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Hot Air Cabinet Drying of Gum Kondagogu (Cochlospermum Gossypium)

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Abstract

The objective of this study was to determine the drying characteristics of gum kondagogu (Cochlospermum gossypium) using hot air stationary cabinet dryer. The three grades of gum having particle size equivalent to US Sieve size-6 were dried at three different temperatures (50, 60 and 70^{o}C) till their constant weights. Page's model was used to predict the drying kinetics from experimental data. For three drying temperatures, the values of drying rate constant (k) varied between 0.2099-0.4669 (h^{-1}), the dimensionless constant (n) values varied between 1.758-2.327 and the coefficient of determination (R^2) values varied between 0.966-0.994. For a particular temperature, grade-III gum showed comparative more drying rate constant value than grade-II gum which in turn was more than grade-I gum. The same trend was followed for other temperatures too. Investigation revealed that the rise in drying air temperature increased both the drying process and the drying rate.

Keywords: Gum kondagogu; Hot air drying; drying kinetics; Cochlospermum gossypium.

1. Introduction

India is the largest producer and exporter of tree gums (Verbeken et al., 2003). The carbohydrate nature and moisture content present in the gums is responsible for microbial contamination upon exposure to the external environment, which can be prevented by proper handling and the use of preservatives like formaldehyde and benzoic acid (Jani et al., 2009). Increasing demand of natural ingredients over synthetic ones immensely contribute to explore and develop new plant products for food and pharmaceutical use. Gum kondagogu is a tree exudate from India and the forests of Andhra Pradesh are its richest source where more than four million tribal people, economically the most backward community, are employed in gum collection (Singh & Singh, 2013). Food and Agriculture Organization (FAO), Rome, included the gum exudates from *Cochlospermum gossypium* under gum karaya (*Sterculia urens*), which is a well recognized as safe for human consumption and included in the list of food additives (FAO, 1991).

Biochemical, enzymic and hematological profiling of rats feeding gum kondagogu passed the subchronic toxicity test recommended by the joint expert committee on Food Additives (Janaki & Sashidhar, 2000). Compositionally gum is a heteropolysaccharide of glucose, mannose, galactose, arabinose and rhamnose along with glucuronic acid, galacturonic acid as major monomers (Vinod et al., 2008a). The physico-chemical characterizations reveal that gum kondagogu absorbs large amount of water, swell and produce gel of higher viscosity (Janaki & Sashidhar, 1998). Morphological and structural studies established the amorphous and irregular particle size structure of gum (Vinod et al., 2008b).

Gum kondagogu has been successfully tested as a gelling agent in plant tissue culture media for *in vitro* shooting and rooting in *Syzygium cuminii,* somatic embryogenesis in *Albizzia lebbeck* (Jain & Babbar, 2002) and direct shoot organogenesis of rough lemon (*Citrus jambhiri* Lush.) (Singh et al., 2013). Its various other roles in pharmaceutical industry include 1) Sustained release polyelectrolyte complex carrier for Diclofenac-sodium (non- steroidal anti-inflamatory drug) otherwise known to cause stomach ulceration (Naidu et al., 2009), 2) Mucoadhesive microcapsules for Glipizide (anti-diabetic) with improved absorption (Putta et al., 2010), 3) Gastro-retentive floating system for Metformin-hydrochloride (anti-hyperglycemic) for enhanced dosage efficacy (Lakshmi et al., 2010) and 4) Matrix material for colon targeted orally administered tablets for Metoprolol (antihypertensive) having enhanced bioavailability (Sarujana et al., 2011).

Girijan Co-operative Corporation (GCC), a state owned corporation having monopoly rights over gum collection and sale reported the annual production of more than one thousand quintals of this valuable product. Gums provide a valuable source of income in very poor countries rather than more developed countries and millions of people around the world make use of these products in their everyday life. Natural gums possess low cost, biodegradable, non-toxic and environmental friendly advantages over synthetic products (Robbins, 1988).

Gum kondagogu is the most recently studied gum for its scientific analysis. The present report is the first in drying studies of this gum. The stationary tray dryer is used because of its simple design, easy to install, operate and maintain as these parameters are suitable for low cost drying methods used in developing countries.

