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DRYING CHARACTERISTICS AND REHYDRATION QUALITY OF SOLAR DRIED POINTED GOURD (*TRICHOSATHES DIOICA ROXB.*)

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Abstract: Pointed Gourd (*Trichosathes dioica Roxb.*) is an important summer season vegetable crop of India. Fresh pointed gourd has a very short shelf-life of 3-4 days. Lack of suitable technology for enhancing shelf life and processing leads to huge post harvest losses. Solar drying of pointed guard samples were carried out after blanching in water at 100˚C for 4 min. and qualitative changes of the dried product were observed. Blanching pre-treatments was done in plain water for 4 min. (S_1) and 0.5% potassium metabisuphite (S_2). Sample without blanching was considered as control (S_c). The samples were then dried in the solar cabinet dryer (54 ±5˚C). Six thin layer drying models have been used to fit the experimental moisture ratio obtained for pointed gourd by nonlinear regression analysis using NLREG Statistical program. According to the results, Page model shows a good fit with the highest correlation for the samples. Solar cabinet dried product were found good and acceptable in sensory quality, pointed gourd blanched in KMS solution was the best followed by blanched in water. The rehydration ratio (4.75) and coefficient of rehydration (0.476) were the highest in pointed gourd blanched with KMS solution among all the samples. The result showed that the rehydrated products could be well utilized for substituting the fresh product in off-season.
Keywords*:* Pointed gourd, Blanching, Solar Dehydration, Rehydration, Shelf-life, Sensory quality.

Introduction

Pointed gourd (*Trichosanthes dioica* Roxb.) is a chief vegetable grown during the summer and rainy season all over India, Myanmar, Sri Lanka and Bangladesh. Fruits of pointed gourd plant are used as vegetable in Indian traditional food system for time immemorial. It is cooked in various ways either alone or in combination with other vegetables or meats. It is referred to 'King of gourds' because of its higher nutrient content [1]. Pointed gourd is emerging as a very potential crop for its nutritional & medicinal importance. Bulk packaging of fresh pointed gourd in gunny bag followed by moistening with water and un-favourable storage conditions of high temperature and low relative humidity tend to rapid shriveling, skin and core yellowing of fruit, development of hard seeds and fungal infestation. Fruit surface wrinkling is more prominent in pointed gourd even with a low water loss (7-8%) from its fresh weight [2]. Under ordinary storage conditions, pointed gourd has a very short

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shelf-life of 3-4 days. To improve the appearance and shelf-life of fruit, traders and retailers often use unsafe chemicals and treat them with $CuSO_4$ and malachite green solution to mask yellow color [3]. Carnauba wax emulsion (1:10) [4] has been recommended by previous researchers to enhance the shelf life only for four days.

Drying is one of the preservation technique used to prolong shelf-life of the food crop and make it available throughout the year [5]. Natural sun drying is the traditional method used in most of the tropical and subtropical countries [6]. But the quality of the food crop dried is found to be poor due to contamination by dust, birds, rodents and insects [7],[8]. A simple solar cabinet drier which use sun as source of energy can solve the problem of the farmers at village level for drying crops. Solar driers are pollutant-free and eco-friendly and economical. In order to accelerate the preservation time and to reduce the wastage through bacterial action, the products are dried using different types of solar dryers [9], [10], [11], [12]. Several studies have been reported on drying behaviour of various vegetables such as tomato [13], onion [14], cabbage [11], cauliflower [15] and okra [12]. Here, in this study a solar cabinet drier was utilized to dry the pointed gourd in thin layers and drying kinetics were studied. Blanching is applied to control the enzyme activity and browning in vegetables. Cauliflower blanched with 0.75% potassium mata-bisulphite (KMS) and dehydrated at 70˚C were found the best in quality and storability [16]. A study on hot water blanching of cabbage for 2 min in 0.5% KMS before solar drying resulted in good quality dried product [11]. The investigation was conducted to evaluate the effect of blanching on the quality of dehydrated pointed gourd slices dried in the solar cabinet dryer and evaluating different models for suitability to fit in the experimental data.

