, protein, fat, ash, and total carbohydrate, respectively, while the corresponding values are 11.70, 31.5, 2.90, 5.92 and 47.98% moisture, protein, fat, ash and total carbohydrate for developed mushroom powder.

**Keyword:** Mushroom, Mechanical drying, Activation energy, Flour, Cake

## Introduction

Mushrooms are not true vegetable in the sense that they do not have any leaves and therefore, contain no chlorophyll, roots, or seeds and really do not need any light to grow. It is a fungus, which grows in the dark and propagates by releasing spores. Mushrooms are found all over the world and have been a time honored food in many cultures (Chang and Buswell, 1996). They have been in use not only for consumption but also for medicinal purposes (Bobek *et al.,*1997; Chocksaisawasdee *et al.,* 2010; Yang *et al.*, 2001).Today, mushrooms are eaten by people for their flavor, texture as well as for the health benefits that they accord. Mushrooms are liked for their delicious flavor, low calorific value and high protein, vitamins of B-groups and mineral contents. It contains proteins on a dry weight basis and has no cholesterol and is almost fat free (Walde *et al.,*2006).

Oyster mushrooms are a diverse group of saprotrophic fungi belonging to the genus *Pleurotus* (Kong, 2004).Pacioni and Lincoff (1981) described that *Pleurotus ostreatus* have cap size 6-14 cm and is often imbricate, superposed, violet black to brownish gray in color, fading with age, eccentric and asymmetrical, shell or spatula shaped and smooth shiny. These mushrooms are a good source of non-starchy carbohydrates, with high content of dietary fiber and moderate quantity of proteins, including most amino acids, minerals, and vitamins. The protein content varies from 1.6 to 2.5% and the niacin content is about ten times higher than that of any other vegetable as reported by Croan (2004). Moreover, Randive (2012) studied that oyster mushrooms are rich in Vitamin C, B-complex and mineral salts required by the human body. Oyster mushroom powder, rich in protein and low in fat contents, can be incorporated into various recipes for improving the nutritional status of vulnerable population in developing countries (Dunkwal *et al.,* 2007).

Mushrooms are highly perishable commodities and start deteriorating after harvesting. The development of brown color is the first sign of deterioration and a major factor contributing to quality losses. This is due to enzymatic action of polyphenol oxidase on phenolic substances (Dunkwal *et al.,* 2007). Celen *et al.*, (2010) found that drying temperature has a significant effect on the moisture removal from mushrooms. Heat treatments like drying have been reported to affect color and texture of various products like tofu, milk paneer, banana and potato (Kotwaliwale *et al.,* 2005).

Drying, a process of moisture removal caused by simultaneous heat and mass transfer is one of the processes used for preservation. Drying also results in reduced transportation and storage costs (Yucel, *et al*. 2010. The rate of drying, storage stability, rehydration characteristics, and quality changes depend on the type of drier, processing parameters, and also pretreatment of the dried material such as osmotic dehydration. It has been shown that osmotic dehydration as a pre step to drying results in increased dryer throughput. In general drying is energy consuming. Thus, in order to reduce the energy consumption as well as to increase dryer productivity, it is necessary to improve the energy efficiency and reduce processing time, in manipulating pre-treatments and process variables.

Dehydrated mushroom powder prepared with or without osmosis pre-treatment can be used in making bakery products such as biscuits, breads, cakes etc. Dehydrated mushroom as such can also be eaten in a mixed vegetables curry or soup. With these points into consideration, the present study has been designed to achieve the following objectives:

i. to compare the proximate composition of fresh and dehydrated mushroom;
ii. to determine the drying behavior of fresh and osmosed mushroom and
iii. to assess the sensory quality of cake supplemented with mushroom powder.

## Materials and Methods

Cabinet dryer with accessories of the Department of Food Technology and Rural Industries was used. Chemicals and solvents used in the study were of analytical reagents grade. Distilled water was used from the laboratory stock. Wheat flour, sugar, salt, baking powder, egg and other ingredients were procured from the local market.

