Effect of pretreatments on drying attributes and quality assessment of bael powder

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Abstract Drying is an important method in long term storage of agricultural products. Present experiment was performed to determine the effect of different pretreatment such as steam blanched, 1% sugar and 1% sodium benzoate in bael pulp along with untreated using hot air dryer at 50 to 70°C temperature during drying. Falling rate period was observed. The dehydration characteristic became analyzed through mathematically fitting the drying results which were obtained by experiments to Newton, Page and Two-term drying models. R^2, chi-square and root mean square error of moisture ratios were estimated to determine the best fit model. Result showed that Two term model is best to describe the dehydration characteristics of bael pulp. The bael powder was analyzed for its quality characteristics in respect of phenols, ascorbic acid, antioxidant, carotenoid and sensory test before packaging and during storage. The sample dried at 60°C pretreated with 1% KMS was showed best results.

Keywords* - *Antioxidant, ascorbic acid, carotenoid, drying, hot air dryer, models, phenol

I. INTRODUCTION

Bael (*Aegle marmelos*) is a native fruit of India which is belongs to family Rutaceae[1]. It is very important due to its medicinal value. Bael fruit consist of many useful compounds i.e. phenolics, alkaloids, carotenoids, flavonoids, coumarins, pectins, tannins and terpenoids [2], [3]. It is one of the nature's wealthy source of antioxidants and is very useful for health. It also has amazing aroma. As bael is a seasonal fruit and is not available throughout the year. So preservation can be used to reduce post harvest losses and retain of nutrition. Drying is one of the most common methods for preservation of bael fruit pulp for longer time. The dried products have very long shelf-life at ambient temperature. Drying can be described as the employment of heat under managed conditions to eliminate the maximum amount of water usually present in a food with the aid of evaporation. In drying heat penetrates into the product and moisture is eliminated by evaporation. Among different types of drying tray drying is the most cost effective method.

However excessive moisture content of bael can result rapid deterioration after cropping. Hence, the dehydration is used to enhance the stability of fruits by means of reducing the water activity to decrease physical and chemical reactions which could arise during storage. However thermal treatments result degradation reaction and are believed to cause destruction of natural antioxidants in food [4],[5],[6].Two important variables to be controlled are temperature of treatment and its duration[7]. There is also economic importance of dehydrated bael powder which used in formulated drinks, baby foods and other products. Very limited works have been done on bael powder. The objective of this study is to investigate effect of temperature and pretreatment on quality of bael powder.

II. MATERIALS AND METHODS

Mature fruits were bought from local market then fruits were washed under running water and scooped out the pulp after removing its hard shell. After removal of seeds1st part of pulp (200 g) dried without any pretreatment used as control. 2nd part (200 g) steam blanched for 5 min, 1% sugar added in 3rd part (200g) and 1% KMS added with 200 g pulp (4 th part). Samples were dried at 50^0C, 60^0C and 70^0C. Moisture removal was analyzed after every 30 mins interval until the equilibrium moisture reached.After drying samples were grounded in mixer grinder to produce bael powder and packed in polyethylene packet and stored for further studies.

A. Analytical parameters

The % moisture content of different substrates was measured on the basis of initial weight of the samples [8]. The loss in weight was reported as moisture %.

$$\% \text{ moisture (d.b)} = \frac{\text{moisture content (w.b)}}{100 - \text{w.b}} \times 100$$

Total phenolic content of bael pulp was determined by folin-ciocalteu method [9] at a wavelength of 765 nm using gallic acid standard and expressed as mg of gallic acid/g of fruit. Ascorbic acid of bael pulp was determined by titrimetric method [8].

Antioxidant content was determined by FRAP method and the value expressed as mM $FeSO_4$ /g fruit [10].

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Total carotenoids of bael pulp had been measured in step with the method of Talcott and Howard (1999) [11].

Descriptive sensory evaluation became done to decide the impact of drying on the sensory quality of bael powder. A 10-untrained member of sensory panel [12] was used for evaluation. The characteristics considered were colour, taste, aroma and overall acceptability (OA).

