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Research article

Dehydration Kinetics of hog-plum (*Spondias mangifera*), hog-plum jelly and hog-plum leather

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A B S T R A C T

The current investigation was carried out to assess the kinetics of drying of raw hog-plum (*Spondias mombin*) along with its value-added product: jelly and leather. Hog-plum leather and jelly were prepared from fresh hog-plums (Barishal and Mymensingh variety) pulp and juice. Dehydration of two varieties hog-plum (Barishal and Mymensingh) pulp and associated developed jelly and leather was carried out using a cabinet dryer. Drying rate decreased with an increase in thickness and lower drying rate constant with consequent lower diffusion constant. The 'n' value of the power-law equation relative drying rate constant with thickness was calculated and found to be 1.4 mm. Under similar drying conditions, drying time decreases with increases in temperature. Diffusion coefficient (D_c) versus inverse absolute temperature ($Tabs^{-1}$) was plotted and activation energy (E_a) for the diffusion of water was 25.1 and 63.9 Kcal/gmol for Barishal and local hog-plum respectively. The activation energy (Ea) for the diffusion of water for Barishal hog-plum pulp was lower than Mymensingh hog-plum pulp. During drying at constant temperature (60°C) and with a constant thickness (6 mm), the effect of ingredients was determined for leather from two varieties of hog-plum. Effect of ingredients on dehydration kinetics was observed that the higher the ingredients, the higher is the resistance to mass transfer. Moreover, of the added ingredients milk powder showed the highest resistance.

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1. INTRODUCTION

Hog plum (*Spondias mombin*) popularly called "Amra" is a well-known fruit in Bangladesh. Botanically it belongs to the family of Anacardiaceae and obtained from *Spondius mombin* belongs to the mango family, Anacardiaceae (Arif et al., 2009). The thicker, leathery skin covers a pink-yellow pulp inside, with a texture that is much like avocado. The flesh is thin around the large seed. Hog-plum is a fruit of mixed taste of sweet and sour which is familiar in botany as Droop. It can be separated into three parts: skin, flesh or pulp and stone. Pulp is the main portion of hog-plum, for human consumption (Chadha, 2001). This fruit is either taken as fresh or canned and widely used in the preparation of jam, jelly and pickles etc. It possesses various kinds of medicinal values (Islam et al., 2016). It is effective against scurvy, rickets and some other complex diseases (Bhuiyan, 2012).

It is apparent that the marketing of the most important fruit, hog-plum of Bangladesh is still unorganized and primitive (Mahin et al., 2016). Only a small potion of hog-plum produced is processed and preserved by house wives and small processors by traditional methods like sun drying in Bangladesh (Islam and Sujan, 2016). The quality of ripe and green hog-plum highly depends on the collection at suitable time and way. Due to poor keeping quality of hog-plum and difficulties of transportation, preservation and marketing facilities, a huge quantity of these valuable fruits are being damaged and spoiled. During the peak season, a large quantity of this fruit is usually wasted due to its short shelf life and for this reason the producer is forced to sell them at a very low price locally. To reduce the wastage of this fruit and to get a reasonable price by the producer of this fruit, preservation is necessary. By processing products from it or preserving the fruit by adopting suitable means of food preservation can increase the utility of this fruit. Drying is a very important preservation method because it is the easiest and most common way to preserve a variety of food products (Carvalho et al., 2014). Quality dried products are in great demand worldwide. Until canning was developed at the end of the 18^{th} century, drying was virtually the only method of food preservation. It is still the most widely used method since the other processes such as canning, freezing etc are not always cost effective for developing countries. Drying can be accomplished in a mechanical dryer, direct sunlight or solar dryer. In the mechanical dryer, desired temperature and airflow could be maintained. Compared to sun/solar drying higher airflow and temperature can be used in mechanical drying (Aral and Bese, 2016). This leads to high production rates and improved quality products due to shorter drying time and reduction of the risk of insect infestation and microbial spoilage. Since mechanical drying is not dependent on sunlight so it can be done as and when necessary. But mechanical drying of agricultural products is an energy consuming operation in the post-harvesting technology (Togrul and Pehlivan, 2004).

