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Full Length Research Paper

Prediction of drying model and determination of effects of drying temperature on Mucilage and Vitamin-C contents of Fluted Jute (*Corchorus capsularis)* Leaves

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This study investigated the suitable drying model and the effects of different drying temperatures on the mucilage property of fluted jute leaves (*Corchorus capsularis* , . A cabinet dryer was employed to dry a well cleaned leaves in a thin layer, differently at air temperatures of 40, 50, 60 and 70 ℃ respectively. Five thin layer-drying models (Lewis, Page, Modified page, Henderson and Pabis, and Logarithmic) were fitted to the experimental moisture ratio data. The dried samples were analyzed for mucilage and vitamin C contents. Drying of *Corchorus* leaves prominently occurred in falling rate period. Among the mathematical models investigated, the Logarithmic model satisfactorily described the drying behaviour of *Corchorus* leaves with highest R^2 and lowest RMSE , MBE, and χ^2 at 40, 50, 60 and 70 ^{0}C respectively. Viscosity was at its highest at 70 ^{0}C and lowest values at 40 ℃ while Vitamin C was highest at 50 ^{0}C and lowest at 40 ℃. Based on the result of this study, drying temperature of 50 ℃ and Logarithmic model were recommended for drying of Corchorus for better retention of vitamin C, though 70 ^{0}C retained higher quantity of mucilage, but not significantly different to that of 50 ^{0}C.

Key words: Fluted jute leaves, mucilage, Vitamin C, modelling, drying.

INTRODUCTION

Green leafy vegetables constitute an indispensable constituent of human diet. In Africa, they are consumed as cooked complements to the major staples, like cassava, cocoyam, guinea corn, maize, millet, rice and plantains. Many of these leaf vegetables are common in all parts of Nigeria, but some are restricted in their natural distribution because of climatic factors.

Corchorus spp. is a member of the family Tilaceae, common names include: Long fluted jute, Jew's marrow, African Sorrel, Bush Okra. Local names include: 'ewedu', 'lalo', 'krin krin'. Two main types are common, one with finely serrate leaves, called ' Amugbadu' and the other is shorter with coarsely serrated short leaves called Oniyanya' Oniyanya' (Oguntona, 1998). It is cultivated as a vegetable and has the advantage of tolerance to many soil conditions. Among any communities, the leaves are valued as a cooked vegetable because of its high proportion of mucilage.

The renewed interest in non-orthodox medicine in the World has dramatically increased the demand for plant-based medicine in global market (Natesh 2000).

According to Chen and Saad (1981), Corchorus species contain important bioactive compounds such as cardiac glycosides, stropanthidin, b-sitosterol, terpenoid-corosin, flavone glycoside, urasolic acid, vitamin C, b-carotene, mucilage, and others which are potential ingredients for developing plant-based drugs. The leaves are rich in protein, b-carotene, iron, calcium, vitamin B, and vitamin C. They also contain oxydase and chlorogenic acid. According to Awogbemi and Ogunleye (2009), the folic acid content is substantially higher than that of other folacin-rich vegetables.

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Table 1.Results for Vitamin C and Viscosity Contents of Dried *Corchorus* leaves.

Treatment ℃	Vitamin C (mg/100g)	Viscosity (Pascal/ses)
40	359.4[d]	2.692
50	1078.75[a]	2.693
60	890.03[b]	2.694
70	531.25[c]	2.969

Values are means of three replicates; values in a column denoted by different letters differ significantly at p <0.05.

Drying is one of the oldest methods known for the preservation of agricultural products such as fruits and vegetables, and is the most common in food engineering unit operations. Drying of agricultural products enhances their storage life, minimizes losses during storage, and save shipping and transportation costs (Doymaz 2005). According to Gogus (1994) and Sokhansanj and Jayas (2006), when carried out correctly, the nutritional quality, colour, flavour and texture of rehydrated foods are slightly less than fresh foods. However, if drying is carried out incorrectly there is a greater loss of nutritional and eating qualities and possibly even food poisoning.

Drying kinetics of food is a complex phenomenon and requires dependable models to predict drying behaviour (Akpınar and Bicer, 2003). There are several studies describing the drying behaviour of various fruits, vegetables and medicinal plants such as onions (Singh and Sodhi, 2000), garlic cloves (Sharma and Prasad 2001), black tea (Panchariya *et al*., 2002), grapes (El-Ghetany. 2006), apple (Kaya *et al*., 2007), Mint leaves, (Kadam *et.al* 2011b), tomato slices (Abano *et al.,* 2011) and other various vegetables (Awogbemi and Ogunleye, 2009)

The objectives of this study therefore are to investigate the effect of drying temperatures on the viscosity of *Corchorus capsularis* and to predict the mathematical drying models, at four different temperatures, that best describe the drying phenomenon of 'ewedu'.

