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Study on Effect of Microwave Drying on Drying and Quality Characteristics of Guava (*Psidium guajava)*

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ABSTRACT : The Higher water content of guava makes them highly perishable. Guava was dried to enhance storage stability, minimize packaging requirement and reduce transport weight. Osmotically dehydrated and control guava slices were microwave dried using four different power levels (20W, 40W, 60W and 80W). The osmotic dehydrated samples were found to have more moisture removal as compared to control sample. Dried guava slices were evaluated for quality attributes, viz. Vitamin C retention, rehydration ratio, color, sensory and microbial activity. Pretreated samples have more ascorbic acid retention than control sample. Drying models were developed to optimize the drying conditions in order to minimize the most production losses in the industry occur during drying, drying characteristics of guava slices was overall better predicted by the Lewis's model.

Keywords: Guava, Osmotic dehydration, Microwave drying and Drying model

1. INTRODUCTION

The estimated postharvest loss per hectare in India is about 49% **(Sehgal, 1999).** Guava prices become very low during main season and sometimes farmers have to pay to throw away their produces because of higher perishable nature of the produce. Fresh guava has 92 to 94% moisture and it can be stored for 2 to 4 weeks at 0°C **(Mudgal and Pandey, 2007).** Processing of guava can be an alternate for extending the shelf life. The most serious constraint for shelf-life enhancement is the activity of micro-organisms. Drying is one of the methods used to prolong the shelf life of guava. Various drying methods including osmotic dehydration have been studied on guava. The use of microwaves in drying of fruits has increased in the last few decades, mainly due to more accurate process control, good MW penetration into fruit tissues and shorter processing times. Microwave drying provide low process temperatures and faster water evaporation, offering shorter drying times and higher quality of dried product compared to other drying methods. The role of microwaves is to heat the water molecules in the product and these molecules migrate from the interior to the surface of the product, whereas hot air is supposed to remove free water at the surface **(Sanga *et al*., 2000)**. The use of microwaves overcomes the problem of poor heat transfer in vacuum-drying. In microwave drying, heat is generated in the tissues by the microwaves. The energy transfer rates in MW-assisted drying are much higher than inconventional drying operation, especially during the falling rate period. However, the microwave drying process can have very high costs. Several studies have shown that using pretreatments prior to microwave-drying could decrease drying time and thus drying costs. Osmotic dehydration seems to be an efficient way to remove up to 50% of initial moisture **(Beaudry, 2001**). The study was undertaken with the following objectives: To study the drying characteristics of guava by microwave drying method, to study the physicochemical, sensory and microbial quality of guava slices and to evaluate the drying model for drying characteristic of guava.

2. MATERIALS AND METHODS

2.1 Procurement of Raw Material

Fresh guava was procured from the local market of Allahabad city. It was ensured that the fruits have good physiological maturity as well as none kind of damage and infestation.

2.2 Pre-treatment of guava

Guava was washed, sliced (approx 3mm thickness) and dehydrated through osmosis by putting them in sugar syrup (70° Brix) at 2:1 fruit to sugar ratio at ambient temperature (23±1°c) for 18 hrs, ascorbic acid added to osmotic solution at concentration of 1% (mass%) in order to prevent the fruit pieces from browning. After osmotic dehydration, the guava slices was rinse with warm water to remove the adhering solution and gently dried with an absorbent paper towel.

2.3 Microwave drying

The pretreated guava slices were dried in microwave oven shown in plate 3.1. Drying was carried out at different microwave power 20, 40, 60 and 80W. The sample of guava design was dried simultaneously, in order to ensure uniform drying conditions. After the dried guava slices were analyzed for different physicochemical analysis.

2.3.1 Determination of moisture content

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

$$\text{Moisture content (wet basis)} = \frac{M_1 - M_2}{M_1} X\ 100$$

$$\text{Rate of drying} = \frac{\text{M.C. lost}}{\text{Time difference}}$$

Where M_1 is the weight of sample before oven drying (g), M_2 is the weight of sample after oven drying (g) and M.C. is the moisture content of sample (% w.b).