B. Mathematical modeling of moisture removal

The reduction of moisture ratio with drying time was used to analyze the experimental drying data. The moisture ratio (MR) was calculated [13] as follows:

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

Where MR= Moisture Ratio, M_t= Moisture content in time t (% db), M_e=Equilibrium moisture content (% db), M_i=Initial moisture content (% db)

To describe drying behaviour of pretreated bael three different established thin layer drying were used [14], [15], [16]:

Newton model: MR= exp(-kt)
Page model: MR= exp($-kt^n$)
Two term model : MR= a exp(-kt)+ b exp (-gt)

Chi-square value (χ^2) [17]:

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

Root mean square error [18]:

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

Where: MR_{exp} = Experimental moisture ratio, MR_{pred} = Predicted moisture ratio, N = Number of observations, z = Number of constants

III. RESULTS AND DISCUSSION

The initial moisture content of bael pulp was 66% (w.b). The experiments were performed at temperature ranging from 50-70º C until final moisture reached. In the initial stage of drying the decrease of moisture content was high due to the presence of high moisture. The amount of moisture reduction decreases with increasing time. These results were very similar with previous research work [16]. Results showed in fig 1-3 that drying time reduced with increasing temperature for all samples may be the result of increasing vapour pressure within the samples with increasing temperature. As a result of it moisture removed quickly from samples. The graph shows falling rate period.

Moisture ratio reduced constantly with drying process. Diffusion which has governed the inner mass transfer might be the reason of continuous decrease in moisture ratio. Decrease of moisture ratio was faster with increasing temperature[16]. Results showed that pretreatment have positive effect on moisture ratio.

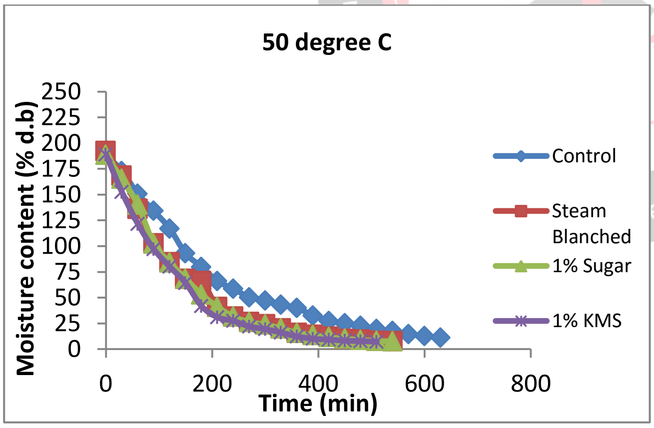

Fig.1

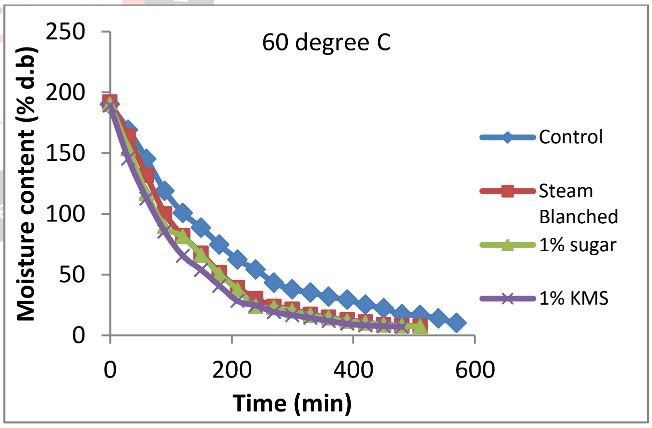

Fig.2

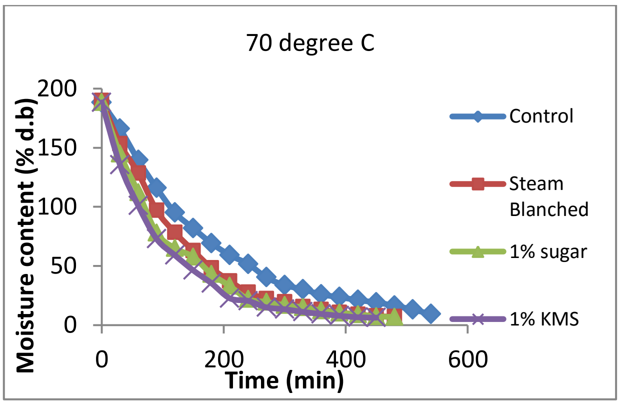

Fig.3 **Moisture content against drying time curve of untreated and pretreated bael pulp dried at (Fig 1) 50, (Fig 2) 60 and (Fig 3) 70 °C**

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In this experiment the most acceptable model was shown by statistical analysis (SPSS) among three drying models suggested by previous researchers[16], [19]. RMSE, chi-square values and R^2 values were given in table 1. Depending on lowest RMSE, chi-square value and highest R^2 value the suitable kinetic model was selected. All three models shown high R^2 value (0.984-0.999) which indicate drying characteristics of bael pulp could satisfactorily describe by these models. Among all models the Two term model shows the highest R^2 (0.999-0.996), lowest RMSE (0.009-0.0188) and χ^2 (0.00008-0.00039).