Materials and methods

Preparation of Samples: Fresh tender fruits of pointed gourd were procured from local vegetable market and its initial moisture content was measured using standard oven drying method. The pointed gourd fruits were washed in running water and blanched in boiling water at 100˚C for 4 min. The blanched samples were immediately cooled by immersing in cold water and spread on a stainless steel sieves to drain excess water. Blanched pointed gourd samples (S_1) weighing 500g each were prepared after removing ends of the blanched fruits, whereas, samples (S_2) were prepared by blanching pointed gourd in a solution of boiling water and 0.5 % potassium meta bisulphate (KMS) for 4 min. and cutting ends. Sample of raw pointed gourd (S_c) was taken as control. The size of the cut pointed gourd pieces used for drying were approximately 3.5 – 4.0 cm.

Solar Cabinet Drying: Drying of pointed gourd samples was carried out by using a solar cabinet dryer having two trays of 10-12 kg capacity each. The pointed gourd samples were spread uniformly on the drying trays and then the trays were inserted into the solar cabinet dryer and subjected to solar drying for a period of 7 h from 10.00 A.M. till 5PM. The temperature and relative humidity of ambient air as well as drying air (inside solar cabinet drier) was measured hourly. The weight loss per hour of samples was also recorded. All the data were recorded in triplicate. At the end of the day the samples were taken out of the dryer, wrapped in plastic sheet and kept at a dry place in the laboratory. The moisture loss was recorded till the samples attained constant weight. The overall quality of all the three dehydrated samples (S_1, S_2, S_c) was evaluated on the basis of their sensory quality, rehydration and nutritive value.

Drying Kinetics: Thin layer drying model is generally used to understand the drying characteristics of agricultural products. The moisture ratio (MR) is defined as follows:

$$MR = \frac{M - M_e}{M_0 - M_e} \quad (1)$$

where, M, M_0 and Me are moisture content at any time, initial moisture content and equilibrium moisture content, respectively. But Me is found to be negligible. So, the moisture ratio is simplified as follows [11], [17]. :

$$MR = \frac{M}{M_0} \quad (2)$$

Thin layer drying models used in the analysis of drying characteristics are usually theoretical, semi-theoretical or purely empirical. Some semi-theoretical drying models which have been widely used for high moisture content crops such as vegetables like pointed gourd are presented in form of Eqs. (3)–(8) [11],[13], [14], [17], [18].

Newton	$MR = \exp(-kt)$	(3)
Page	$MR = \exp(-kt^n)$	(4)
Henderson & Pabis	$MR = a \exp(-kt)$	(5)
Logarithmic	$MR = a \exp(-kt) + c$	(6)
Two term exponential	$MR = a e^{-kt} + (1-a) e^{-kat}$	(7)
Wang & Singh	$MR = 1 + at + bt^2$	(8)

Where t is the drying time and k, n, a, b and c are drying constants. The experimental moisture ratio (MR) obtained using Equation (2) is fitted to these six mathematical models.

The coefficients and the constants of the model are predicted by non-linear regression analysis using statistical program NLREG 4.1 Version. The correlation coefficient (R^2) was one of the primary criteria to select the best equation to account for variation in the drying curves of dried pointed gourd samples. The model that has highest correlation coefficient (R^2), is considered as the most relevant model for drying pointed gourd samples.

Quality Parameters: The quality of the solar dehydrated pointed gourd samples as affected by different blanching pretreatments was evaluated based on their sensory, nutritional, and rehydration characteristics described as follows:

Sensory Evaluation: Sensory evaluation was performed using Hedonic rating test of 9-point scale [11] ranging from 9 = like extremely to 1=dislike extremely with 10 panel members.

Nutritional Quality Evaluation: Ascorbic acid in fresh and dehydrated pointed gourd samples were determined by using 2,6 dichlorophenol indophenol dye by volumetric method.