2.3.2 Moisture content of sample during drying

Moisture content during drying was computed through mass balance. For this purpose, weight of the sample during drying was recorded in every minute. The samples were weighed through electronic weighing balance. The following formula was used to calculate the moisture content:

$$\text{M.C.} = \frac{\text{Wt. of sample at desired time} - \text{Wt. of bone dry material}}{\text{Wt of sample at any time}} X\ 100$$

$$\text{Wt of bone dried material} = \frac{\text{Initial wt. of the sample X100} - \text{Initial M.C.}}{100}$$

2.4. Physico-chemical analysis

2.4.1. Vitamin C Determination

Vitamin C of dried guava (Psidium guajava) slices was determined by 2, 4-Dichlorophenol Indophenols' dye method**.**

2.4.2. Rehydration Ratio

Five g of dehydrated sample was taken into a small container and 120 ml of distilled water was added. Container was cover with a watch glass and the water was brought to boil for 15 minutes. Sample was turn out onto a white dish which surface was covered with a piece of filter paper to soak the excess water and the weight of sample was record and rehydration ratio was calculate by the following formula.

$$\text{Rehydration ratio} = \frac{B}{A}$$

Where B is the weight of sample (g) after rehydration and A is weight of sample (g) before rehydration.

2.4.3. Color Determination

Fruit color was determined by direct reading using L*a*b* color space due to the uniform distribution of colors, and because it is very close to human perception of color, the L*a*b* color values were measured using a Hunter Lab colorimeter to obtain the values: L* (brightness/darkness), a* (redness/greenness) and b* (yellowness/blueness). The measurements were taken from randomly selected fresh fruits and averaged.

2.4.4. Microbiological analysis

The microbial analysis of product was done by the standard method of **Ranganna (1986).** Total plate count method (TPC) procedure was used to determine the number of microorganisms in the dried guava slices. The serial dilution (1:10, 1:100 and 1:1000) of the dried guava slices was prepared. One ml of each dilution was transferred to sterilized Petri plates. 10 ml of the sterilized melted cooled agar medium was added to each plate and rotated gently for uniform distribution of the organism and the agar was allowed to solidify.

3. DRYING MODELS

Simplified drying models have been used to quantify drying kinetics of various fruits and vegetables. The experimental drying data for guava were fitted to the exponential thin layer drying models as shown in Table 3.1 by using non-linear regression analysis. Regression analyses were performed using MS Excel 2007.

Table 3.1. Thin layer drying models

Model name	Model
Page	$MR = \exp(-kt^N)$
Lewis	$MR = \exp(-kt)$
Henderson and pabis	$MR = a \exp(-kt)$

The moisture ratio (MR) can be calculated as

$$MR = \frac{M - M_e}{M_i - M_e}$$

The goodness of fit for each model was evaluated based on root mean square error (RMSE), chi square (χ2), and relative percent error (PE). The predicted moisture ratio was compared to the experimental moisture ratio using root mean square error and chi square as shown in the following equations **(McMinn, 2006).**

$$RMSE = \left[\frac{1}{N}\sum_{i=1}^{n}(MR_{exp,i} - MR_{predicted,i})\right]^{\frac{1}{2}}$$

$$\chi^2 = \frac{1}{N-n}\sum_{i=1}^{n}(MR_{exp,i} - MR_{predicted,i})^2$$

$$PE = \frac{100}{N}\sum_{i=1}^{n}\frac{|M_{exp,i} - M_{predicted,i}|}{M_{exp,i}}$$

4. RESULTS AND DISCUSSION

The Fresh guava contains approx 85.6% moisture content, after osmotic dehydration 50% of moisture was removed and only approx 35.96% of moisture remains in guava slices. The osmotic dehydrated samples were found to have more moisture removal in less time as compared to control sample. The final moisture content of control sample at 20, 40, 60 and 80W were reach upto 3.60%, 2.81%, 1.66% and 2.17% respectively and the final moisture content of osmoticaly dehydrated sample at 20, 40, 60 and 80W were reach upto 2.66%, 0.64%, 1.02%, 0.89% respectively. Drying rate was affected highly by increase in microwave power whereas it was reduced with increase in drying time. The 80 watt sample was found to be having a highest drying rate with shorter drying time as compare to other samples similar work has been reported by **Changrue and Orsat (2009)**. Ascorbic acid content was decreased with increasing microwave power and time. 20W pretreated sample had highest ascorbic acid content 214.2mg/100g. At 40, 60 and 80W the ascorbic acid content of pretreated sample was 156.3mg/100g, 116.6mg/100g and 98.6mg/100g respectively. The pre-treated dried guava samples had higher rehydration ratio as compare to control samples and found highest in sample dried at 40W. Rehydration ratios of osmoticaly dehydrated sample were observed 4.92, 7.482, 5.68 and 5.054 at 20, 40, 60 and 80 watt respectively.

The color determination of guava slices show that color parameters (L*, a* and b*) changed after microwave drying. The brightness (L* value) of guava slices was decreased and the value of a* increased in both control and osmoticaly dehydrated sample after microwave drying. The value of b* increased only in 60 and 80 watt control sample and decreased in all remaining sample as compare to fresh guava.