Processing of hog-plum into a dried product is an important method of reducing perishability and also to increase storage stability. Leather and jelly can be produced from fresh and dehydrated hog-plum. However, during the drying hog-plum may undergo undesirable changes such as shrinkage that has a negative effect on the required characteristics of dehydrated product for commercial usage. The analyses of the drying kinetics data permits to understand the moisture transfer inside the foods considering the shrinkage of samples and mechanisms involved. In the last fifty years, many studies were done to investigate the drying of foods, especially potatoes. Such analyses aid practitioners not only to decide how significant is internal resistance as compared with external resistance to the moisture transfer but also select a suitable air-food contactor assuring better quality attributes of final products (Bacelos et al., 2011).

Several drying systems available in the literature for explaining of drying characteristics of fruits and vegetables have been used by Munmun (2005) for cucumber, Bacelos et al. (2011) and Jabeen et al. (2015) for potato, Begum et al. (1985) for green beans, Lebert et al. (1994) for cassava chips, Shams-Ud-Din et al. (2000) for cauliflowers and Krokida and Marinos (2003) for various fruits and vegetables. On the basis of the information so far accumulated, the present work has been undertaken to study the drying behavior of Mymensingh and Barishal hog-plum using mechanical drying system and to develop leather and jelly from Mymensingh and Barishal hog-plum.

2. MATERIALS AND METHODS

The experiment was conducted in the Laboratory of the Department of Food Processing and Engineering, Chattogram Veterinary and Animal Sciences University, Chattogram-4225, Bangladesh.

Materials

Two varieties of hog-plum (*Spondias mombin*), one grown in Barishal and another in Mymensingh were collected from the local market. The other materials such as sugar, citric acid, agar-agar, skim milk, KMS, packaging materials (low density polythene) and necessary materials and machineries were provided from the laboratory stock.

Development of hog-plum products Leather and Jelly

Fresh hog-plums (Barishal and Mymensingh variety) were used separately for extraction of pulp and juice**.** Preparation of hog-plum leather and jelly were done as the procedure described by Akther et al. (2013). Consideration of drying efficiency, palatability, nutrient contents, storage stability etc. lead to design drying experiments with the following formulations for hog-plum leather samples:

Development of leather from Barishal variety hog-plum
Sample 401: Pulp + 0.15% KMS (Potassium Metabisulphite)
Sample 402: Pulp +4.5% sugar +0.15% KMS (Potassium Metabisulphite)
Sample 403: Pulp +4.5% milk+0.15% KMS (Potassium Metabisulphite)
Sample 404: Pulp +4.5% sugar +4.5% milk+0.15% KMS (Potassium Metabisulphite)

Development of leather from Mymensingh hog-plum
Sample 501: Pulp +0.15% KMS (Potassium Metabisulphite)
Sample 502: Pulp + 4.5% sugar +0.15% KMS (Potassium Metabisulphite)
Sample 503: Pulp + 4.5% milk +0.15% KMS (Potassium Metabisulphite)
Sample 504: Pulp + 4.5% sugar +4.5% milk+0.15% KMS (Potassium Metabisulphite)

Modeling of Kinetics of Dehydration

Biological product when dried is thin layer under constant external condition (air flow, temperature) may show three period of drying. These are:
Constant rate drying period ($M_c \leq M_t \leq M_o$)
First falling rate period ($M_{hyg} \leq M_t \leq M_c$)
Second falling rate period ($M_e \leq M_t \leq M_{hyg}$)
Where,
M_t = Moisture content (dry basis) at any time,
M_c = Critical moisture content (dry basis),
M_{09} = Initial moisture content (dry basis),
M_{hyg} = Hygroscopic moisture content (dry basis),
M_e = Moisture content (dry basis) in equilibrium with drying air condition.

A constant rate period of drying is observed for the use when external resistant to vapor removal from product surface is much higher compared to internal resistance of moisture transport to product surface (Vega et al., 2007). In this case the water vapor pressure at the product surface remains at or near the saturation water vapor pressure. The rate of water removal in this period may be approximated by an analogy with the wet bulb thermometer analysis as presented by Brooker et al. (1974). Constant rate period, if any, would be followed by first falling rate period and it begins from the critical moisture content (where constant rate period discontinues) and ends at the maximum hygroscopic moisture level. The second falling rate period begins when the moisture content is within the hygroscopic range. Both the first and second falling rate periods can be characterized by the same basic diffusion equation with the difference being that effective diffusion coefficient (D_e) Changes from a higher value for the 1st falling rate period to a lower value for the second falling rate period (Goyal et al., 2007).