MATERIALS AND METHODS

Materials

A cabinet dryer was used. Other materials used include a Digital Weighing balance (accuracy of ± 0.01g), and a bowl.

Methods

Drying Experiment

The *Corchorus* leaves used for this experiment were all sourced from a farm located at Alaba Layout, South Gate of the Federal University of Technology, Akure. The leaves were separated from the stem and placed in a stainless steel tray. Fifty (50) grams of the leaves were spread in thin layer inside a cabinet dryer. Drying was performed at four different temperatures, 40 ºC, 50 ºC, 60 ºC and 70 ºC. Drying continued until two successive constant weights were obtained.

Modeling of drying curves

For this study, five (5) mathematical models were reported to predict drying conditions; other models showed a very wide variation. These models and their equations are Lewis,. Henderson and Pabis, Page, Modified Page and Logarithmic. Sigma plot Software (Windows Version, 10.0, Synstat Software Inc) was used for the modeling of equations, and the generation of the R^2 Values. Windows Excel (Microsoft Office Suite, Microsoft Inc.) was used in the Calculation of the Root Mean square error (RMSE), Mean Bias error (MBE) and χ^2 values and plotting of the drying curves and the model validation curves for each temperature.

Vitamin C and Viscosity Determination

Both Vitamin C (Ascorbic acid) and Viscosity (mucilage) were carried out using a method described by AOAC (1990).

RESULTS AND DISCUSSION

Effect of Drying Temperature on Viscosity and Vitamin C of *Corchorus*

The result in Table (1) showed the effect of drying temperature on the vitamin C content and the viscosity of the leaves. The sample dried at 50 ℃ has the highest value of 1078 mg/100 g, while the sample dried at 40 ℃ had the lowest value at 359 mg/100 g. According to (Ihenkoronye and Ngoddy 1985), vitamin C is heat labile; the low value may be due to the elongated drying period as compared to other samples. This result also agreed with the one reported by Famurewa (2011), when effect

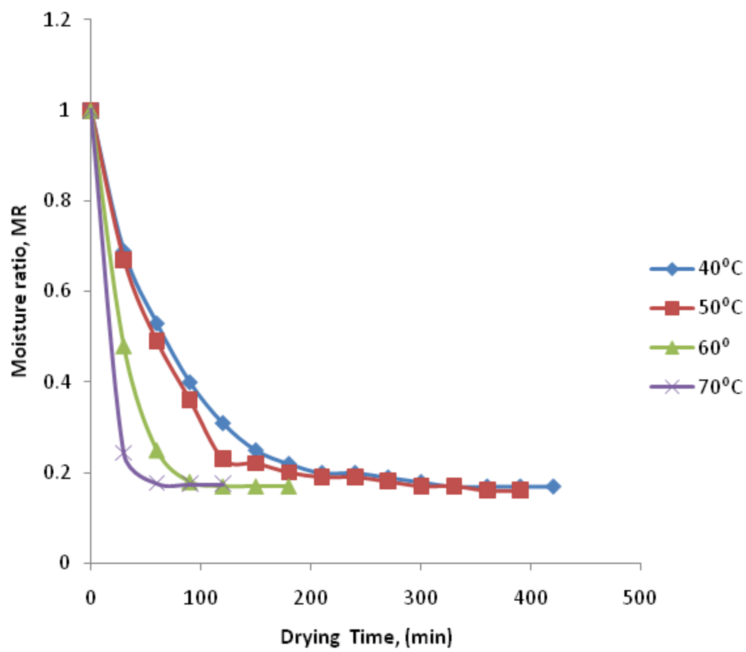

Figure 1. Drying Curves of ***Corchorus*** at different temperatures.

Table 2. Values of Model constants for *Corchorus* dried at 70℃.

Model	Model Constants	R^2	RMSE	MBE	χ2
Lewis	b=0.0344	0.8906	0.107177	-0.04486	0.014359
Page	n=0.1592, b=0.8468	0.9988	0.107177	-0.04486	0.074767
Modified Page	n=0.1592, b=0.3519	0.9988	0.107176611	-0.04486	0.01914471
Henderson and Pabis	a=0.9725, b=0.0332	0.8920	0.107176611	-0.04486	0.01914471
Logarithmic	c=0.1737, a=0.8263, b=0.0828	1.0000	0.107176611	-0.04486	0.028717065

of drying on *worowo* (*Senecio biafrae*) was investigated. For the Viscosity, the sample dried at 70 ℃ had the highest value, while the sample dried at 40 ℃ s still had the lowest values.