### Mechanical drying

Cabinet dryer was used for the dehydration of fresh and osmotically dehydrated mushroom. Prior to air drying, osmotic dehydration was carried out by using 20% salt solution for 6 h following Hawkes and Flink (1978) and Islam (1980). Fresh or osmotically dehydrated mushroom of known moisture content was placed in the dryer. Drying commenced in the drier at constant air velocity (0.6 m/s) and air dry bulb temperature. Air was blown by a fan passing through a heater, then across the tray of products, which was dried from both sides. Weight loss was determined gravimetrically from known initial moisture content and used as a measure of the extent of drying. The dried (12% moisture content) mushrooms were made into powder by using a laboratory grinder.

### Chemical analysis

Fresh and dried mushrooms analysed for their chemical composition, represent the gross content of important chemical constituents: moisture, protein, fat, carbohydrate, vitamin-C and ash contents.The moisture content of the mushroom and mushroom powder was determined in accordance with moisture measurement method for grain(AOAC, 2000). Ash, fat and protein were also determined according to AOAC (2005) method.

### Total carbohydrate

Carbohydrate content of the samples was determined as total carbohydrate by the difference obtained by subtracting the measured protein, fat, ash and moisture from 100 (Pearson, 1970).Total carbohydrate content of foods has, for many years, been calculated by such difference, rather than by analyzing.

### Procedure for preparation of cake

For the preparation of cake an electric mixer machine was used for mixing ingredients. Specified amount of ingredients (wheat flour,mushroom powder,baking powder) were weighed acurately in an electrical balance and shortening oil and egg were mixed in a mixer machine at least for 5 minutes. Afterthat blended sugar was mixed to produce a cream. In the later stage, other ingredients such as salt, essence and finally, the flour were mixed at a low speed for 10 minutes to ensure homogenous distribution of the components.After making the batter, portion of it was poured in a pre-greased cake pan and baked in a baking oven for 40 minutes at 160$^{o}$C.

**Sensory evaluation**

The consumer's acceptability of developed products was evaluated by a taste testing panel. The hedonic rating test (1-9) was used to determine this acceptability and a score card was used for judging the products. The panelists were requested to assign appropriate color, flavor, texture and overall acceptability of blanched and unblanched mushroom products. The results were evaluated by Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT) procedures of Statistical Analysis System (SAS, 1985).

## Results and Discussion

**Effect of temperature on drying behavior of fresh and osmosed (in 20% salt solution) mushrooms**

Mushroom was dried in single layer with or without osmosis in 20% salt solution at three different air dry bulb temperatures (55°C, 60°C and 65°C). The experimental moisture ratio (MR) values were plotted against drying time (t) on semi-log paper as per Broker *et al., (*1974), Islam (1980) and Okos *et al.,* (1992) and regression lines were drawn in Fig. 1(a), 1(b), 1(c), and 1(d). The regression equations developed are as follows:

**For Fresh mushroom (without osmosi**s)
$MR=0.811e^{-0.3t}$ for 55°C
$MR=0.844e^{-0.41t}$ for 60°C
$MR=0.782e^{-0.56t}$ for 65°C

**For osmosed mushroom in 20% salt solution at 12°C**
$MR=0.793e^{-0.21t}$ for 55°C
$MR=0.780e^{-0.31t}$ for 60°C
$MR=0.804e^{-0.45t}$ for 65°C

**For osmosed mushroom in 20% salt solution at 27°C**
$MR=0.824e^{-0.25t}$ for 55°C
$MR=0.879e^{-0.41t}$ for 60°C
$MR=0.857e^{-0.50t}$ for 65°C

**For osmosed mushroom in 20% salt solution at 45°C**
$MR = 0.851e^{-0.32t}$ for 55°C
$MR = 0.836e^{-0.45t}$ for 60°C
$MR = 0.808e^{-0.55t}$ for 65°C
where, MR= moisture ratio, t = time in h

