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Effect of pretreatments on drying behavior of eggplant

✉Md. Junaeid Khan[1,2], Farjana Yeasmin[1,3], Md. Nazrul Islam[1], Raju Ahmmed[1,2], Pabitra Chandra Das[1,4] and Md. Hatem Ali[5]

[1] Department of Food Technology and Rural Industries, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh.
[2] Department of Food Engineering, Dhaka University of Engineering and Technology, Gazipur, Gazipur-1707, Bangladesh.
[3] Department of Agro Product Processing Technology, Jessore University of Science and Technology, Jessore-7408, Bangladesh.
[4] Department of Chemical and Food Process Engineering, Rajshahi University of Engineering & Technology, Rajshahi-6204, Bangladesh.
[5] Department of Seed Science and Technology, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh.

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Correspondence:
Md. Junaeid Khan
✉: junaeidkhn@duet.ac.bd

Abstract

Eggplant is a familiar and admired vegetable in Bangladesh. It is a highly perishable vegetable and cannot be preserved long. Drying is an ancient preservation method used to extend shelf-life of fruits and vegetables. Different Pretreatments may affect the drying kinetics of foods. A study was conducted to evaluate how pretreatments affect the drying behavior of eggplant. Proximate composition of fresh eggplant was analyzed. The samples of constant thickness (8 mm) were dried at 50°C, 55°C and 60°C to determine the effect of temperature on drying rate constant, while for determining the effect of thickness on rate constant, eggplant slices of 4, 6 and 8 mm thicknesses were dried at a constant temperature of 55°C. It was observed that, drying rate decreased with the increase in thickness and the index 'n' was found to be 0.89 at 55°C. Under similar drying condition at constant thickness (8 mm), drying time showed an inverse relationship with temperature. The activation energy (E_a) was calculated as 3.242 Kcal/g-mole. Eggplant slices having the highest thickness (8 mm) were blanched at 70°C, 75°C and 80°C for 1, 2 and 2.5 minutes, respectively using hot water bath to determine the effective blanching time and temperature. It was observed that the samples blanched at 75°C and 80°C for 2 minute were enough to inactivate the enzymes. Pretreated (blanched, sulphited and blanched plus sulphited) eggplant slices having constant thickness (8 mm) were dried at constant temperature of 55°C. The drying time was influenced by pretreatments. The highest drying rate was observed for eggplant slices with blanched plus sulphited (5% KMS solution) samples while eggplant slices with 5%KMS solution dipped for 10 minutes showed the lowest drying rate. In case of fresh slices, drying time was lower than blanched and sulphited samples but higher than blanched plus sulphited samples. Pretreatment was also found effective on the color changes (preservation or degradation). Blanching gave a bright color compared to fresh sample but less bright compared to sulphited samples. In case of SO_2 retention, blanched plus sulphited sample showed higher retention than sulphited sample. Sulphited sample retains 44.8 ppm SO_2/100g of sulphited sample, while the blanched plus sulphited sample retains 280 ppm SO_2/100 g of blanched plus sulphited sample.

Introduction

Eggplant (*Solanum melongena* L.) is one of the foremost well-known vegetable in Bangladesh and other portion of the globe. It is largely cultivated in almost all districts of Bangladesh. About eight million farm families are involved in eggplant cultivation (Hossain *et al.,* 2013). In Bangladesh, it was cultivated in 80195 ha of land with a total production of 347541 metric tons during the Rabi season of 2016-17 (BBS, 2018a). In Kharif season of the same year, however, it was cultivated in 45665 ha of land with production of 159891 metric tons (BBS, 2018b).

Contrary to the common belief, it is quite high in nutritive value and can be compared with tomato (Seth and Choudhury, 1970). It has higher calorie, iron, phosphorus and riboflavin contents than tomato (Shaha, 1989). The unripe fruit is basically utilized as a cooked vegetable. Eggplant is a familiar vegetable crop for its easier cooking quality, better taste and lower market price.