Table 1 Statistical results of three thin-layer drying models

Temperature	Sample	Model								
		Newton model			Page model			Two term model		
		R^2	Chi-square (χ^2)	RMSE	R^2	chi-square (χ^2)	RMSE	R^2	chi-square (χ^2)	RMSE
50^0C	Control	0.984	0.00157	0.039	0.995	0.0005	0.0211	0.996	0.00039	0.0188
	Steam Blanched	0.989	0.00104	0.031	0.996	0.0004	0.019	0.996	0.00049	0.0197
	1% sugar	0.993	0.0006	0.024	0.997	0.0003	0.016	0.997	0.0003	0.016
	1% KMS	0.991	0.0008	0.028	0.9975	0.0002	0.014	0.9975	0.0002	0.014
60^0C	Control	0.989	0.0011	0.032	0.996	0.0004	0.0183	0.9966	0.00035	0.01677
	Blanched	0.992	0.0008	0.027	0.998	0.0002	0.013	0.998	0.0002	0.013
	1% sugar	0.995	0.0004	0.02	0.997	0.0003	0.017	0.997	0.0003	0.016
	1% KMS	0.9965	0.0003	0.017	0.9979	0.0002	0.013	0.998	0.0002	0.012
70^0C	Control	0.989	0.0010	0.031	0.9976	0.0002	0.015	0.9976	0.00027	0.014
	Blanched	0.995	0.0005	0.022	0.9986	0.0001	0.0094	0.999	0.00009	0.009
	1% sugar	0.997	0.0003	0.015	0.997	0.0002	0.015	0.997	0.0003	0.015
	1% KMS	0.9984	0.0001	0.01	0.999	0.0001	0.010064	0.999	0.00008	0.009

The most acceptable model for bael pulp drying was estimated by comparing the predicted moisture ratio against experimental moisture ratio in fig 4-7. It was shown that Two term model was accurate for describing the drying attributes of bael pulp.

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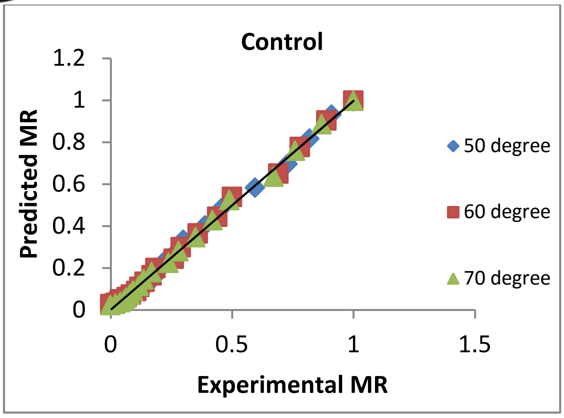