2. Material and Methods

2.1 Procurement of gum

Fresh gum kondagogu (Grade I, II, III) was purchased from Girijan Cooperative Corporation Ltd. Visakhapatnam, India and stored in airtight polypropylene jars and sealed till further use. Gum samples having particle size equivalent to US Sieve size-6 (Fig. 1) were used in the study.

Fig. 1: Gum kondagogu (Cochlospermum gossypium) grade-I (A), grade-II (B), grade-III (C)

2.2 Experimental

Gum kondagogu was dried on perforated trays in a cabinet dryer (*La Parmigana*, Italy) at 50, 60 and 70+ 1°C respectively. The cabinet dryer was consisted of an electric fan with double direction timed flow; heating unit with six electric resistances, each 1Kw, timer to switch off at the end of the drying cycle, digital thermostat and temperature control probe. The dryer was started about 1 h before each drying run to achieve steady-state conditions at respective drying temperatures. After the dryer reach internal consistency, 25 g of the gum samples were uniformly spread onto the perforated trays in a single layer. The moisture loss was recorded at 15 min intervals for initial 2 hours and at 30 min. interval afterwards till the weight of gum became constant. The initial weight was considered as the mass at zero drying time. The trays containing the sample were taken out, weighed and placed back at each interval in about 30 s to avoid any significant temperature variation in the dryer. The dryer was thermostatically controlled and air velocity was set at a constant speed. Gum samples of all the three grades used were without any treatment. All the experiments were repeated three times and the average value was used to analyze data.

2.3 Moisture analysis

Initial moisture content of gum samples were determined by oven drying to constant weight at 105°C as per AOAC (1984) standards, using thermostatically regulated universal oven and weighing balance (Shimadzu, model BL-220). The moisture content was calculated as:

% Moisture content (dry basis) = (amount of moisture loss / weight of dried sample)* 100 (1)

The final moisture content after hot air cabinet drying was taken as equilibrium moisture content for the calculation of drying ratio and further fitting of an appropriate model.

2.4 Modelling

The page's thin layer drying model was used to describe the drying behavior of gum. The equation used as:

$$M.R. = (m_t - m_e) / (m_o - m_e) = \exp(-k\, t^n) \qquad (2)$$

Where: *M.R.* is the moistur ratio,

m_t denotes moisture content at any given instant time t (% d.b.),

m_e represents the equilibrium moisture content (% d.b.),

m_o is the initial moisture content (% d.b.),

t is time in hours,

k is the coefficient called drying rate constant and

n is the dimensionless constant

2.5 Statistical Analysis

The drying data was statistically analyzed using Microsoft excel software.

3. Results and Discussion

Heated air drying progressed as a newer technique of drying due to its economic and hygienic value (Das et al., 2004). 37-71°C is recommended for drying, as too low drying temperature may elicit microbial growth during initial stages of drying, where as too high temperature may affect the quality of food material (Abano & Sam-Amoah, 2011). Therefore, temperature range of 50-70°C was considered in the experimental design for hot air drying of gum. The moisture content of the three grades of gum samples (Fig. 1) as a function of drying time for 50, 60 and 70°C drying air temperatures is shown in Fig. 2. All the drying curves showed an initial rapid drying period and a later slow drying period, which appeared as a common feature. The rate of moisture loss was higher at higher temperatures and the total drying time was reduced substantially with the increase in air temperature. The drying process enhanced with the increasing temperature, as the final moisture content resulting from the drying at higher temperature were less than that of drying at lower temperature. Of all the temperatures the initial drying rate was maximum at highest temperature (70°C) and minimum at lowest temperature (50°C). As drying time proceed the drying rate decreased continuously at all temperatures. However, for all the temperatures, drying rate was highest during initial period of drying i.e. for first 15 min. For grade-I gum, the initial moisture content of 27.38% (d.b.) was reduced to 10.72, 8.58, 5.07% (d.b.) at 50, 60, 70°C drying temperature respectively. For grade-II gum, the initial moisture content of 26.90% (d.b.) was reduced to 12.99, 11.21 and 7.66% (d.b.) by drying at 50, 60 and 70°C temperature respectively. For each drying temperature the respective time span for drying were 300, 480 and 420 min. for both grades-I and II gums. For grade-III gum, the initial moisture content of 22.10% (d.b.) was reduced to 9.64, 7.35 and 5.78% (d.b.) by drying at 50, 60 and 70°C temperature respectively and the time span for drying were of 270, 390 and 420 min.