Rehydration Characteristics: Rehydration quality characteristics of dehydrated pointed gourd samples were determined by rehydration test as described by [11], [15]. The dehydrated samples of 10 g each were placed with 200 ml distilled water in glass beakers and brought to boil on an electric heater. The boiling was continued for another 10 minutes. The excess water was drained off through filter paper (whatman No. 4). The drained samples were weighed Rehydration ratio (R_r), coefficient of rehydration (C_r) and moisture content (M_c) in the rehydrated samples were computed using following equations as described by [15]

$$R_r = \frac{C}{D} \tag{9}$$

$$Cr = \frac{C(100-A)}{(D-\frac{BD}{100})\times 100} \tag{10}$$

and

$$Mc,\%wb = \left[\frac{C-(\frac{D-BD}{100})}{C}\right]\times 100 \tag{11}$$

Where, A = Moisture content of samples before dehydration, (% wb)
B = Moisture content of dehydrated sample, (% wb)
C = Drained weight of rehydrated sample, g
D = Weight of dehydrated samples taken for rehydration test, g

Results and discussion

Solar cabinet drying characteristics of pointed gourd: Initial moisture content of raw pointed guard was 86.5% (w.b.). The ambient air temperature varied from 40°C to

47.0˚C during solar cabinet drying of the pointed gourd samples and the temperature of the drying air inside the dryer ranged from 57.0˚C to 65˚C. The relative humidity of the drying air inside the solar cabinet dryer was found in the range of 28 to 55%. It is obvious that solar cabinet drying rate is affected by temperature as well as relative humidity. Blanching and KMS treatment also affected solar drying of pointed gourd samples. The moisture ratio obtained through the experiment is applied to six different mathematical models. Using NLREG statistical program the model constants and the regression constants, and coefficient of determination (R^2) for these six models are given in Table 1. From the table, it is obvious that the Page models have the highest (R^2) and therefore represents the drying characteristics of pointed gourd better than the other models used.

Drying curves showing variation in moisture ratio with drying time for experimental data and the best fit Page model is plotted from Fig.1 , for raw/untreated (S_c), blanched (S_1) and KMS treated (S_2) pointed gourd samples. As it is clear from Fig.1, that KMS treated (S_2), blanched (S_1) and untreated (S_c) pointed gourd samples required 20 h (3 days), 21 h (3 days) and 27 h (4 days) to reach constant moisture ratios, respectively. The final moisture content was found to be 4.249%, 4.06% and 5.10% (w.b.) for KMS treated (S_2), blanched (S_1) and untreated (S_c) dried pointed gourd samples, respectively. The observed and predicted values of moisture ratio calculated by Page model showed a straight line for raw, blanched and KMS treated samples of pointed gourd. For cabbage slices it had been also reported that Page model is the most suitable model to illustrate the drying kinetics [11].

Effect of Blanching Pretreatment on Quality: Sensory quality evaluation of solar dehydrated pointed gourd as influenced by pretreatments is shown in Table 2. Mean scores for overall acceptability (OA) of 6.0, 7.0 and 7.5 were obtained for dehydrated raw (S_c), blanched (S_1) and 0.5% KMS treated (S_2) samples, respectively. Analysis of variance (ANOVA) to see the effect of pretreatments on quality attributes indicated the significant effect at 1% level for colour and appearance, whereas it was found significant at 5% level for overall acceptability (OA). The samples of pointed gourd blanched in KMS solution (S_2) were the best followed by blanched (S_1) and untreated raw samples (S_c). [11] ,[16] and [17] also found that KMS treatment before drying produced the best results. Untreated pointed gourd samples were liked least, as indicated by the mean scores in Table 2.

Reconstitution Quality: The reconstitution quality of dehydrated pointed gourd samples is shown in (Table 3). Rehydration ratio (RR) and coefficient of rehydration (C_r) was highest in pointed gourd samples with pre-treatment (S_2) followed by treatment (S_1) and untreated (S_c)

samples. The rehydration ratio (RR) was found as 3.50, 4.02 and 4.75 for raw (S_c), blanched (S_1) and KMS treated (S_2) samples. However, reconstitution quality of all pointed gourd samples was reasonably good. The moisture contents of all the rehydrated samples were above 74% (wb) which depict that the rehydrated product could be very well utilized for substituting the fresh product in off season. These findings are in conformity with those of [11], [15].

Ascorbic acid: Ascorbic acid contents of dehydrated pointed gourd samples are tabulated in Table 3. As much as 29 mg/100g of ascorbic acid was found in fresh pointed gourd while it reduced to 12.8, 13.5, and 16.6 mg/100g in the dried (S_2), (S_1) and (S_c) products, respectively. The results are in conformity with the findings of [11] where a major loss of ascorbic acid was observed after dehydration of banana and cabbage. The Vitamin C (ascorbic acid) being heat liable was reduced drastically during drying of different pointed gourd samples. The poor retention of ascorbic acid in dehydrated vegetables might be due to thermal or oxidative changes in the vitamins.