Fig 4

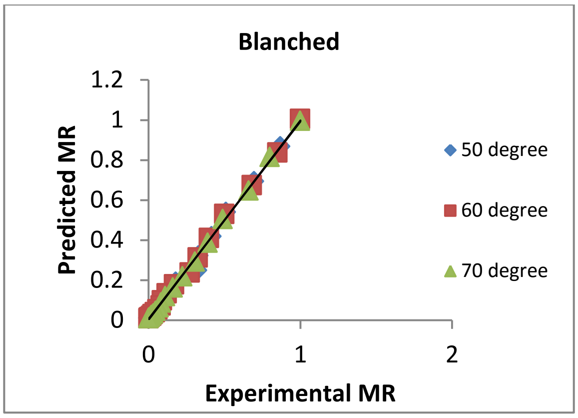

Fig 5

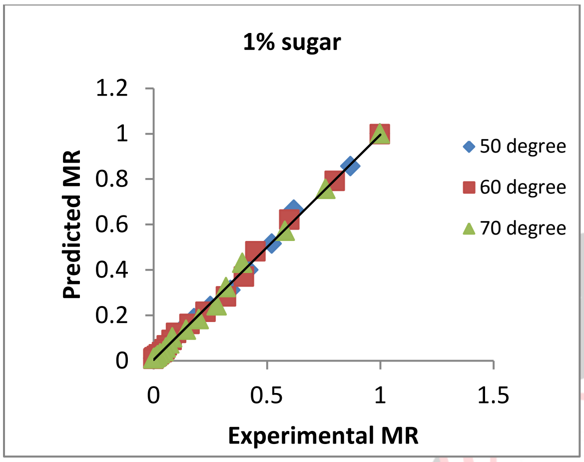

Fig 6

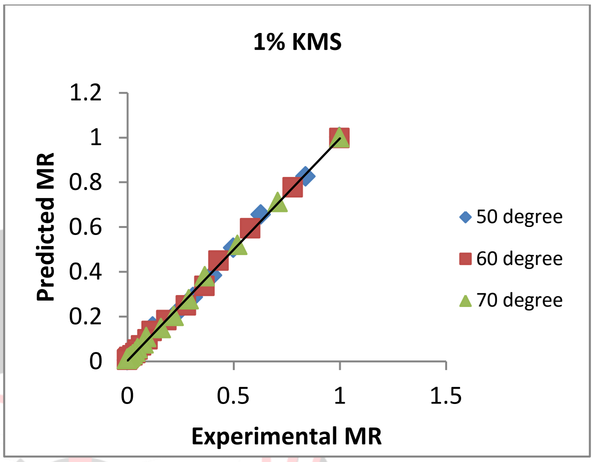

Fig 7

(Fig 4-7) Comparison of predicted vs experimental value

Results revealed that vitamin C degraded with increasing temperature. Vitamin C most affected by temperature and time of storage. Vitamin C is very unstable during heat treatment. Vitamin C content degenerated during drying involves oxidation and hydrolysis [20]. It was observed from fig 8 that all pretreated sample retained more vitamin C than untreated sample. Among all pretreatments sample with 1% KMS showed maximum amount of vitamin C (1.21 mg/100 g) at 60^{0}C after 3 months of storage which was followed by steam blanched and 1% sugar samples.

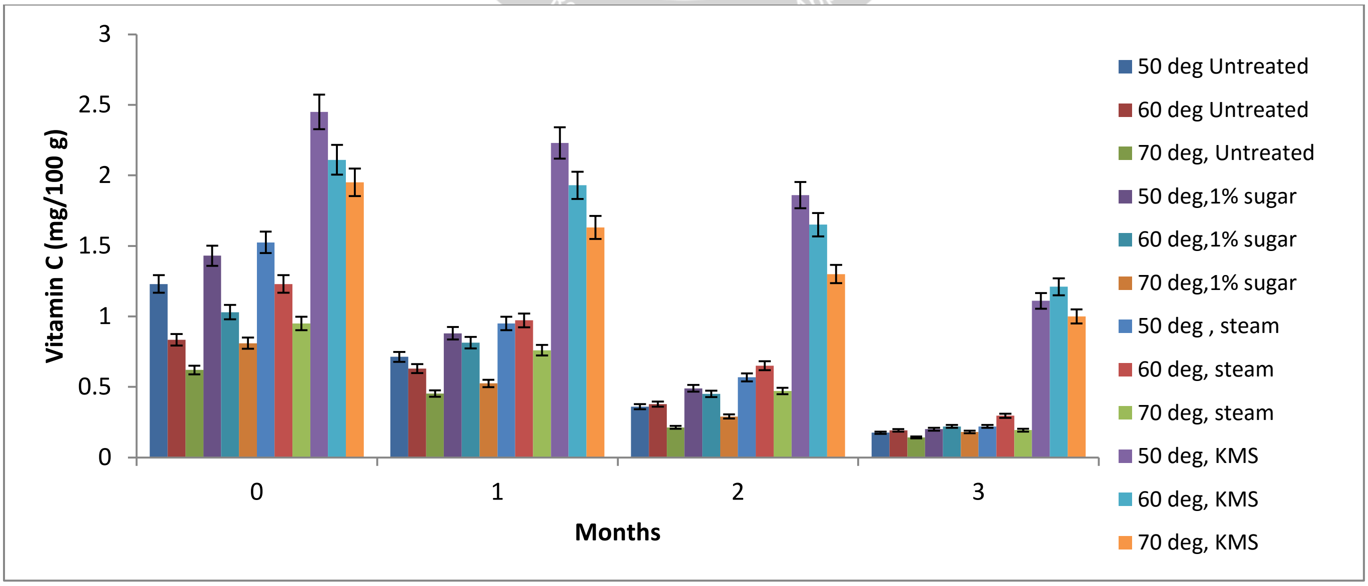

Fig 8: Storage study of vitamin C

Degradation of phenolic content increased with time and temperature. Thermal breakdown of polyphenols can happen during drying that can affect the cell structure [21]. Phenolic compounds degraded due to the effect of polyphenol oxidase (PPO)

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enzymatic activity [22]. Result showed that total phenol content degraded during storage [23]. PPO protein utilized polyphenols as substrate which cause degradation of phenolic compounds [24]. It was obtained from fig 9 that maximum retention of total phenol observed in sample with 1% KMS at 60°C (24.33 mg GAE/g) and steam blanched 24.05 mg GAE/g and sample with 1% sugar 19.69 mg GAE/g after 3 months of storage.