Since food dehydration is most frequently assumed to take place by diffusion process, Fick's second law of diffusion is applied for describing mass transfer during drying. The expression is;

$$\frac{\partial M}{\partial t} = \nabla^2 D_e M \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where,
M = Moisture content (Dry basis), T = Time and
D_e = Effective diffusion co-efficient (cm^2/sec).

To find a solution from the above unsteady state diffusion equation for one dimensional transport for the case of initial uniform moisture distribution in the sample and negligible external resistance appropriate boundary conditions are assumed. The solution for an infinite slab (With thickness, l) when dried from one major face (Islam, 1980 and Aral and Bese, 2016) is:

$$MR = \frac{M_t - M_e}{M_0 - M_e} = \frac{8}{\pi^2} \sum_{n=0}^{\alpha} \frac{1}{(2n+1)^2} Exp\left[\frac{-(2n+1)^2 \pi^2 D_e t}{L^2}\right] \frac{\partial M}{\partial t} = \nabla^2 D_e M \ldots\ldots\ldots (2)$$

Where,

MR= Moisture ratio

Mt = Moisture content at the time t
Mo= Initial moisture content
Me= Equilibrium moisture content respectively.
For low M_e values and for moisture ratio MR less than 0.6, equation (2) reduces to:

$$MR = \frac{M_t}{M_o} = \frac{8}{\pi^2} e^{-\frac{\pi^2 D_e t}{L^2}} = \frac{8}{\pi^2} e^{-mt} \text{ or } \ln MR = \ln \frac{8}{\pi^2} - mt \dots\dots\dots (3)$$

Where,

$$M = \frac{\pi^2 D_e}{L^2} = \text{drying rate constant, sec}^{-1} \dots\dots\dots (4)$$

Consequently, a straight line should be obtained when plotting L_n MR values vs time (t). The slope of regression line is the drying rate constant, m from which the effective diffusion co-efficient, D_e is calculated.
The diffusion co-efficient, D_e has an Arrhenius type of relationship with drying air bulb temperature (abs). The relationship is as follows (Heldman, 1974).

$$\frac{d\ln D_e}{dT_{abs}} = \frac{E_a}{RT_{abs}} \text{ Or, } \ln De = \ln Do - \frac{E_a}{RT_{abs}} \dots\dots\dots (5)$$

Where, D_0 is the constant of integration and usually referred to as a frequency factor when discussion Arrhenius equation. E_a is activation energy of diffusion of water, kcal/g-mol. R is universal gas constant 1.98cal/g-mol ^{0}K and T_{abs} is absolute temperature, ^{0}K.

From equation (5) it is seen that plotting diffusion co-efficient (De) versus the inverse absolute temperature on semi-logarithmic coordinates would lead to the evaluation of activation energy for diffusion of water during drying and activation energy was calculated by non-linear regression analysis.

From the semi-theoretical equation as shown in equation (3), it may be noted that the drying rate constant, m is a function of the square of thickness of the product being dehydrated, as seen in equation 4, Symbolically, this may represent as:
$m = A (L)^{-n}$

$$\text{or, } \log(m) = \log A - n \log(L) \dots\dots\dots (6)$$

Where,

$$A = \pi^2 D_e, n = 2$$

The above relationship shows that if external resistance to mass transfer is negligible and if simultaneous heat and mass transfer effects are taken into account, the value of the exponent of the power law equation should be 2. But the above conditions are not always satisfied and experimentally determined 'n' value is found to be less than 2 (Islam, 1980).

Mechanical drying of hog-plum

Cabinet dryer (Model OV-165, Gallen Kamp Company) was used for dehydration of two types of hog-plum pulp and leather. The dryer consists of chamber in which trays of products were placed. Air was blown by a fan over a heater and then across the trays of products being dried. The velocity of air was recorded (0.6 m/s) by an Anemometer (HOLDPEAK 866B Digital Anemometer).