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Table 1: Thin layer drying model values fitted for different pointed gourd samples

Model	Sample Type	Constant(s)	Correlation Coefficient (R^2)
Newton	Raw	k = 0.04531	0.798
	Blanched	k = 0.03982	0.664
	KMS treated	k = 0.05262	0.720
Page	Raw	k = 0.000674 n = 2.4914	0.993
	Blanched	k = 0.000161 n = 3.884	0.993
	KMS treated	k = 0.000176 n = 3.1873	0.978
Henderson & Pabis	Raw	k = 1.3017 a = 0.0760	0.785
	Blanched	k = 0.0579 a = 1.2567	0.761
	KMS treated	k = 0.07323 a = 1.26714	0.806
Logarithmic	Raw	k = 1.1318×10^{-5} a = 3524.89 c = -3523.74	0.961
	Blanched	k = 0.5479×10^{-5} a = 8546.66 c = -8545.45	0.875
	KMS treated	k = 0.57248×10^{-5} a = 9306.19 c = -9305.00	0.919
Two term exponential	Raw	k = 0.0934 a = 2.3066	0.962
	Blanched	k = 0.09568 a = 2.3560	0.877
	KMS treated	k = 0.11368 a = 2.3221	0.898
Wang & Singh	Raw	a = -0.01561 b = -0.000785	0.955
	Blanched	a = 0.011224 b = -0.00267	0.984
	KMS treated	a = -0.00245 b = -0.002398	0.970

Table 2. Sensory quality of solar dehydrated pointed gourd as influenced by pretreatments

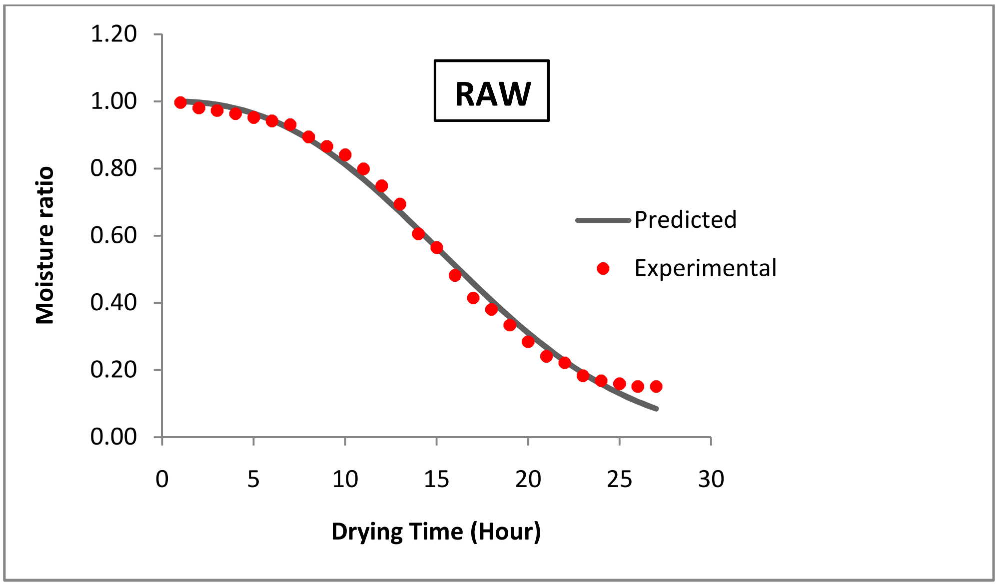
Quality attributes	Treatments		
	Untreated (U_T)	Blanched (T_1)	0.5% KMS treated (T_2)
Colour	5.8±0.12	6.7±0.25	7.6±0.52
Appearance	4.6±0.24	5.2±0.16	7.2±0.29
Overall acceptability(OA)	6.0±0.41	7.0±0.23	7.5±0.45

