Study on Drying and Quality Characteristics of Tray and Microwave Dried Guava Slices

Sneha Tripathy[1], John Diamond Raj[2] , Mayank Mishra[3]

[1]M.Tech Agricultural Process and Food Engineering, Department of Food Process Engineering, VSAET, SHIATS, Allahabad - 211007.

[2]Assistant Professor, Department of Food Process Engineering, VSAET, SHIATS, Allahabad - 211007.

[3] M.Tech Agricultural Process and Food Engineering, Department of Food Process Engineering, VSAET, SHIATS, Allahabad - 211007.

Abstract- Uniform sizes of guava (*Psidium guajava L.*) unblanched, blanched and blanched with KMS samples were dried at three different temperatures (50, 60 and 70°C) at constant velocities and power (20, 40 and 60W). Dried samples were evaluated for quality attributes, viz. moisture content and drying rate. The samples were heat sealed in low density polyethylene bags (LDPE) and stored at room temperature. The initial average moisture content of unblanched, blanched and blanched with KMS samples were observed to be 551.8905% (db). Drying rate of unblanched guava slices had highest at 50°C and 70°C and the drying rate of samples at 60°C had highest for blanched samples in tray drier. In microwave, the drying rate of KMS blanched samples had highest at 20, 40 and 60W. Moisture loss increased from guava with increased in power of microwave and time of drying. The drying rate of guava slices under tray drying decreased as the drying time progressed and finally attained zero drying rates.

Keywords: Drying, Drying rate, Guava, Moisture content, Microwave drying, Thin layer modelling, Tray drying.

1. INTRODUCTION

Guava (*Psidium guajava*) is common tropical fruit cultivated and enjoyed in many tropical & subtropical regions. This fruit is appealing for its unique tropical flavour and is considered as an excellent source of nutrients and antioxidant phytochemicals, especially ascorbic acid. It is commonly called as poor man's fruit. It is one of the most important and legendary fruits of India and because of its hardy and prolific bearing nature, it is well adapted to grow in most Indian states. The water content of guava ranges from 81-88%, which makes it highly perishable (7-10 days) in nature and lead to the post-harvest losses in storage, handling and transportation, resulting in economic losses. Therefore, for long term storage and distant transportation, drying is the cheapest and easiest way of preservation.

In India, the estimated post-harvest loss per hectare is about 49% (**Sehgal, 1999**). During the seasonal glut, the production of guava becomes very high and consequently the price decreases. Due to highly perishable nature of guava, sometimes farmers have to pay to throw away their produces. In order to avoid this losses, processing can be an alternative for extending the shelf-life of the guava. Guava is a rich source of Vitamins C, A, B_2 (riboflavin) and minerals like calcium, phosphorus and iron (**Millar and Bazore, 1945**).

Drying is an ancient method of preservation of food and this involves the removal of majority of the water normally present in the food by evaporation, Dehydration, or drying, is a simple, low-cost way to preserve food that might otherwise spoil (**Mazza and LeMaguer, 1980**). Tray drying and Microwave power drying are the methods which has been used; among which microwave power dryer is rapid, uniform and energy efficient as the microwaves penetrate to the interior of the food causing water to get heated within the food. This greatly increases the vapour pressure differential between the centre and surface of the product, allowing rapid removal of moisture from the food. Eventually, the objective of this literature is to propose best fit mathematical model using tray and microwave power drying and also optimize conditions of guava slices.

2. MATERIALS AND METHODS

2.1 Procurement of Raw materials: Fresh and good quality of guavas (*Psidium guajava* L.) of variety "Allahabad Safeda" was purchased from fruit sellers in Allahabad on the daily basis prior to each set of experiment.

2.2 Blanching pre-treatment: After washing, the sliced guava pieces were blanched by tying them in muslin cloth and dipping the sample in boiling water for 5 minutes. The blanched samples were cooled immediately by keeping them under running tap water to prevent overcooking of the sample and drained to remove the excess water for blanched sample.

2.3 Chemical pre-treatment: After washing, the sliced guava pieces were blanched with potassium meta-bisulphate (KMS) by tying them in muslin cloth and dipping the sample in boiling water containing KMS for 5 minutes. The KMS blanched samples were cooled immediately by keeping them under running tap water to prevent overcooking of the sample and drained to remove the excess water for blanched with KMS (1% solution of potassium Meta bisulphate) sample.