Observed Drying Rate during Drying of *Corchorus* leaves

The drying times needed to reach equilibrium moisture content were 420, 390, 160, and 120 min respectively for 40℃, 50℃, 60℃ and 70℃. The results showed that as the temperature was increasing successively by a difference of 10 ℃, drying time was also decreasing. The drying curves showed that the constant rate period was absent; and drying took place in the falling rate period and the moisture loss was faster at the beginning than towards the end of the drying period (Figure 1). These observations are in good agreement with the reports of Sharma and Prassad (2001), Demir *et al*., (2004) and Premi *et al.,* (2010).

Mathematical Models for Fitting of the Drying Curves

Moisture ratio drying data for *Corchorus* were fitted into five mathematical models (Lewis, Page, Modified page, Henderson and Pabis, and Logarithmic). The co-efficient of correlation and statistical analyses for the samples are listed in Tables 2, 3, 4, and 5. In all the models, R^2 values were greater than 0.90 except the Henderson and Pabis model indicating, the fitness of the models in predicting the data and drying behaviour. Results show that the highest value for R^2, and lowest value for χ^2, MBE and RMSE were obtained using the Logarithmic Model. This model can therefore be considered as to represent the drying behaviour of *Corchorus* leaf The results obtained are similar to those reported by Kadam *et al.,* (2011a) for

Table 3. Values of Model constants for *Corchorus* leaf dried at 60℃.

Model	Model Constants	R^2	RMSE	MBE	χ2
Lewis	b=0.0192	0.9163	0.082938	-0.0254	0.008025
Page	n=0.5178, b=0.1442	0.9821	0.038389	-0.00226	0.002063
Modified Page	n=0.5178, b=0.0237	0.9821	0.038389	-0.00226	0.002063
Henderson and Pabis	a=0.9516, b=0.0181	0.9204	0.038389	-0.00226	0.009158904
Logarithmic	c=0.1565, a=0.8470, b=0.0340	0.9981	0.012446285	1.42857E-05	0.000271093

Table 4. Values of Model constants for *Corchorus* leaf dried at 50℃.

Model	Model Constants	R^2	RMSE	MBE	χ2
Lewis	b= 0.0092	0.8628	0.088378	0.02447	0.102258
Page	n= 0.5712, b= 0.0739	0.9672	0.043194	-0.00409	0.110779
Modified Page	n= 0.5712, b= 0.0105	0.9672	0.043194	-0.00409	0.110779
Henderson and Pabis	a= 0.8862, b= 0.0079	0.8836	0.081406463	-0.024021429	0.110779025
Logarithmic	c= 0.1620, a= 0.8423, b= 0.0168	0.9963	0.014506624	-3.96508E-18	0.120849845

Table 5. Values of Model constants for *Corchorus* leaf dried at 40℃.

Model	Model Constants	R^2	RMSE	MBE	χ2
Lewis	b= 0.0080	0.8712	0.083912	-0.01865	0.007544
Page	n= 0.5872, b= 0.0627	0.9763	0.036	-0.00355	0.008124
Modified Page	n= 0.5872, b= 0.0089	0.9763	0.036	-0.00355	0.008124
Henderson and Pabis	a= 0.8766, b= 0.0067	0.8977	0.074780465	-0.01938	0.008124497
Logarithmic	c= 0.1664, a= 0.8307, b= 0.0145	0.9989	0.007607146	6.66667E-06	0.008801538

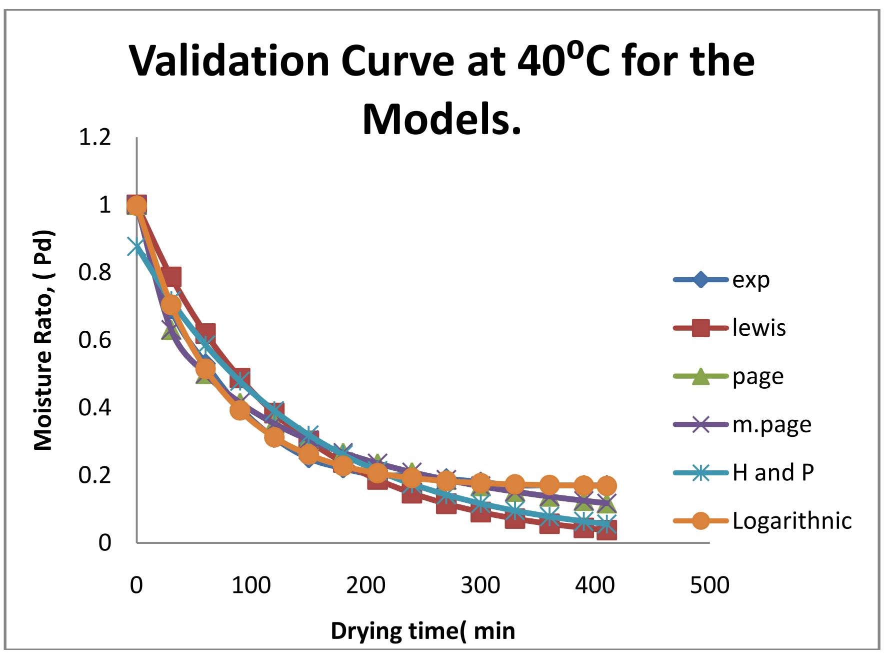

Figure 2. Validation Curve for various models at 40℃.