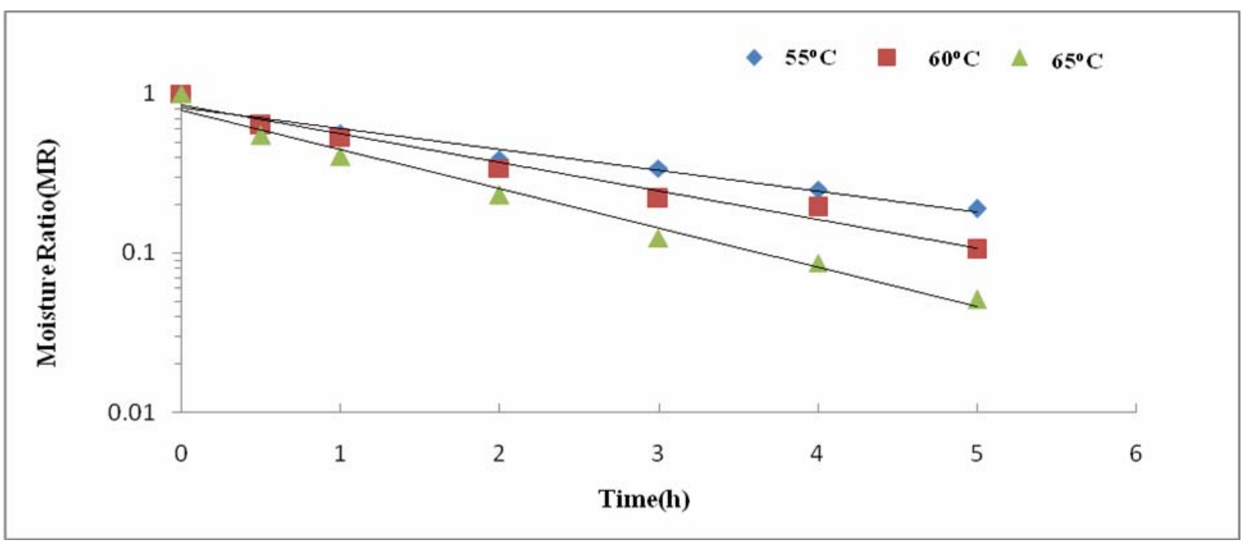


Fig. 1(a). Effect of temperature on drying time of fresh mushroom

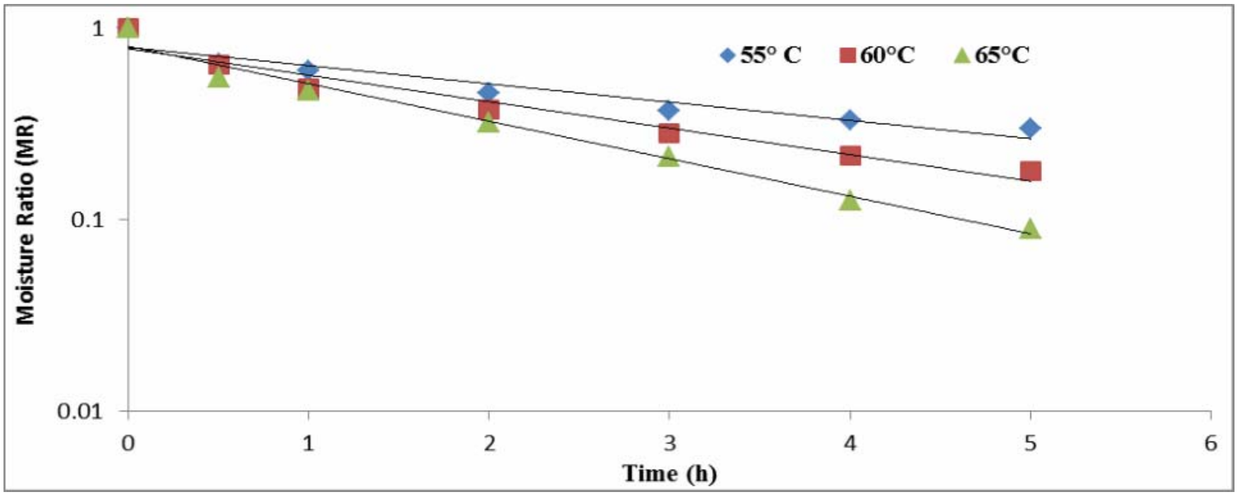


Fig. 1(b). Effect of temperature on osmosed mushroom in 20% salt solution at 12°C