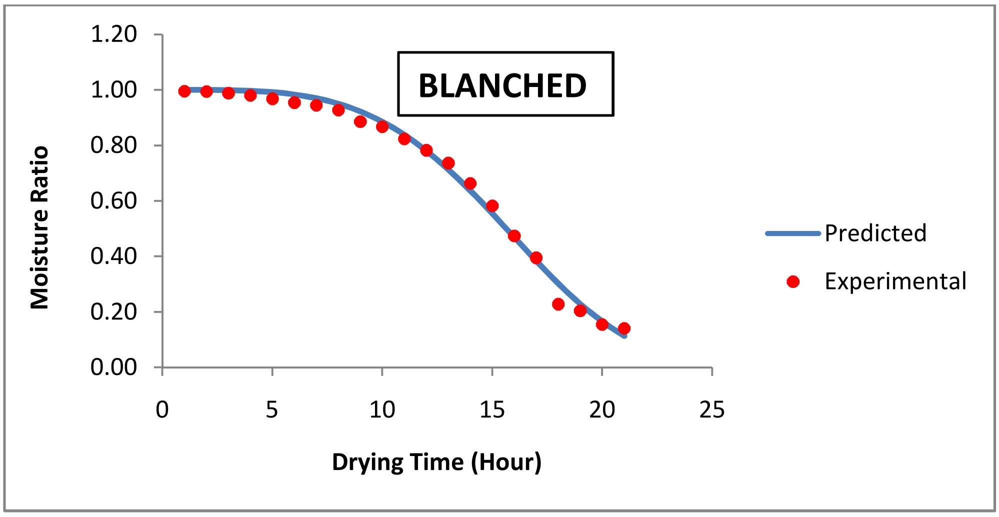
n = 3 replications and 10 panelists

CD(1%)	Colour	Appearance	OA
Treatment	0.61101	0.8344	1.3019
CV (%)	3.0212	4.8863	6.1139

Table 3: Reconstitution qualities and ascorbic acid content of dried pointed gourd

Sl No.	Quality attributes	Treatments		
		Untreated (S_c)	Blanched (S_1)	0.5% KMS treated (S_2)
1	Rehydration ratio (Rr)	3.50	4.02	4.75
3	Coefficient of Rehydration (Cr)	0.365	0.409	0.475
4	Moisture in rehydrated samples (%)	75.0	76.5	78.8
5	Ascorbic acid (mg/100g)	16.6	13.5	12.8





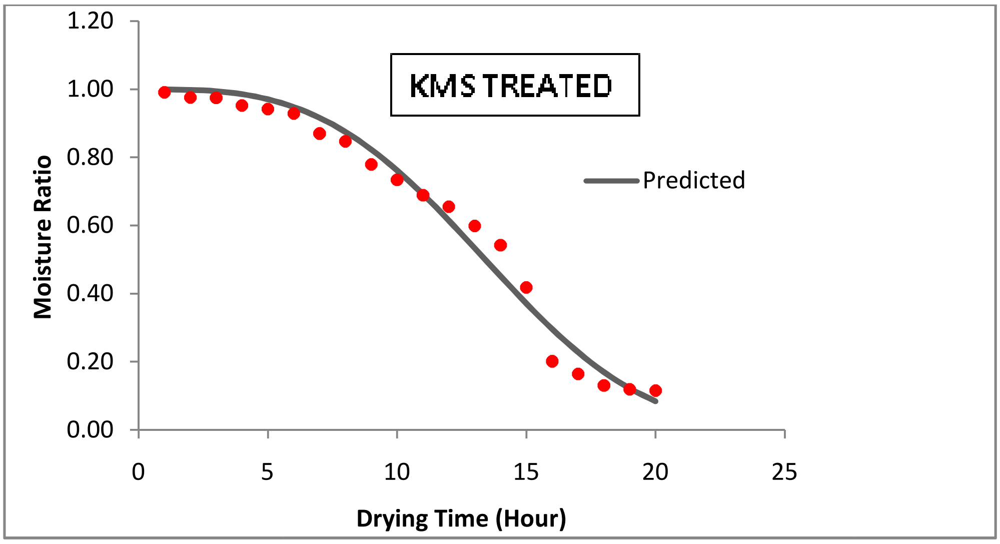


Fig. 1 Variation of experimental values of moisture ratio and those estimated using Page model for raw, blanched and KMS treated pointed gourd with drying time