2.4 Tray drying: The pre-treated samples of guava slices were dried using tray dryer. Drying were carried out using three different temperatures 50, 60 and 70°C and two pre-treatments viz. blanching and blanching with KMS having three replications each. In order to ensure uniform drying, the samples of the guavas were dried simultaneously. The dried guava slices were analysed for different physicochemical analysis.

2.5 Microwave drying: The pre-treated guava slices were dried in a microwave dryer. Drying was carried out at three different microwave generation power being 20, 40 & 60W and two pre-treatments viz. blanching and blanching with KMS having three replications each. In order to ensure uniform drying, the samples of the guavas were dried simultaneously. The dried guava slices were analysed for different physicochemical analysis. The microwave oven was allowed to cool down for 30 min. between experiments.

Guava
↓
Slicing (3mm thickness)
↓
Washing
↓
Blanching
↓
Drying of guava slices using tray drier and microwave oven
↓
Packaging (LDPE)
↓
Storage at room temperature

Fig 1. Processing Flow chart for dehydrated guava slices

3. Physicochemical analysis

3.1 Determination of moisture content

Initial Moisture Content

A standardization procedure of AOAC (1980) was followed to estimate the moisture content of food.
The moisture content of the sample was computed using these following equations.

$$\text{Moisture content}(\%\ \text{w.b.}) = \frac{W1-W3}{W2-W1} \times 100 \quad \text{---------- (a)}$$

$$\text{Moisture content (db)} = \frac{\text{M.C(wet basis)}}{100-\text{M.C(wet basis)}} \times 100 \quad \text{-------- (b)}$$

M.C. (lost) = M.C. (current) – M.C. (Previous) ------ (c)

Where,

W_t = Weight of sample at any time t, (g)

W_{t+Dt} = Weight of sample at any time t+Dt, (g)

D_t = Time interval, (min)

W_d = Weight of bone dry material, (g)

M.C. = moisture content of sample (% w.b. and d.b.)

M.C. = moisture content of sample (% w.b. and d.b.)

M_1 = wt. of sample before drying (g)

M_2 = wt. of sample after drying (g)

$$\text{Wt. of bone dried material} = \frac{\text{initial weight of sample} - \text{initial M.C}}{100} \quad \text{---------- (d)}$$

3.2 Drying rate

Drying rate is the drying per unit time per gram of dry matter. The rate of drying is determined by the moisture content and the temperature of the grain. The temperature, the (relative) humidity and the velocity of the air are in contact with the grains.

Drying rate = $\frac{\text{Amount of moisture removed(g)}}{\text{Time taken(min)} \times \text{total bone dried weight of sample in (g)}}$ --------- (e)

Similarly, the drying rate was approximately proportional to the difference in moisture content between the product being dried and EMC at the drying air state.

$DR = \frac{Mt+dt-Mt}{dt}$ ------------ (f)

Where,

Mt = moisture content at time t (% db)

Mt+dt = moisture content at time t+dt (%db)

dt = time of successive measurement (min)

3.3 Dehydration ratio

Dehydration ratio is the ratio of mass of guava slices before drying to the mass of dehydrated samples. Dehydration ratio (D_{ratio}) was calculated as mass of sliced guava before loading to the dryer to mass of dehydrated material at the time of removal from drier **(Tunde-Akintunde, 2008**).

$D_{ratio} = \frac{M_{before}}{M_{after}}$ -------------- (g)

Where,

M_{before} = mass of sample before drying (*g*)

M_{after} = mass of sample after drying (*g*)

4. Statistical Analysis

4.1 Mathematical Modelling

Three statistical tools were used to examine the fitness of the above models to the drying data. The tools are Chi-square (x^2) **(Midilli, Kucuk, & Yapar, 2002)** or Mean Square Error (MSE) **(Saeed, Sopian, & Zainol Abidin, 2008**), Coefficient of determination (R^2), Sum of Squares Error (SSE)**)** and Root Mean Square Error (RMSE). The analysis was conducted using XLSTAT (2015 version) statistical software. XLSTAT is Microsoft Excel add-in software.