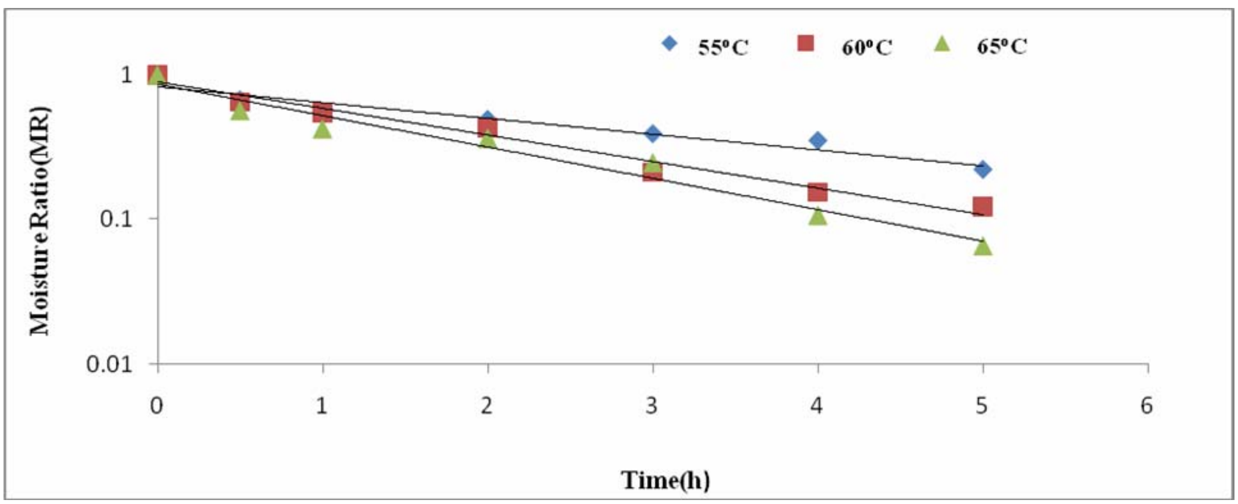


Fig.1(c). Effect of temperature on osmosed mushroom in 20% salt solution at 27°C

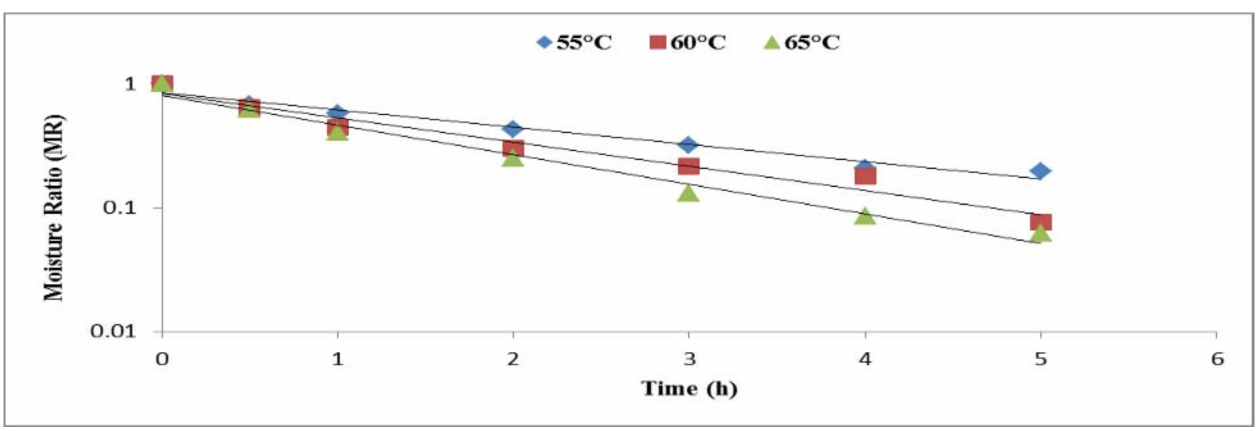


Fig. 1(d). Effect of temperature on osmosed mushroom in 20% salt solution at 45°C