For determining the effect of temperature and thickness on the rate of drying, two types of hog-plum (Barishal and Mymensingh) were washed thoroughly and then peeled and cut into pieces by knife and boiled in pressure cooker for 30 minutes. Following cooling pulps were collected by squeezing the flesh of the hog-plum. The pulp was then blended in an electric blender and the samples were taken for determination of moisture content. Hog-plum pulps (Barishal an Mymensingh) of 3 mm, 5 mm and 7mm thickness were placed in steel trays in single layer and drying commenced in the drier at a constant air velocity (0.6 m/s) and at a specific dry bulb temperature (60^{0}C). To determine the rate of drying of pulp of constant thickness (7 mm) was dried at different temperature such as 50^{0}C, 55^{0}C and 60^{0}C. Gravimetrically determined weight loss of samples of known initial moisture content was used as a measure of the extent of drying. Four samples of leather prepared by the mechanical drying method and then placed in trays as sheet (6 mm thickness) and dried with constant temperature (60^{0}C) and drying commenced as mentioned previously.

Statistical analysis

Regression analysis was done by using the MATLAB statistical computer program (Agbossou et al., 2016).

3. RESULTS AND DISCUSSION

Mechanical drying

In mechanical drying under controlled conditions two types of hog-plum pulp were dried using 3 different thickness (3 mm, 5 mm and 7 mm) at a specific drying bulb temperature 60^0C to determine the effects of thickness on drying time. Another experiment was conducted to determine the effect of temperature on drying time the pulps of constant thickness (7 mm) were dried at 3 different temperatures, such as 50^0C, 55^0C and 60^0C. Another experiment was conducted to determine the effect of ingredients on drying time at constant thickness (6 mm), at a specific dry bulb temperature (60^0C) and other conditions were kept constant.

Influence of thickness on drying behavior

For the determination of the influence of thickness on drying time, 3 mm, 5 mm and 7 mm hog-plum pulp (Barishal and Mymensingh) were dried at a constant, air dry bulb temperature of 60^0C in the mechanical drier. The results were analyzed by using equation (3) and moisture ratio (MR) Vs drying time (hr) was plotted on a semi-log graph paper and the plot is shown in Figure 1.

For three different thickness three equations were developed. These are:

For Barishal hog-plum pulp (Figure 1a)

$MR = 0.9467e^{-0.0777t}$ (for 7 mm; t =hr) ....(7)

$MR = 0.9782e^{-0.1595t}$ (for 5 mm; t = hr)............(8)

$MR = 1.0333e^{-0.3748t}$ (for 3 mm; t = hr)............(9)

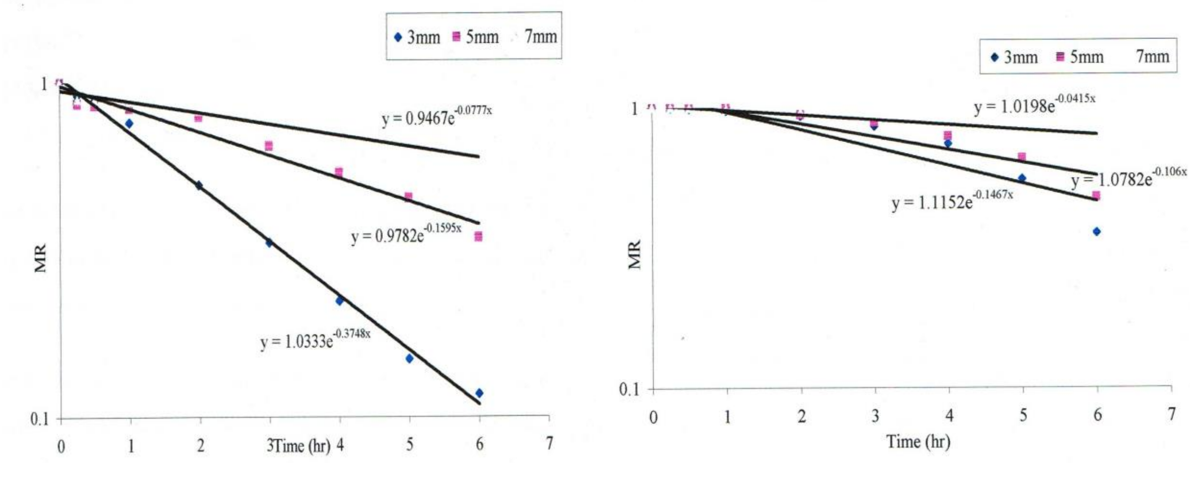
Or, Mymensingh hog-plum pulp (Figure 1b)