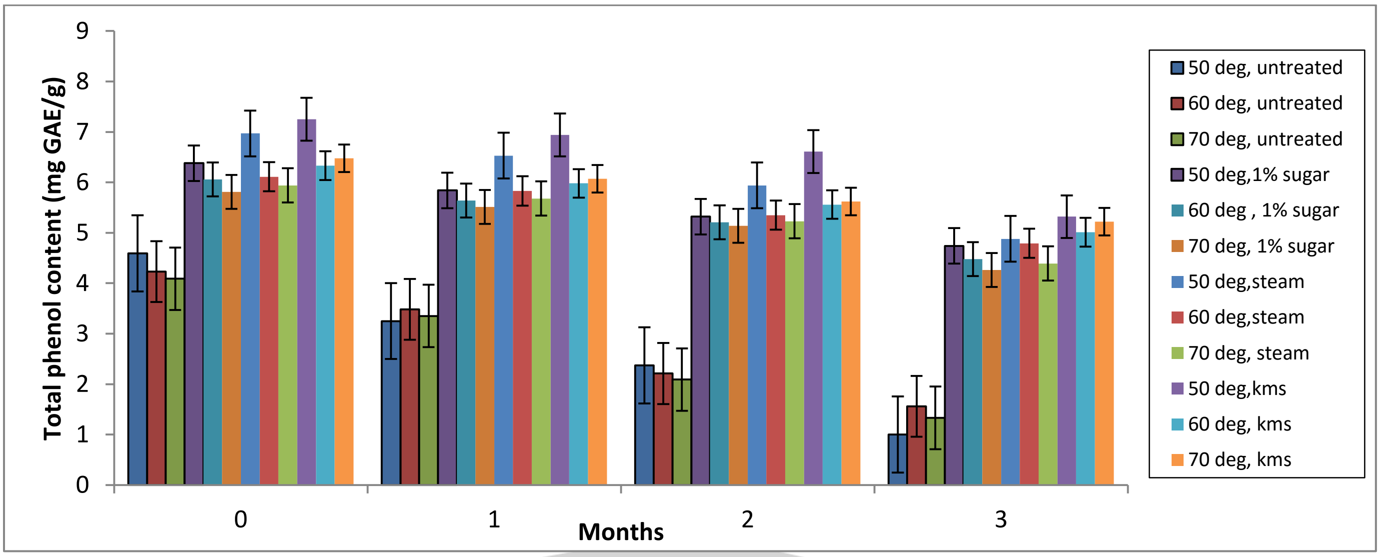

Fig: 9 Storage study of Total phenol content

Result showed that maximum retention of carotenoid in sample with KMS at 50^0C (6.61µg/g) which was followed by steam blanched (5.94 µg/g) and sample with 1% sugar (5.32 µg/g). As carotenoid was heat sensitive and sensitive to oxidative degradation [25] for this carotenoid degraded at higher temperature.