Table.1. Thin layer drying mathematical models

S/N.	Model Name	Model	References
1	Logarithmic	MR = a exp(-kt) + c	(Erbay & Icier, 2009), (Midilli, Kucuk, & Yapar, 2002).
2	Henderson &Pabis	MR = a exp(-kt)	(Henderson & Pabis, 1961)
3	Modified Page	$MR = exp(-kt)^n$	Whith *et al.* (1978)

$$x^2 = \frac{\sum_{i=1}^{N}(MR_{exp,i} - MR_{pre,i})^2}{N-n} \quad \text{-------------- (h)}$$

$$R^2 = 1 - \left[\frac{\sum_{i=1}^{n}(MR_{pre,i} - MR_{exp,i})^2}{\sum_{i=1}^{N}(\overline{MR}_{pre} - MR_{esp,i})^2}\right] \quad \text{-------------- (i)}$$

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N}(MR_{pre,i} - MR_{exp,i})^2}{N}} \quad \text{-------------- (j)}$$

$$SSE = \left[\frac{\sum_{i=1}^{N}(MR_{exp,i} - MR_{pre,i})^2}{N}\right] \quad \text{-------------- (k)}$$

Where,

$MR_{exp,i}$ = *ith* experimental moisture ratio

$MR_{pre,i}$ = *ith* predicted moisture ratio

N = the number of observations

n = number of constant

5. Materials used for packaging

LDPE (low density polyethylene) was used for dried guava packaging. After cooling the dried product, it was packed at room temperature and stored at room temperature away from sun light.

6. Results and Discussion

Experiments were conducted to study the tray and microwave drying characteristics of dried guava slices at three different temperatures (50, 60 and 70°C) and three different powers (20, 40 and 60W). The dried guava samples were then packed in LDPE bags and stored at room temperature. Studies on the quality were based on the physicochemical characteristics (i.e. moisture content and drying rate) which were determined for fresh samples. The results of the study are presented and discussed in the following section.

6.1 Tray Drying characteristics

Guava slices were dehydrated using tray dryer three different temperatures 50, 60 and 70°C to final equilibrium moisture content. The initial average moisture content of the guava slices was found to be 551.8905% (db). The relationships were plotted in between moisture content and drying rate vs. drying time. The moisture content decreased very rapidly during the initial stage of drying, as the moisture removal was faster at the surface of the product. Decrease in drying rate with respect to time suggests a decreased drying rate with the decrease in moisture content.

6.1.1 Effect of the pre-treatment and tray dryer on the moisture content of the guava slices during the drying process.

The initial average moisture content of the unblanched, blanched and blanched with KMS guava slices was 551.8905% (db). It was found that the moisture content decreased continuously with drying time and increasing in the drying temperature. Different results were obtained in which the pre-treatments affect the drying time. The pre-treated samples were found to have a shorter time as compared to unblanched sample. Thereafter, the moisture content of samples was decreased slowly with increase in drying time and attained final equilibrium moisture content. Similar results were also obtained by **Mudgal and Pande (2008).** The amount of the moisture removed increases as the drying temperature increases resulting in the lesser dying time to achieve the final dried product.

At 50°C air temperature, the average initial moisture content of unblanched, blanched and blanched with KMS slices were 551.89% (db), 554.02% (db) and 548.08% (db) respectively. Guava slices were reduced to 31.94%, 48.13% and 43.35% (db) respectively at the end of 540, 580 and 520 minutes drying respectively.

At 60°C drying air temperature, the average initial moisture content of the guava unblanched, blanched and blanched with KMS slices were 548.08% (db), 524.60% (db) and 548.08% (db) respectively. The guava slices were reduced to 24.43%, 22.06% and 34.95% (db) at the end of 520, 520 and 540 minutes drying respectively.

At 70°C drying air temperature, the average initial moisture content of the guava unblanched, blanched and blanched with KMS slices were 558.76% (db), 547.24% (db) and 541.84% (db) respectively. The guava slices were reduced to 31.15%, 28.94737% and 39.21% (db) at the end of 500, 460 and respectively.