The process optimization is necessary to minimize the energy consumption (Belghit et al., 2000). Various types of mathematical models ranging from theoretical models based on classical diffusion theory to the purely empirical models are in use to describe the drying behavior of food materials. The drying of foodstuffs in the falling rateperiod is a diffusion-controlled process and may be represented by Fick's second law of diffusion.

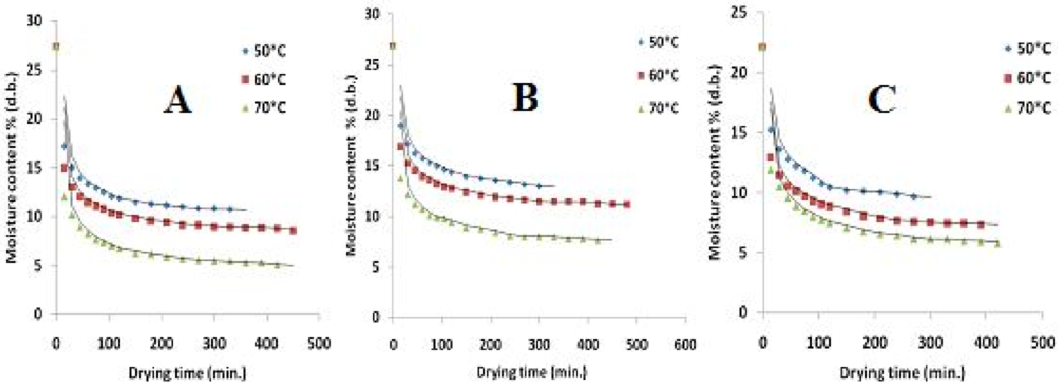

Figure 2: Drying curves for Gum kondagogu (Cochlospermum gossypium) grade-I (A), grade-II (B), grade-III (C) at temperature 50-70^{o}C in hot air cabinet dryer.

Table 1: Coefficients of equation (3) (Page's model) for hot air cabinet drying of Gum kondagogu.

Grade	Drying Temperature (^{o}C)	Drying rate constant (k)	Dimensionless number (n)	Coefficient of determination (R^2)
Grade-I	50	0.3216	1.758	0.984
	60	0.2301	2.327	0.994
	70	0.2099	2.289	0.991
Grade-II	50	0.3958	1.811	0.979
	60	0.3379	1.955	0.966
	70	0.2591	2.131	0.972
Grade-III	50	0.4669	2.224	0.985
	60	0.3689	1.807	0.972
	70	0.3429	2.015	0.983

The coefficients were determined and their values are given in Table 1. For different temperatures, drying rate constant (k) varied from 0.2099 to 0.4669 (h^{-1}), dimensionless number (n) varied from 1.758 to 2.327 and coefficient of determination (R^2) varied from 0.966 to 0.994. Because of drying process enhancement in terms of drying time and reduction in final moisture content the value of drying rate constant (k) appeared to be decreased with increase in drying temperature. For each particular temperature, Grade-III gum showed comparative more drying rate constant (n) values than grade-II gum, which in turn was more than grade-I gum. The value of dimensionless number (n) was more than 1. Page's equation adequately described the hot air drying of gum kondagogu over a range of drying air temperatures in the falling rate period.

4. Conclusion

Drying is necessity in developing countries like India where farmers are using traditionally evolved methods based upon natural sources like sun drying and wind drying, having major drawback of contamination. The application of drying technology on this locally available plant based biocompatible gum may boost its industrial use. The use of preservatives to prevent deterioration upon storage can be exempted by proper drying of gums. Total drying time considerably reduced with the increase in drying air temperature. Drying took place in the falling rate period and the Page's model was found to describe well the drying behavior of gum kondagogu. It would be economical to dry gum at 70^{o}C.

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