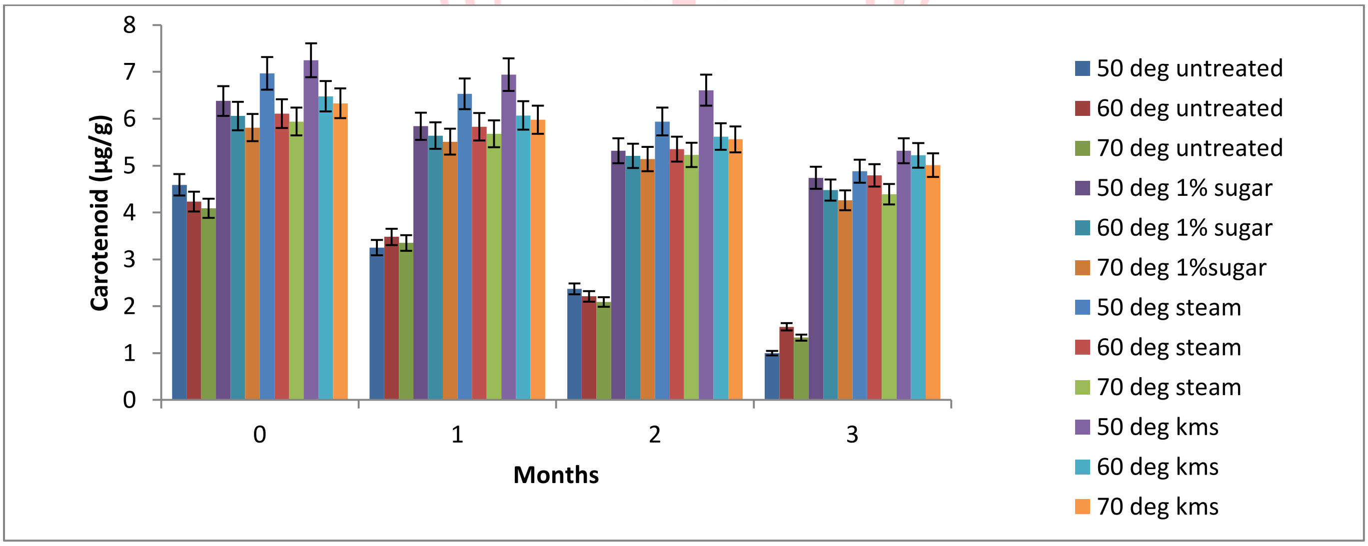

Fig: 10 Storage study of carotenoid content

. Result showed that antioxidant declined during storage in all temperature for all samples. Degradation of total antioxidant increased significantly with increasing storage period. This might be due to reduction of ascorbic acid and phenolic compounds during storage [26] that probably liable for HAP contribution in the powder. The loss of total antioxidant was slightly lower in the pretreated samples during storage. This might be due to pre treatment effect as well as effect of other factors like temperature and storage period on the powder which might have caused this change. Maximum retention of antioxidant showed in sample with KMS 18.89 mM $FeSO_4$/g.

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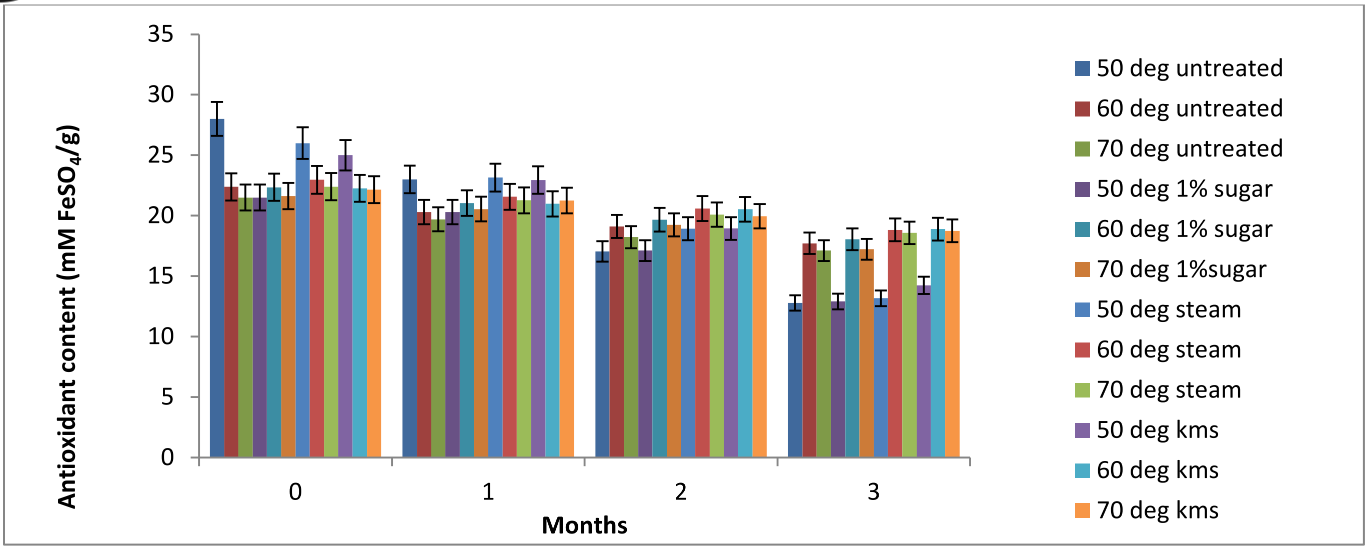