$MR = 1.0198e^{-0415t}$ (for 7 mm; t = hr)............(10)

$MR = 1.0782e^{-0.1061t}$ (for 5 mm; t = hr)..........(11)

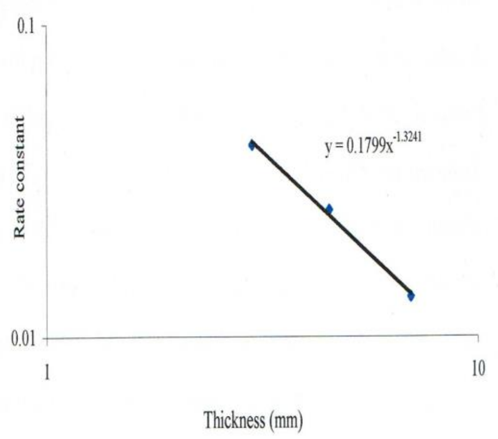
$MR = 1.1152e^{-0.1467t}$ (for 3 mm; t = hr) ....(12)

It is observed that for specific moisture ratio 3 mm hog-plum pulp requires the least time to dry at 60^0C. In other words, drying time increases and drying rate constant decreases with increasing sample thickness.

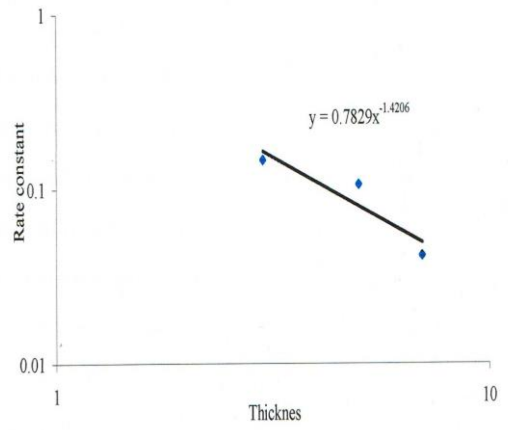


(a) **(b)**

Figure 1. Effect of thickness on drying rate of (a) Barisal hog-plum and (b) Mymensingh hog-plum pulp



(a)



(b)

Figure 2. Influence of thickness on drying rate constant (a) Barishal hog-plum and (b) Mymensingh hog-plum pulp

The relationship between drying rate constant and sample thickness was developed from the plot of drying rate constant versus sample thickness on log-log scale (Figure 2). This relationship can be represented by power law (regression) equations which are as follows:

For Barishal hog-plum (Figure 2a)

$m = 0.1799L^{-1.3241}$...(13)

For Mymensingh hog-plum pulp (Figure 2b)

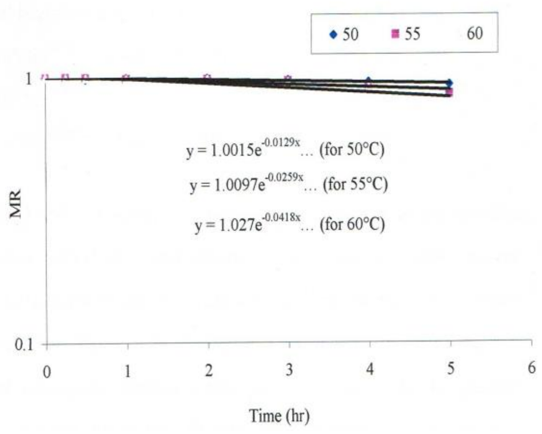
$m = 0.7829L^{-1.4206}$...(14)

Where,

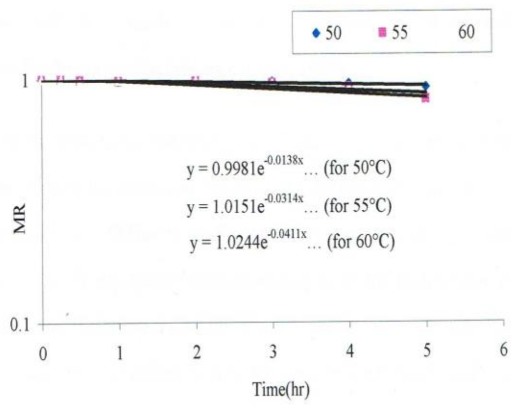
m = drying rate constant (hr^{-1})

L = sample thickness (mm)

From the above equations, it is seen that the values of index 'n' for the Barishal and Mymensingh hog-plum pulp of the power law equation are 1.3241 and 1.4206 at 60^0C. This value is lower than 2 as predicated by equation (3). Hai (2002) found an 'n' value of 0.49 for banana using similar air velocity (0.6m/s). Kamruzzaman (2005) dried aroids under similar conditions and found 'n' value of 1.15.