Drying is one of the most widely used and natural as well as ancient methods of food preservation. It stops the biochemical changes in perishable plant materials by lessening the moisture content of the material (Raja *et al.*, 2017). Dehydrated products have longer shelf life with higher nutrient concentration than fresh vegetables (Chauhan and Sharma, 1993). Drying can be done by a number of conventional and advanced techniques. Cabinet dryer removes moisture by stream of hot air under controlled conditions. Heat applied in drying process changes the nutritional and sensory attributes of the product.

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Blanching prevents browning and deterioration of the quality of fruits and vegetables by inactivating enzymes (Rudra *et al.*, 2008). Hot water blanching or blanching with KMS prior to drying stops the enzymatic spoilage and thus improves the color and texture (Prajapati *et al.*, 2009). Different pretreatments like blanching, sulphitation, blanching with sulphitation, etc. were done to prevent deterioration of food quality including color, flavor and texture prior to drying of eggplant. Considering the above views, this study has been designed to determine the effects of blanching and sulphiting on ezymatic activity of eggplant and to determine the impact of pretreatments on drying behavior of eggplant.

Materials and Methods

The study was carried out in different laboratories of the Department of Food Technology and Rural Industries, Bangladesh Agricultural University, Mymensingh-2202.

Materials and Equipment

Wholesome and fresh eggplants were collected from local market of Bangladesh Agricultural University, Bangladesh. Cabinet dryer (1816, Modern Laboratory Equipment Co., Inc., New York, USA) was used for the drying operation.

Chemical analysis

Proximate composition and chemical analysis of fresh eggplants were done as per methods given by AOAC (2012).

Sample Preparation

Eggplants were visually sorted for firmness, size and absence of physical damage and finally washed thoroughly. Then the eggplants were cut into slices of 4 mm, 6 mm and 8 mm thickness using hand slicer.

Pre-treatment prior to Drying

Blanching: Eggplant slices of 8 mm thickness were blanched at 70°C, 75°C and 80°C for 1, 2 and 2.5 minutes respectively in a hot water bath.

Blanching with Sulphitation: Blanched eggplant slices were further sulphited by dipping 5% potassium metabisulphite (KMS) solution for 5, 10 and 15 minutes.

Drying Process: Cabinet dryer was used for drying operation of eggplant slices. The dryer comprised of a drying chamber in which products of known moisture content and weight were placed with trays. Hot air was blown across the trays of products being dried. The samples were dried at 50°C, 55°C and 60°C up to 5 hours to determine the effect of temperature on drying behavior of eggplant while for determining the effect of thickness on drying eggplant slices of 4, 6 and 8 mm were dried at 55°C. For determining the effect of pretreatments, pretreated eggplant slices having 8 mm thickness were dried at constant temperature of 55°C. The sample's weights were recorded at 60 minutes intervals as well as the moisture contents of eggplant slices were determined at each time interval.

Total sulphur-dioxide (SO_2) content in sulphited eggplant slices: The total SO_2 content (ppm) in sulphited eggplant slices was determined as per Ranganna (2005) using following equation:

$$SO_2 \text{ ppm} = \frac{\text{Titre value} \times 0.0016 \times 10^6}{50}$$

Adequacy of blanching: Adequacy of blanching was performed as per Ranganna (2005).

Results and Discussion

Proximate composition

The fresh eggplant was examined for moisture content, ash content, fat, protein, vitamin C, acidity and total solid content. The results are displayed in *Table 1*. These results are nearly comparable to those reported by Sultana *et al.* (2014) and USDA (2018).

Table 1. Proximate composition of fresh eggplant

Composition	Percentage (% wb)*	Percentage (% db)**
Moisture (%)	91.5	1076.47
Protein (%)	1.12	1.13
Ash (%)	0.54	0.52
Fat (%)	0.25	0.25
Acidity (%)	0.138	0.138
Vitamin C (mg/100g)	9.08	9.98
Carbohydrate (%), By difference	8.5	6.95

*wb = wet basis; **db = dry basis

Impact of thickness on drying time and rate constant

Eggplant slices of 4mm, 6mm, and 8mm thicknesses were dried in a cabinet dryer at a constant temperature of 55°C. Semi theoretical drying equation was used to analyze the results. Accordingly the Calculated moisture ratio (MR) values were plotted against drying time (hour) on a semi-log coordinate (Fig. 1).