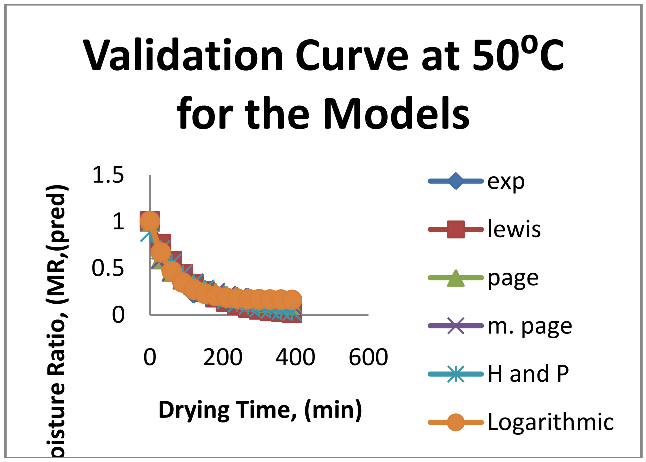

Figure 3. Validation Curve for various models at 50℃.

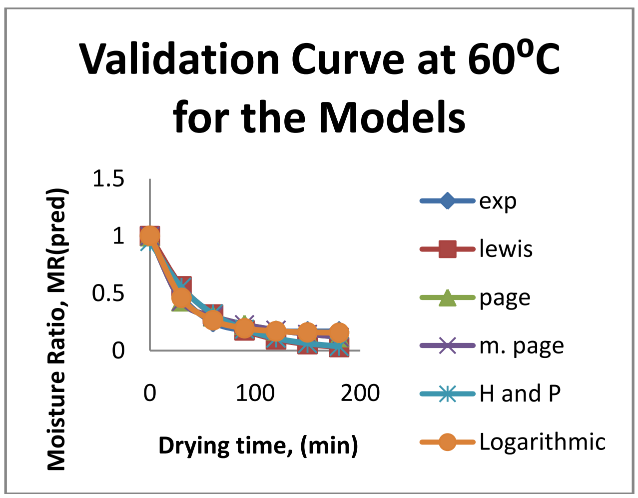

Figure 4. Validation Curve for various models at 60℃.

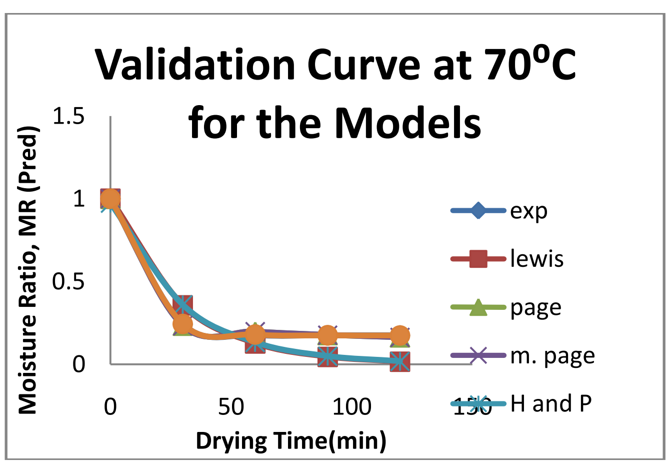

Figure 5. Validation Curve for various models at 70℃.

basil leaves, Kadam *et a*l., (2011b) for mint leaves, Togrul and Pehlivan, (2002) for apricots; Erenturk *et al*., (2004) for rosehip and Goyal *et al*.,(2007) for plum. The mathematical models were subjected to validation, by plotting both the experimented and predicted Moisture ratio values against the drying time. (Figures 2-5). The Figures showed that Logarithmic Model established by mathematical model gave the best fit between experimental and predicted moisture ratios for the four levels of drying temperatures.

CONCLUSION

Corchorus leaves were dried at 40, 50, 60 and 70°C temperature, the drying rate decreased continuously throughout the drying period. Constant rate period was absent and the drying process of the leaves took place in falling rate period. Drying time decreased considerably with increased temperature. Logarithmic model was the best among the selected models for describing the drying behaviour of *Corchorus* leaves. The sample dried at 50 ℃ showed the highest retention of vitamin C, while the sample dried at 70 ℃ showed the highest retention of viscosity though not significant to that at 50 ^{0}C.

It can then be concluded from the results of this study that Logarithmic model is the most suitable to describe the drying phenomenon of *Corchorus* leaves and 50 ^{0}C is the best drying temperature to retain its vitamin C and mucilage contents.

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