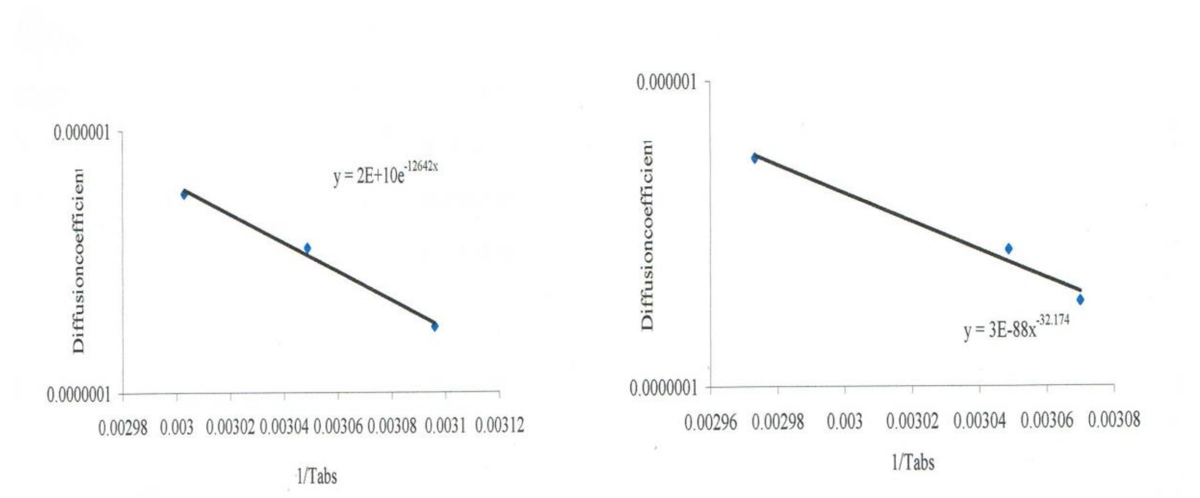


(a)



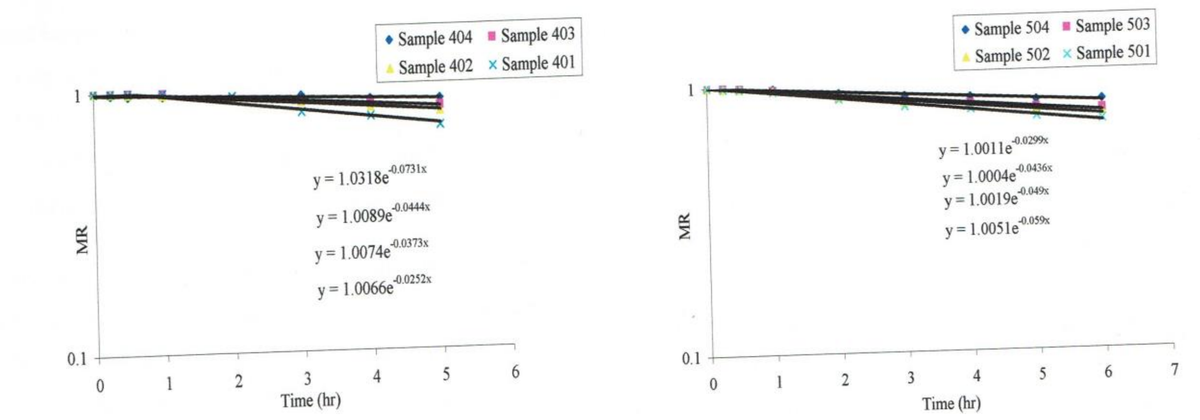
(b)

Figure 3. Effect of temperature on drying rate of (a) Barisal hog-plum and (b) Mymensingh hog-plum



(a) **(b)**

Figure 4. Effect of temperature on diffusion coefficient of (a) Barisal hog-plum and (b) Mymensingh hog-plum