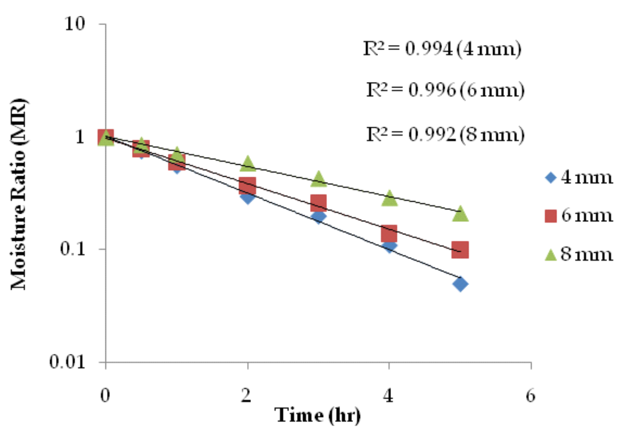

Fig. 1. Effect of thickness on rate of drying of eggplant slices at 55°C

The following regression equations were developed:
MR = $1.0151e^{-0.579t}$ (4 mm; t = hour) ……... (1)
MR = $0.9804e^{-0.466t}$ (6 mm; t = hour) ……....(2)
MR = $1.0146e^{-0.307t}$ (8 mm; t = hour) ……....(3)
From the Fig. 1 and above equations (1 to 3), it is seen that for a specific moisture ratio, eggplant slices of 4 mm thickness required the lowest drying time, and was closely followed by 6 mm thick slices, while slices of 8 mm thickness required the highest drying time. In other words, drying time was increased and thus also drying rate constant was decreased with increasing sample thickness. The relationship between drying rate constant and sample thickness was developed by plotting drying rate constant against sample thickness on a log –log coordinate (Fig. 2):

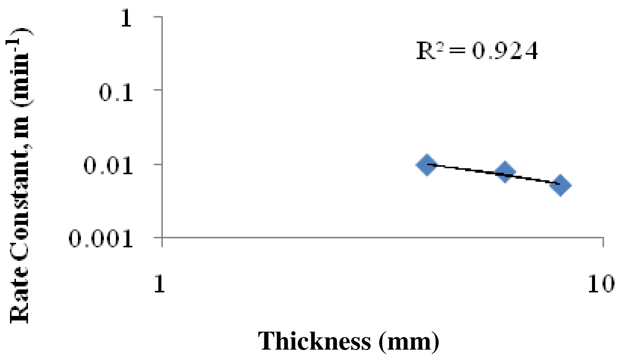

Fig. 2. Effect of thickness on rate constant at 55°C

Therefore the developed power law equation is-
m = $0.0346l^{-0.89}$ ………………………(4)

Where, m and l represent drying rate constant and sample thickness respectively.

From the equation 4, it is seen that the value of index 'n' of the power law equation is 0.89 instead of 2 as predicted by theoretical drying equation. This value shows that the outside resistance to mass transfer was very significant. This also indicates that at constant condition, higher air flow rates would provide higher drying rates. Lower 'n' value such as 0.85 has been reported for drying onion at 45°C by Babu *et al.* (1997) while Islam *et al.* (1997) found an 'n' value of 0.66 for drying of mango.