From the Fig. 1(a-d) and equations, it is revealed that at constant temperature of dryer, the moisture ratio (MR) decreases with time. The results also imply that higher drying rate constant was obtained from the higher rate of water removal with increasing drying temperature from 55 to 65°C for all cases (fresh or osmosed mushrooms). Because of this higher moisture removal rate, the time to reach a desired/specific moisture ratio decreases with increasing temperature. This is due to the fact that the moisture diffusivity increases with the increase in temperatures and also the vapor pressure (relative humidity) of water in air decreases with increase in temperature (Brooker *et al.,*1974). The results also show that rate constant at a given air dry bulb temperature is slightly higher for fresh oyster mushroom than the osmosed mushroom with the exception of the osmosed mushroom at 45°C. This is reasonable as osmosed mushroom (osmosed in 20% salt for 6 h) gained as high as 7.6% salt, which gave additional resistance to moisture removal. However, due to 64% water loss and the solid gained (7.6 %) for 20% salt solution, the osmosed product enters the dryer with four times higher solid content (NSC=3.96). Additionally, due to the effect of salt on water sorption, the osmosed mushroom could be stable at higher moisture content. Without considering advantage of salt infusion in osmosed product, the drying throughput for osmosed product as per Islam (1980) would be approximately 4 times higher than fresh one. Thus, there is a definite advantage in drying osmosed mushroom. While drying potato, Islam and Flink (1982) reported that osmosis pre-treated potato gives 5 to 6 fold increase in product throughput due to moisture loss and solid uptake.

**Effect of temperature on diffusion co-efficient of mushroom**

From the MR and drying time relationship equations, drying rate constants were determined for fresh and osmosed mushrooms in single layer (1.90 $kg/m^2$) at 55, 60 and 65°C air dry bulb temperatures using regression analysis. From the drying rate constants, the diffusion coefficients were determined and plotted against inverse absolute temperature on semi-log paper (Fig. 2(a-d)) and the following Arrhenius type equations were obtained (Singh and Heldman, 2008; Islam, 1980).

$D_e=2034e^{-6783}T_{abs}^{-1}$…………for fresh mushroom
$D_e=14005e^{-8287}T_{abs}^{-1}$..............for osmosed mushroomin 20% salt solution at 12 °C
$D_e=18827e^{-7556}T_{abs}^{-1}$..............for osmosed mushroom in 20% salt solution at 27°C
$D_e = 0.001e^{-2110}T_{abs}^{-1}$……….for osmosed mushroomin 20% salt solution at 45 °C
where $D_e$ = diffusion coefficient ($cm^2/s$),$T_{abs}$= absolute temperature (°K)