Microbial analysis shows absence of plate count in the entire control sample on 0^{th} and 30^{th} day and in the entire pre-treated sample on 0, 30 and 60^{th} day. The growth of bacteria are found on 60 and 90^{th} day in the entire control sample and on 90^{th} day in the entire pre-treated sample. The total plate count of the entire sample is also within the standard limits of fssai.

According to the thin layer drying kinetics criteria, the observed analysis shows that the Lewis model obtained the highest value for the coefficient of determination (R2) and the least value for the reduced chi-square (χ2) and RMSE when compared with the Henderson-pabis and Page model.

Table 4.1.Emperical Constant and model prediction evaluation of Page model

Power level	K (min^{-1})	N	R^2	RMSE	χ^2	PE%
20W (Control)	1.546	0.106	0.851	0.366606	0.526621	4.013776
40W (Control)	1.64	0.252	0.928	0.672309	3.489423	10.83229
60W (Control)	1.473	0.326	0.948	0.845328	6.811201	6.491367
80W (Control)	1.069	0.297	0.920	0.733178	3.709364	7.251849
20W (Pre-treated)	1.513	0.113	0.856	0.36847	0.558599	7.008957
40W (Pre-treated)	1.345	0.136	0.849	0.433094	0.816598	4.7167
60W (Pre-treated)	0.879	0.176	0.843	0.513098	1.19047	6.448414
80W (Pre-treated)	0.855	0.166	0.879	0.503597	1.099313	5.20093

Table 4.2.Emperical Constant and model prediction evaluation of Lewis model

Power Level	K (min^{-1})	R^2	RMSE	χ^2	PE%
20W (Control)	0.089	0.999	0.020863	8.55577E-06	0.104
40W (Control)	0.305	0.963	0.09373	0.00161	2.86683
60W (Control)	0.398	0.982	0.10517	0.00182	3.6543
80W (Control)	0.446	0.991	0.07865	0.00066	2.55078
20W (Pre-treated)	0.114	0.989	0.03837	0.00011	0.41701
40W (Pre-treated)	0.138	0.997	0.02342	1.63917E-05	0.1339
60W (Pre-treated)	0.249	0.990	0.02739	3.06089E-05	0.59804
80W (Pre-treated)	0.231	0.998	0.03406	3.71965E-05	0.50284

Table 4.3.Emperical Constant and model prediction evaluation of Henderson and Pabis model

Power Level	K (min^{-1})	A	R^2	RMSE	χ^2	PE%
20W (Control)	0.089	0.033	0.999	0.119516	0.097286	3.846
40W (Control)	0.305	0.495	0.963	0.130408	0.007209	5.303
60W (Control)	0.398	0.411	0.982	0.159756	0.11988	8.046
80W (Control)	0.446	0.268	0.991	0.148235	0.010494	8.816
20W (Pre-treated)	0.114	0.126	0.989	0.104612	0.005776	3.289
40W (Pre-treated)	0.138	0.031	0.997	0.126029	0.00887	4.849
60W (Pre-treated)	0.249	0.076	0.990	0.134426	0.010502	7.731
80W (Pre-treated)	0.231	0.062	0.998	0.13737	0.01029	7.616

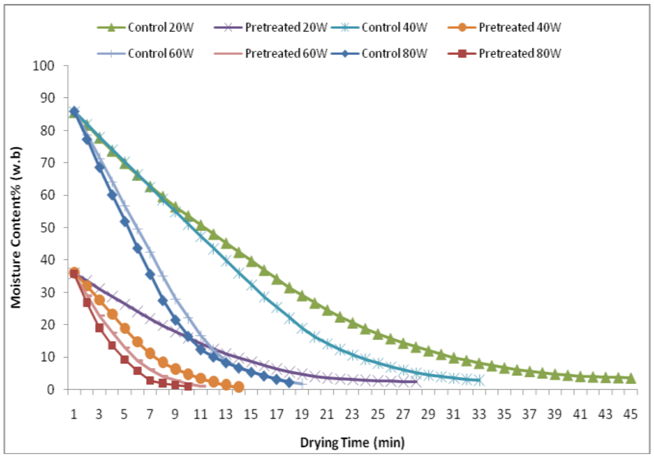

Fig.1. Effect of pre-treatment and microwave power on moisture content of guava slice

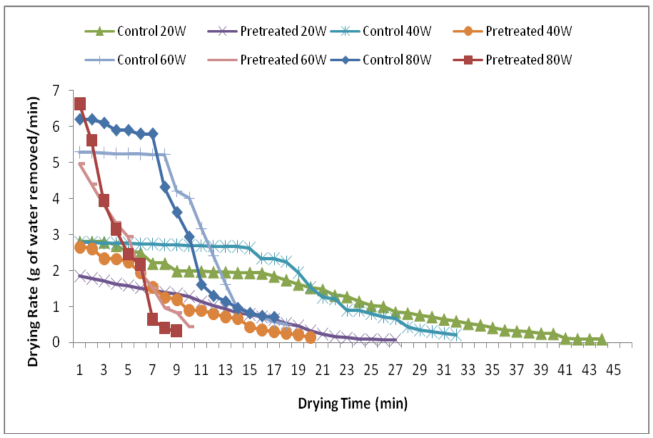

Fig.2 Effect of pre-treatment on drying rate of guava slices at different power level.