Fig: 11 Storage study of Antioxidant content

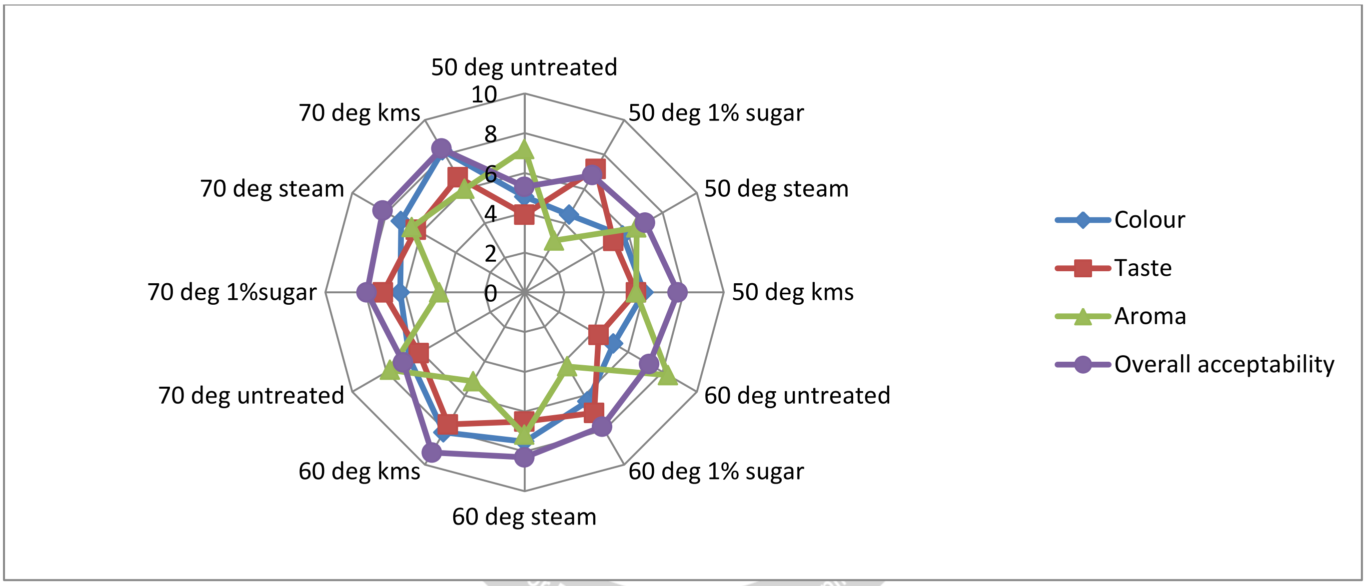

Fig 12: Descriptive analysis on sensory score of bael powder

It was observed that sensory score decreased gradually with increase in storage period at room temperature. The score was significantly decreased during storage. Similar findings were reported by Satkar et al. (2013) [27]. Temperature plays an important role in biochemical changes that leads to development of off flavour as well as discolouration in the beverages. The best sample with high sensory score was sample with 1% KMS.

IV. CONCLUSION

From this experiment it can be concluded that temperature and storage affect the nutritional quality of bael powder. Pretreatment have positive effect on bael powder. Best retention of nutritional quality was observed with samples pretreated with 1% KMS followed by dehydration at 60°C in tray dryer.

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REFERENCES

[1] A K Singh, A K. Chaurasiya , "Post Harvest Management and value addition in Bael (Aegle marmelos Corr.)", International Journal of Interdisciplinary and Multidisciplinary Studies (IJIMS)., vol. 1, no.9, pp. 65-77, 2014.

[2] P Maity, D Hansda, U Bandyopadhyay, and D. K. Mishra, "Biological activities of crude extracts and chemical constituents of bael, Aegle marmelos (L.) Corr",. Indian Journal of Experimental Biology., vol.47, pp.849−861, 2009.

[3] C Suvimol, and A Pranee, "Bioactive compounds and volatile compounds of Thai bael fruit (Aegle marmelos

 DOI : 10.18231/2454-9150.2018.1074

(L.) Correa) as a valuable source for functional food ingredients", International Food Research Journal, vol.15, pp. 45−63, 2008.

[4] V B Vikram, M N Ramesh and S G Prapulla , "Thermal degradation kinetics of nutrients in orange juice heated by electromagnetic and conventional method", J Food Eng. Vol.69, pp.31-40, 2005 .

[5] S P Mazur, A Nes, A B Wold, S F Remberg, B K Martinsen, K. Aaby , Effects of ripeness and cultivar on chemical composition of strawberry (Fragaria x ananassa Duch.) fruits and their suitability for jam production as a stable product at different storage temperatures. Food Chem. Vol.146, pp. 412–422, 2014.

[6] H Remini , C Mertz , A Belbahi , N Achir , M Dornier ,K Madani, " Degradation kinetic modelling of ascorbic acid and colour intensity in pasteurised blood orange juice during storage", Food Chemistry vol.173, pp.665-673, 2015.

[7] I Loannou , I Hafsa , S Hamdi , C Charbonnel and M Ghoul, "Review of the effects of food processing and formulation on flavonol and anthocyaninbehaviour", Journal of Food Engineering. Vol.111, no.2, pp.208-217, 2012.