Effect of temperature on drying time and rate constant

To analyze the effect of temperature on drying time and rate constant, eggplant slices of constant thickness (8 mm) were dried in a cabinet dryer at 50ºC, 55ºC and 60ºC. Semi theoretical drying equation was used to analyze the outputs. The plots of moisture ratio (MR) against drying time (hour) were made on semi-log coordinate (Fig. 3) and subsequently the developed equations are:

MR = $1.0204e^{-0.249t}$ (50ºC; t = hour) ……(5)
MR = $1.0222e^{-0.332t}$ (55ºC; t = hour) …....(6)
MR = $1.0123e^{-0.358t}$ (60ºC; t = hour) …....(7)

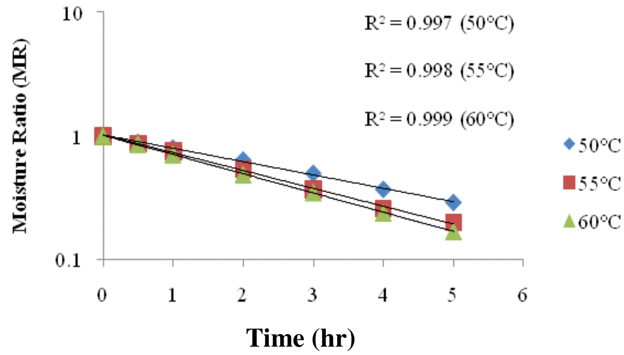

Fig. 3. Effect of temperature on rate of drying of eggplant slices (8 mm)

From Fig. 3 and the above equations (5 to 7) it is seen that, drying rate constant has a positive relationship with temperature. On the other hand, for a certain moisture ratio drying time showed an inverse relationship with temperature. According to Okos *et al.* (1992), the drying rate may primarily increase at very high temperature, but ultimately it may induce case hardening with reduced drying rate and thus product quality deteriorates due to cooking instead of drying. Hence, optimum temperature selection is crucial for drying of any foods (Islam, 1980).

The diffusion coefficients were calculated from the drying rate constants from developed regression lines (Fig. 3).

By plotting diffusion coefficient (D_e) against inverse absolute temperature ($1/T_{abs}$) in a semi-log scale, a regression line was found (Fig. 4) and the following equation was developed:

$D_e = 0.0032\, e^{-1.632\, T_{abs}}$ ……………………(8)

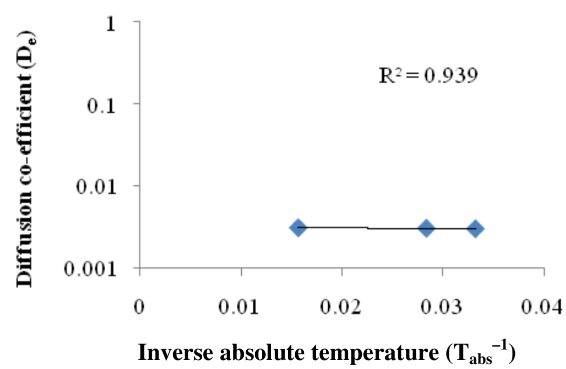

Fig. 4. Effect of temperature on diffusion co-efficient for 8 mm eggplant slices

From the slope, the activation energy of water diffusion from eggplant slices was calculated as 3.242 kcal/g-mole.

Effect of pretreatments on drying time on rate constant

Pretreated eggplant slices of constant 8mm thickness (blanched, blanched plus sulphited and fresh) were dried in a cabinet dryer at constant air temperature of 55°C. Calculated moisture ratio (MR) values were plotted against drying time (hour) on a semi-log coordinate and regression lines drawn (Fig. 5).

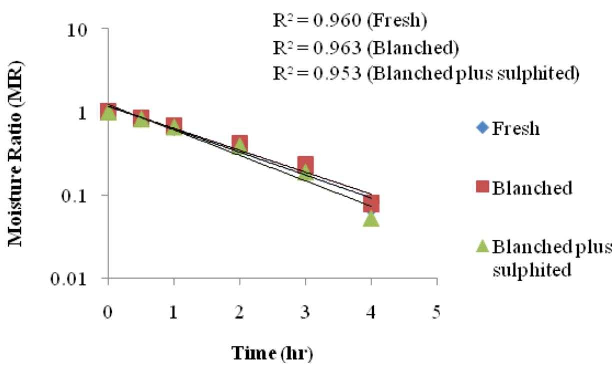

Fig. 5. Effect of pretreatments on drying kinetics of eggplant slices (8 mm) at 55°C

The developed equations were as follows:

$MR = 1.1701e^{-0.634t}$ (Fresh; t = hour) …..................……(8)

$MR = 1.1706e^{-0.608t}$ (Blanched; t = hour) …...................(9)

$MR = 1.2294e^{-0.704t}$ (Blanched plus Sulphited; t=hour) ...... (10)

Fig. 5 was constructed to show the effect of pretreatment on drying time. From Fig. 5 and the above developed equations (8, 9 and 10) it is seen that at constant loading density and constant temperature lowest time is required for drying eggplant slices with blanched and sulphited (5% KMS, dipped in 15 minute) pretreatment and is closely followed by fresh slices, while the blanched sample required the highest time when dried to constant moisture ratio (e.g. 0.1).

Alam (2014) reported that, blanched summer onion of 7 mm thickness has a higher drying rate constant (0.5077/hr) than unblanched summer onion (0.2875/hr). Van Arsdel *et al.* (1973) and Olawale and Omole (2012) observed that, blanching before drying gives better drying rate compared to unblanched product. The observed higher drying rate for blanched eggplant compared to fresh one could be attributed to differences in composition.

Yeasmin (2012) showed that, unblanched samples at 50° C and 55°C gave slightly higher rate constant than blanched sample of similar thickness while at 60°C however, 3 and 7 mm thick sample gave higher rate constants for unblanched samples compared to the corresponding rate constants of blanched samples and 5 mm thick samples had almost similar rate constants for the two cases, blanched or unblanched. We found similar result of Yeasmin (2012) for 8 mm eggplant slices dried at 55°C, i.e., at 55°C, fresh eggplant slices gave slightly higher rate constant than blanched sample of similar thickness.

Adequacy of blanching

To observe the influence of temperature, time and thickness on enzyme deactivation of eggplant slices, adequacy of blanching test was performed for different times.

Table 2. Adequacy of blanching test for 8 mm thick slice at different blanching time and temperature

Temperature (°C)	Time (minute) 1	2	2.5
70	Positive	Positive	Positive
75	Positive	Negative	Negative
80	Positive	Negative	Negative

From Table 2, it is observed that the samples blanched at 75°C and 80°C for 2 minute and 2.5 minute adequacy of blanching was obtained. Adequacy of blanching ensures the inactivation of most heat resistant enzyme 'Per-oxidase'. The inactivation of this enzyme confirms the inactivation of all other enzymes-e.g., catalase (Crook, 2003).

Determination of SO_2 content

Sulphur dioxide content in 8 mm eggplant slices was determined. Infused SO_2 were found in ppm and are given Table 3.

Table 3. SO_2 infusion in 8 mm slices on different conditions

Sample	Dipping Time (minute)	SO_2 in ppm/100 g eggplant
Sulphited	10	44.8
Blanched plus Sulphited	15	280

From the above result we may conclude that blanched plus sulphited eggplant slices absorbed about 6 times more SO_2 than only sulphited samples, while the dipping time was only 1.5 times higher (10 min vs. 15 min) than only sulphited samples. Thus it is concluded that, blanching has a positive effect on absorption of SO_2 due to heat transfer effect and porosity of tissue.

Conclusion

The study was conducted to evaluate the effect of pretreatments on the drying behavior of eggplant. Blanching or sulphitation either alone or in combination are the common pretreatments used for fruits and vegetables. Blanching inactivates enzymes that influence color, texture, flavor and nutritive quality of food products. On the other hand, SO_2 from sulphitation acts as antioxidant and prevent browning. Both pretreatments are additionally improved shelf-life of products by lessening the growth of microorganisms. In the current study, eggplant slices were subjected to blanching with or without sulphitation, while the eggplant slices without any pretreatment served as control. At constant loading density and constant temperature, lowest time is required for drying eggplant slices with blanched and sulphited (5% KMS, dipped in 15 minutes) pretreatment and was closely followed by fresh slices, while the blanched sample required the highest time when dried to constant moisture ratio (e.g. 0.1). Blanching gave a bright color than fresh sample. But, pretreatment sulphitation preserved higher color than other.

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