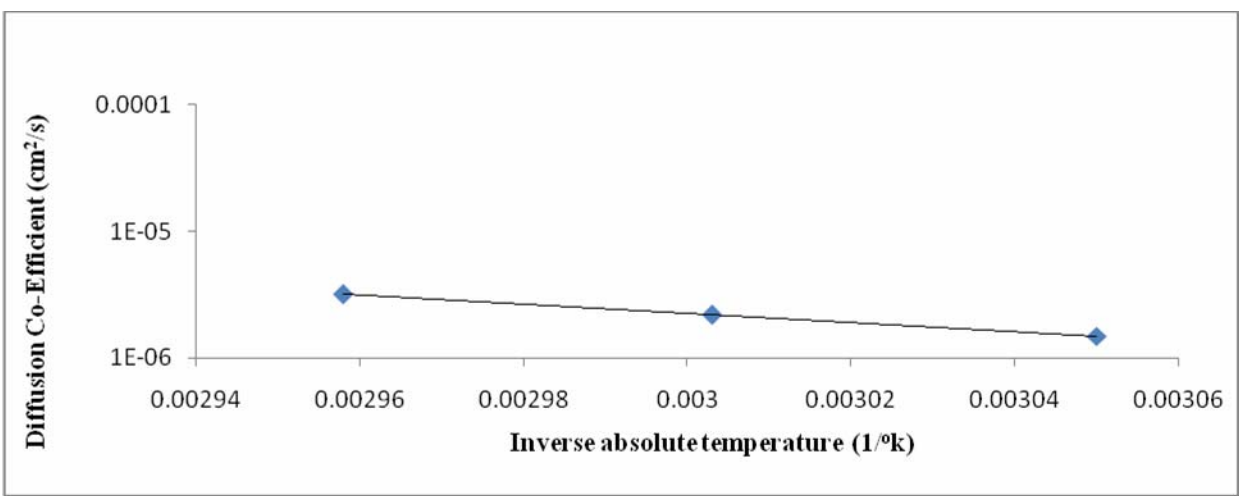


Fig. 2(a). Effect of temperature on diffusion coefficient of fresh mushroom

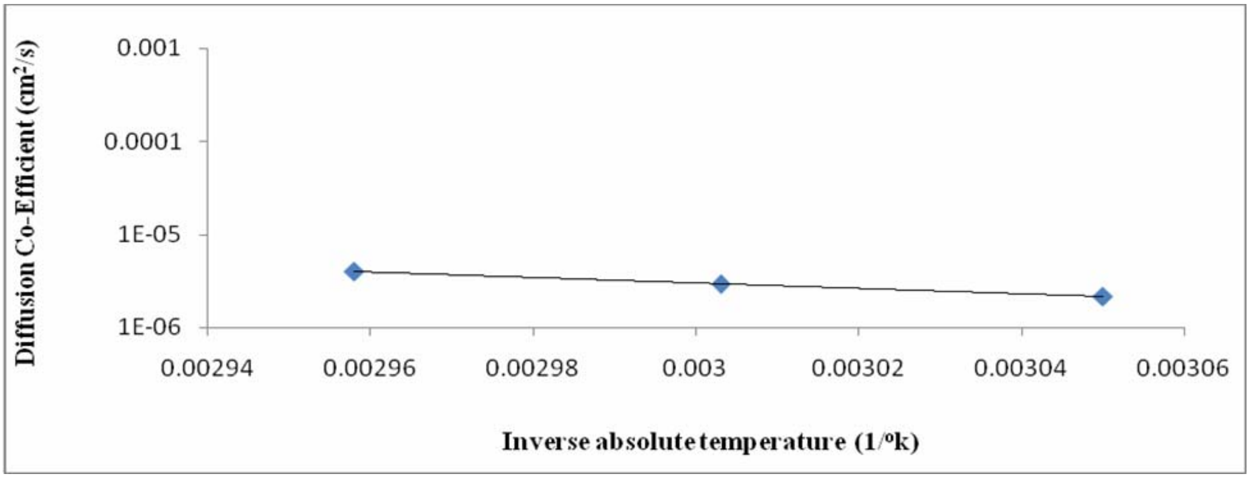


Fig. 2(b). Effect of temperature on diffusion coefficient of osmosed mushroom at 12°C