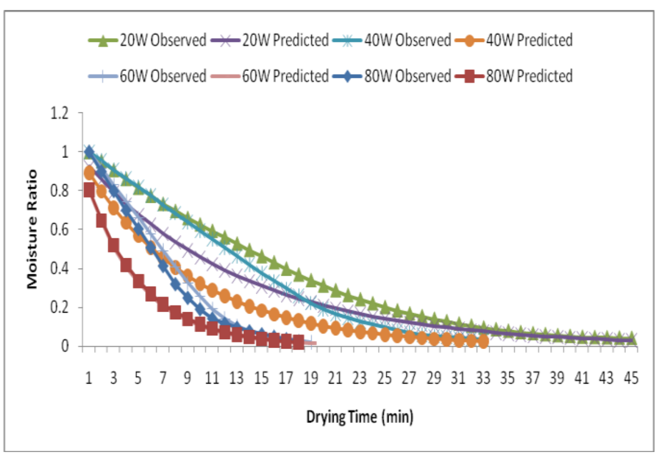

Fig.3. Comparison between the Predicted and Experimental Data of control samples Based on Lewis Model.

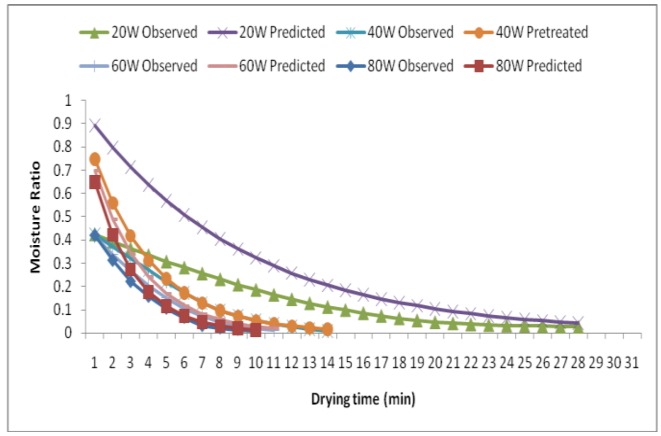

Fig.4. Comparison between the Predicted and Experimental Data of pre-treated samples Based on Lewis Model.

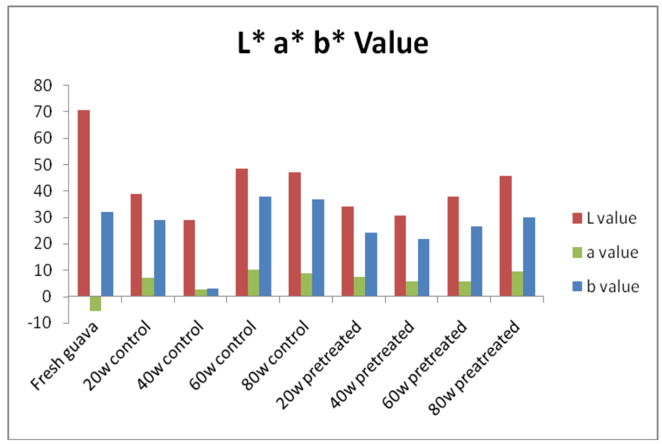

Fig.5. Effect of microwave drying on L* (brightness) value of guava

CONCLUSION

The study concludes that pretreated guava slices were found to have more moisture removal in less time as compared to control sample. The pretreated 40W sample has maximum moisture removal. The Ascorbic acid retention of pretreated samples had highest retention than control sample. Rehydration ratio of pretreated guava slices was highest at every power level of microwave oven and at 40W rehydration ratio was acceptable. Microbial presence of total plate count after 60 days in control and after 90 days in pretreated guava samples was within the limits of fssai. The mathematical modelling for drying characteristics of guava slices was overall better predicted by the Lewis's model. The pretreated 40W guava sample obtained the highest value for the coefficient of determination (R2) and the least value for the reduced chi-square ($\chi 2$) and RMSE.

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