6.1.2 Effect of the pre-treatment and tray dryer on the drying rate of the guava slices during the drying process.

The drying rate decreased with the increase in drying time and decrease in moisture content. After some period, drying rate decreased rapidly with the increase in drying time and then decreased gradually and attained approximately zero drying rates. Similar results were also obtained by **Wang and Brennan (1995).**

The moisture content of guava slices was relatively higher during the initial phase of drying resulting in higher absorption of heat and led to in increased product temperature and higher drying rate to higher moisture diffusion. As the drying of guava slice progressed, the loss of moisture in the product decreased the absorption of heat and resulted in full drying rate during latter part of the drying.

At 50°C air temperature, the drying rate of unblanched guava slices had highest drying rate. The drying rate of the unblanched, blanched and KMS blanched guava slices were 0.076, 0.063 and 0.055g/min/g of dry matter at the end of first 5 minutes drying. It decreased gradually and attained near about zero drying rate at end of drying.

At 60°C air temperature, the drying rate of blanched guava slices had highest drying rate. The drying rate of the unblanched, blanched and KMS blanched guava slices were 0.065, 0.101 and 0.067g/min/g of dry matter at the end of first 5 minutes drying. It decreased gradually and attained near about zero drying rate at the end drying.

At 70°C air temperature, the drying rate of unblanched guava slice had highest drying rate. The drying rate of the unblanched,

blanched and KMS blanched guava slices were 0.095, 0.060 and 0.070g/min/g of dry matter at the end of first 5 minutes drying. It decreased gradually and attained near about zero drying rate at the end of drying.

6.2 Microwave Drying characteristics

Guava slices were dehydrated in microwave oven at 20, 40, and 60W to final equilibrium moisture content. The initial average moisture content of guava slices was 552.472% (db). The moisture content decreased very rapidly during the initial stage of drying. The amount of moisture removed from guava slices increased and time to achieve final moisture content in finished product was reduced with increase in microwave power.

6.2.1 Effect of Pre-treatment and microwave power dryer on moisture content and drying rate of guava during drying process.

The initial average moisture content of unblanched, blanched and blanched with KMS guava samples was 552.472% (db). It showed that the moisture content decreased continuously with drying time and increasing the drying powers. The pre-treated samples were found to have a shorter time to attain equilibrium as compared to unblanched sample. Thereafter, the moisture content of samples decreased slowly with increase in drying time and attained final equilibrium moisture content. With increasing the drying power level the amount of moisture removed from guava increased and time to achieve final moisture content in finished product was reduced.

At 20 watt, initial level moisture content of unblanched, blanched and blanched with KMS samples were observed to be about 553.16% (db), 548.08% (db) and 548.08% (db) respectively. Drying rate of guava slices was reduced to 0.16, 0.15 and 0.16 g/min/g at the end of drying.

At 40 watt, initial level moisture content of unblanched, blanched and blanched with KMS samples were observed to be about 548.08% (db), 522.27% (db) and 564.89% (db) respectively. Drying rate of guava slices was reduced to 0.180, 0.168 and 0.181 g/min/g at the end of drying.

At 60 watt, initial level moisture content of unblanched, blanched and blanched with KMS samples were observed to be about 556.16, 548.08 and 562.69% (db) respectively. Drying rate of guava slices was reduced to 0.198, 0.196 and 0.202 g/min/g at the end of drying.

7. Conclusion

It was observed that slices dried by microwave dryer removed moisture in less time than tray dryer. Microwave dried guava slices were also higher in sensory attributes then tray dried samples. Pre-treated samples have more overall acceptability then control sample. The moisture loss increased from guava with increased in power of microwave and time of drying, drying rate of guava in tray dryer was affected by hot air temperature. Moisture loss increased from guava with increased in power of microwave and time of drying. The pre-treated samples take shorter drying time than unblanched slices.

The mathematical models that best describe the drying process of guava slices were also determined. From the present study, it can be concluded that:

1. The moisture content of guava slices decreased non-linearly with temperature and time during drying process. Pre-treatments were the most pronounced factors affecting drying rate of guava slices.
2. Logarithmic model shows the best fit with highest values for the coefficient of determination followed by Henderson and Pabis and Modified Pages model.

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