[8] S Rangana , Handbook of analysis and quality control for fruit and vegetable products. 2nd edn (Tata McGraw Hill Publishing Company Ltd, New Delhi), 1986.

[9] V L Singleton and J A Rossi, " Colorimetry of total phenolics with phosphomolybdic-phosphotungestic acid reagents", Am J Enol Viticult. Vol.16, pp.144-153, 1965.

[10] R A Moyer, K E Hummer, C E Finn, B Frei, and R E Wrolstad, "Anthocyanins, phenolics, and antioxidant capacity in diverse small fruits: Vaccinium, Rubus, and Ribes", J. Agr. Food Chem. Vol.50, pp.519–525, 2002.

[11] S T Talcott and L R Howard, "Phenolic autoxidation is responsible for color degradation in processed carrot puree", Journal of Agricultural and Food Chemistry. Vol.47, no.5, pp.2109–2115, 1999.

[12] K P Suresh and V R Sagar, "Drying kinetics and physico-chemical characteristics of Osmo- dehydrated Mango, Guava and Aonla under different drying conditions", J Food Sci Technol vol.51, no.8, pp.1540-1546, 2014.

[13] T Y Tunde-Akintunde and G O Ogunlakin, "Mathematical modeling of drying of pretreated and untreated pumpkin", J Food Sci Technol vol.50, no.4, pp.705-713, 2013.

[14] A S Mujumdar , Handbook of industrial drying (second ed. New York): Marcel Dekker, 1995.

[15] S Singh, R Sharma, A S Bawa, D C Saxena , "Drying and rehydration characteristics of water chestnut (Trapa natans) as a function of drying air temperature. J Food Eng, vol.87, pp.213-221, 2008.

[16] A Singh , H K Sharma, N Kumar, A Upadhyay, and K P Mishra, "Thin layer hot air drying of bael (Aegle marmelos) fruit pulp", International Food Research Journal vol.22, no.1, pp.398-406, 2015.

[17] Qing-An Zhang, Yun Song, Xi Wang, Wu-Qi Zhao and Xue-Hui Fan, "Mathematical modeling of debittered apricot (Prunus armeniaca L.) kernels during thin-layer drying", CyTA - Journal of Food. Vol.14, no.4, pp.509-517, 2016.

[18] Akoy E O M, "Experimental characterization and modeling of thin-layer drying of mango slices", International Food Research Journal. Vol.21, no.5, pp.1911-1917, 2014.

[19] K Rayaguru, and W Routray, "Mathematical modeling of thin layer drying kinetics of stone apple slices", International Food Research Journal vol.19, no.4, pp.1503-1510, 2012.

[20] S Thankitsunthorn , C Thawornphiphatdit , N Laohaprasit and G Srzednicki, "Effects of drying temperature on quality of dried Indian Gooseberry powder", International Food Research Journal. Vol.16, pp.355-361, 2009.

[21] K M Youssef, S M Mokhtar, "Effect of Drying Methods on the Antioxidant Capacity, Color and Phytochemicals of Portulaca oleracea L. Leaves", J Nutr Food Sci 4:322. doi: 10.4172/2155-9600.1000322, 2014.

[22] S K Sonawane and S S Arya, "Effect of drying and storage on bioactive components of jambhul and wood apple", J Food Sci Technol. Vol.52, no.5, pp. 2833-2841, 2015.

[23] C Serea, O Barna, M Manley and M Kidd, "Effect of storage temperature on the ascorbic acid content, total phenolic content and antioxidant activity in Lettuce (Lactuca sativa L.)", The Journal of Animal & Plant Sciences. Vol.24, no.4, pp.1173-1177, 2014.

[24] A H Janovitz-Klapp, F C Richard, P M Goupy and J J Nicolas, "Inhibition studies on apple polyphenol oxidase", J. Agric. Food Chem. Vol.38, no.4, pp.926-931, 1990.

[25] R M N A Wijewardana, S B Nawarathne and I Wickramasinghe, "Effect of various dehydration methods on proximate composition and retention of antioxidants in different fruit powders", International Food Research Journa,l vol.23, no. 5, pp.2016-2020, 2016.

[26] I Klimczak, M Małecka, M Szlachta, and A Gliszczyńska-Świgło, "Effect of storage on the content of polyphenols, vitamin C and the antioxidant activity of orange juices". Journal of Food Composition and Analysis, vol.20, no.3, pp.313-322, 2007.

[27] K P Satkar, A A Kulthe and P R Chalke, "Preparation of bitter gourd ready-to-serve beverage and effect of storage temperature on its keeping quality. The Bioscan. Vol.8, no.1, pp.115-117, 2013.

 DOI : 10.18231/2454-9150.2018.1074