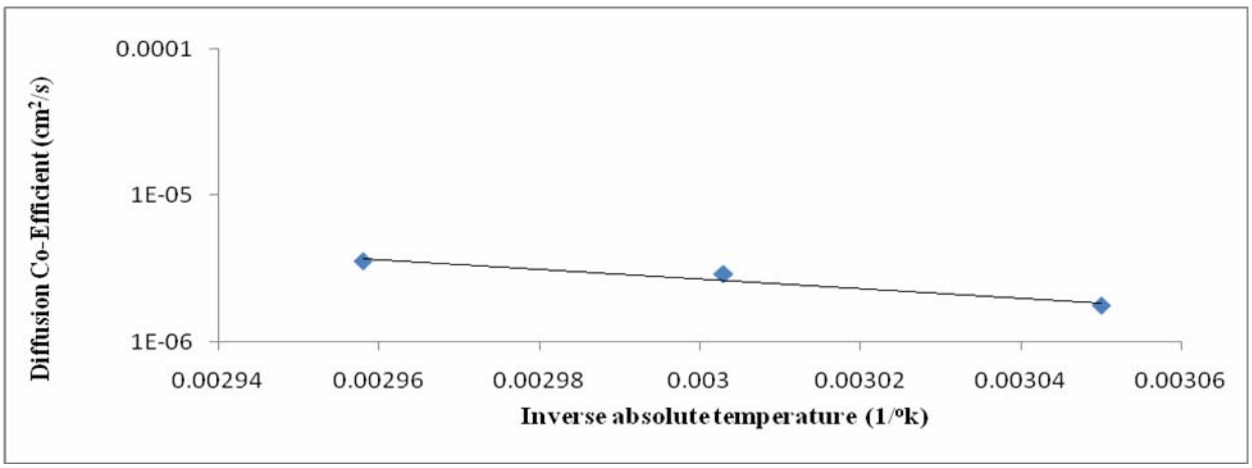


Fig. 2(c). Effect of temperature on diffusion coefficient of osmosed mushroom at 27°C

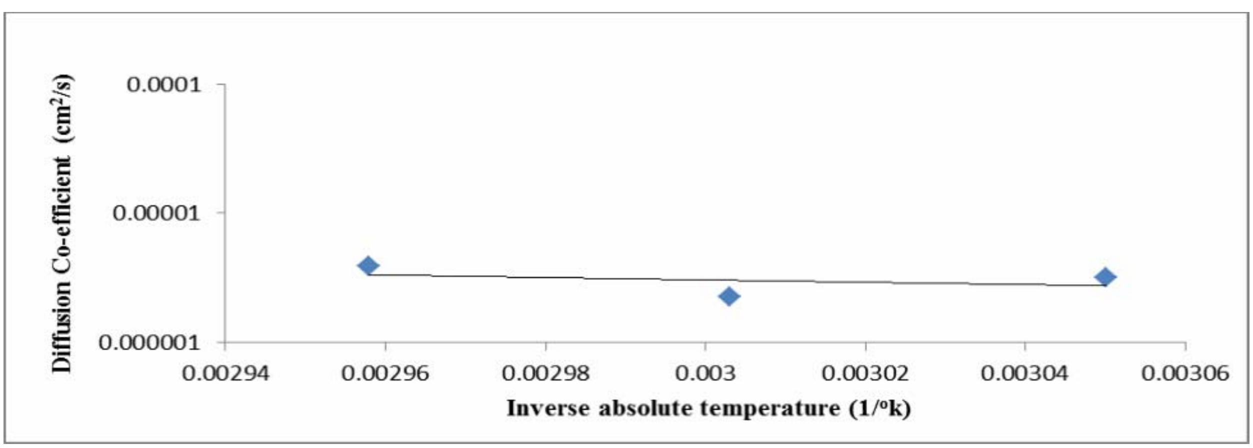


Fig. 2(d). Effect of temperature on diffusion coefficient of osmosed mushroom at 45°C

From the slope of the resultant straight line, activation energy ($E_a$) for diffusion of water was calculated and found to be 13.48 kcal/gm-mole for fresh mushroom, 15.01 kcal/gm-mole for mushroom osmosed at $27^0$C, 16.47 kcal/gm-mole for musroom osmosed at $12^0$C, and 4.19 kcal/g-mole for mushroom osmosed at $45^0$C.

Thus $E_a$ values ranged from 4.19 to16.47 kcal/g-mole for osmosed and non osmosed oyster mushroom. These values are lower than 22.23 that for mushroom reported by Tulek (2011).The differences in activation energy values are due to the differences in chemical composition and cellular structure, as well as process temperature (Islam,1980, Villota and Hawkes (1992).