(a) **(b)**

Figure 5. Effect of ingredient on drying rate of (a) Barisal hog-plum and (b) Mymensingh hog-plum

This value indicates that the external resistant to mass transfer significantly under the given conditions. This also indicates that the higher air flow rates have influence on the higher drying rate. Islam (1980) showed an 'n' value of 1.70 while drying potato using higher air flow rates (2.5 m/s). The above discrepancy of 'n' values is primarily due to airflow rate and thickness, which indicate the relative importance of external or internal mass transfer resistance. However, product structure and composition as well as simultaneous heat and mass transfer effects also play an important role on drying rate. Islam (1980) when working with potato, showed that by taking into account of the simultaneous heat and mass transfer effect value of 'n' could be corrected to 2 from 1.7. Furthermore, at low air velocities within this range of thickness, a slight increase in thickness may show of thickness may show no disadvantage as per as throughput is concerned as noted by Islam (1980).

Influence of temperature on drying time

To investigate the influence of temperature on drying behavior 7 mm thick Barishal and Mymensingh hop-plum pulp were dried in a mechanical drier at three different air-dry bulb temperature, such as 50^0C, 55^0C and 60^0C. The experimental drying data were analyzed using equation (3) and the plots of moisture ration (MR) Vs drying time were made on semi log scale (Figure 3) and the following equations were developed.

For Barishal hog-plum pulp (Figure 3a)
MR. $1.0015e^{-0.0129t}$ (for 50^0C; t = hr) ……... (15)
MR. $1.0097e^{-0.02595t}$ (for 55^0C; t = hr)…….. (16)
MR. $1.0097e^{-0.0418t}$ (for 60^0C; t = hr)……... (17)

For Mymensingh hog-plum pulp (Figure 3b)
MR. $0.9981e^{-0.0138t}$ (for 50^0C; t = hr) ……... (18)
MR. $1.0151e^{-0.0314t}$ (for 55^0C; t = hr) ……... (19)
MR. $1.0244e^{-0.0411t}$ (for 60^0C; t = hr) ……. (20)

From Figure 3 and also from the above equations it is clearly seen that the moisture ratio (MR) (hence moisture content) decreases with time and time to dry to a specific moisture ratio decrease with increasing temperature. From the above figure it is obvious that when temperature of dryer is increased, drying rate constant is also increased. Thus, higher temperature would give faster drying rate. At very high temperature drying rate may initially increase, but later on resultant case hardening will reduce drying rate and product quality will deteriorate due to cooking instead of drying. High temperature may also scorch the product. Thus, selection of optimum temperature for drying is of significance (Islam, 1980).

Table 1. Drying parameters of mechanical dried hog-plum pulp

Sample	Thickness (mm)	Temperature & velocity (0.6 m/s)	Slope (m) hr	Diffusion coefficient (cm^2/s)	Value of exponent (n-value)	Activation energy (E_a) Kcal/g-mol
Barishal hog-plum	7	50^0C	2.15×10^{-4}	1.78×10^{-7}	1.3241	25.1
		55^0C	4.32×10^{-4}	3.57×10^{-7}		
		60^0C	6.97×10^{-4}	5.76×10^{-7}		
Mymensingh hog-plum	7	50^0C	2.3×10^{-4}	1.90×10^{-7}	1.4206	63.9
		55^0C	5.32×10^{-4}	2.88×10^{-7}		
		60^0C	6.85×10^{-4}	5.67×10^{-7}		

To develop the Arrhenius type relationship from the drying rate constants that are determined by regression equation, the diffusion co-efficient were calculated in Table 1. Diffusion coefficient (D_e) versus inverse absolute temperature ($Tabs^{-1}$) was plotted on a semi-log scale and regression lines were drawn (Figure 4). From the slope of the resultant straight line, activation energy (E_a) for diffusion of water was calculated and found to be 25.1 and 63.9 Kcal/g- mol for Barishal and Mymensingh cultivar respectively. The calculated activation energy are higher than 12.5 Kcal/g-mol of activation energy for diffusion of water from potato by Saravacos and Charm (1962), than for cucumber (8.50 Kcal/g-mol) and cauliflower (7.76 Kcal/g-mol) found by Iqbal (2003), than for aroids (5.12 Kcal/g-mol) found by Kamruzzaman (2005) and also higher than that found for mango (4.4 Kcal/g-mol) by Islam et al. (1997). However, the activation energy value for Barishal cultivar is lower than found by Babu et al. (1997). The differences in activation energy may arise from differences in product characteristics as well as process parameters (Islam, 1980).
Dependence of diffusion co-efficient on absolute temperature can be represented as:

For Barishal hog-plum pulp
$D_e = 2\times10^{10}e^{-12642}Tabs^{-1}$................................(21)

For Mymensingh hog-plum pulp
$D_e = 3\times10^{-32.174}Tabs^{-1}$..................................(22)

Effect of ingredients on drying behavior

All samples were dried at 60^0C to 25% mc (moisture content) db using 6 mm thick sheets at constant air velocity. The experimental drying data were analyzed as per equation (3) and depicted in Figure 5 on semi-log coordinate. The regression drawn could be represented as.

For Barishal hog-plum leather
MR= $1.0318e^{-0.0731t}$ (for sample 401, t = hr)..(23)
MR= $1.0089e^{-0.0444t}$ (for sample 402, t = hr)..(24)
MR= $1.0074e^{-0.0373t}$ (for sample 403, t = hr)..(25)
MR= $1.0066e^{-0.0252t}$ (for sample 404, t = hr)..(26)

For Mymensingh hog-plum leather
MR= $1.0051e^{-0.059t}$ (for sample 501, t = hr) ..(27)
MR= $1.0019e^{-0.049t}$ (for sample 502, t = hr)...(28)
MR=$1.0004e^{-0.00436t}$ (for sample 503, t = hr)..(29)
MR=$1.0011e^{-0.0299t}$ (for sample 504, t = hr)...(30)

From the above equations for Barishal hog-plum leather and Figure 5. It is clear that sample 401, gives the fastest drying rate, followed in descending order by sample 402 and 403, while lowest drying rate is given by sample 404. Such difference in drying behavior with respect to varietal difference and initial high solid content has been demonstrated earlier (Rahman, 2003). And from the above equation for local log-plum leather, it is clear that sample 501 gives the fastest drying rate, followed is descending order by sample 502 and sample 503, while the lowest drying rate is given by sample 504. Sample 401 and 501, with no added sugar and skim milk gave no extra resistance to mass transfer as given by sample 404 and sample 504 with added sugar and skim milk, thus sample 401 and sample 501 gave the highest rate of drying. Comparing sample 502 and 503 and sample 402 and 403, it is found that added milk at similar percentage give higher resistance to mass transfer with consequent lower drying rate constant.

Presence of added skim milk and / or sugar in mango pulp has been shown to effect drying on behavior (Rahman, 2003). He also demonstrated that added ingredients, milk showed more resistance to mass transfer than added sugar during air drying of mango pulp and the higher was the initial added solid content, the lower was the drying rate. Since the products are mainly based on hog-plum pulp and their moisture content is around 25% mc_{db}, the products will be shelf-stable with or without KMS (Potassium Metabisulphite) (Desrosier, 1977). For an added safety measure, these products contained 0.15% KMS (Potassium Metabisulphite). Though no systematic study on storage stability was conducted, sample packaged in double-layer polythene and kept in tin can be shelf-stable at room temperature.

4. CONCLUSIONS

By dehydrating hog-plum at 60^0C., it is observed that 3 mm thick pulp required the least time, while 7 mm thick pulps require more drying time. This behavior was attributed to a lower drying rate constant with consequent lower diffusion constant. Experiments were conducted to show the influence of temperature on drying behavior of hog-plum (both two variety) pulp for constant thickness (7 mm) at 50^0C, 55^0C, and 60^0C at constant air velocity (0.60 m/s). It was observed that drying time decreases with an increase in temperature. Diffusion coefficient (D_e) versus inverse absolute temperature (Tab^{-1}) was plotted and activation energy (E_a) for the diffusion of water was calculated and found to be 25.1 and 63.9 Kcal/g-mol for Barishal and Mymensingh hog-plum, respectively. The activation energy (E_a) for the diffusion of water for Barishal hog-plum pulp was lower than Mymensingh hog-plum might be from differences in variety. It was also revealed that the higher the added ingredients the higher is the resistance to mass transfer than added fewer ingredients during air drying hog-plum leather.

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