**Composition of fresh mushroom and mushroom powder**

The fresh mushroom and mushroom powder were analyzed for moisture, protein fat, ash, vitamin-C, total carbohydrate and energy. The results are presented in Table 1.Comparing the composition of fresh and dried mushrooms as wet weight basis(Table 1) it is observed that fat, ash and protein contents in the dried product are significantly increased, which may due to reduction of moisture during drying, giving a higher amount of nutrient as well as higher food value for a given quantity of dried powder compared to fresh one. Again in Table 1, dry weight basis calculation shows that protein and minerals are slightly affected, while vitamin-C and fat are affected badly upon drying due to heat and oxidation (Villota and Hawkes,1992).

**Table 1. Comparison of composition between fresh mushroom powder on wet weight basis (wb) and dry weight basis (db)**

| Composition | Fresh Mushroom | | Mushroom powder | |
|---|---|---|---|---|
| | (wb) | (db) | (wb) | (db) |
| (%) Moisture content | 89.56 | 857.82 | 11.70 | 13.25 |
| (%)Protein | 3.834 | 36.72 | 31.50 | 35.67 |
| (%) Fat | 0.44 | 4.21 | 2.90 | 3.28 |
| (%) Ash | 0.91 | 8.72 | 6.92 | 7.80 |
| Vitamin-C (mg/100g) | 8.14 | 77.93 | 3.42 | 3.87 |
| (%) Carbohydrate | 5.26 | 50.35 | 46.98 | 53.20 |
| Energy | 64.40 kcal | | 560.42 kcal | |

**Sensory evaluation of cake**

Initial taste testing indicated that cake containing 0, 5% and 7% mushroom powder was subjected to sensory evaluation. A panel of 30 trained tasters evaluated the color, texture, taste and overall acceptability. The mean score for each attributes is presented in Table 2. A two-way analysis of variance indicated that except texture (sample 410) all these sensory attributes of the cake were significantly affected ($p<0.05$) by addition of different level of mushroom cake in the formulations and found that sample 521 made from 7% wheat flour substituted by blanched mushroom powder was the most acceptable product securing 8.00 (out of 9) among other sample and ranked as “like very much”. However, other samples 321,410,411 and 512 were equally acceptable at 5% level of significance and ranked as “like moderately”.

**Table 2. Mean sensory scores on sensory attributes on mushroom cake (observation number, n=30)**

| Sensory Attributes | Product Type for the sample * | | | | | LSD(<0.05) |
|---|---|---|---|---|---|---|
| | 321 | 410 | 411 | 512 | 521 | |
| Color | $7.6^a$ | $7.4^a$ | $7.8^a$ | $7.8^a$ | $8.0^a$ | 0.5955 |
| Texture | $7.8^a$ | $7.2^b$ | $7.8^a$ | $7.6^{ab}$ | $8.0^a$ | 0.5517 |
| Taste | $7.8^a$ | $7.6^a$ | $7.8^a$ | $7.6^a$ | $8.0^a$ | 0.5947 |
| Overall acceptability | $7.6^a$ | $7.8^a$ | $7.8^a$ | $7.8^a$ | $8.0^a$ | 0.4555 |

[* 321 = cake made from wheat flour, 410 = 5% wheat flour replaced by powder made of unblanched mushroom, 411 = 5% wheat flour replaced by powder made of blanched mushroom, 512 = 7% wheat flour replaced by powder made of unblanched mushroom, 521 = 7% wheat flour replaced by powder made of blanched mushroom]

## Conclusion

The present study revealed that there is a definite advantage in drying of osmosed mushroom than fresh mushroom. The drying throughput for osmosed product would be approximately 4 times higher than fresh one. The drying osmosed product, particularly those osmosed in salt solution, would give high dryer efficiency. Moreover, infused salt will act as a safely measure against spoilage due to undesirable delay in drying.

Dehydrated mushroom can be used as vegetable, soup, etc. and to make cake by substituting upto 7% wheat flour. Thus, market value of dehydrated mushroom can be increased with consequent increased yield and production of mushroom. This would definitely lead to higher consumption at home and the value-added product can also be exported abroad to earn foreign exchange.

## Acknowledgement

The authors are grateful to NST (National Science and Technology), authority as the research was supported by a research fellowship from NST, Ministry of Science and Technology, Government of the People's Republic of Bangladesh.

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