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Utilization of Carrot Pomace for the Preparation of a Value Added Product

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Abstract: This study was conducted to explore the possibility of utilization of waste residues (pomace) obtained during carrot juice extraction for the preparation of a value added product viz. carrot based condensed milk product (gazrella, an Indian sweetmeat). The carrot pomace was treated osmotically in two ways: Firstly, dipping in 65°Brix sucrose syrup, secondly, by adding 35% sucrose (dry powder) to the pomace. The product was further dehydrated convectively at 60°C temperature up to 4-5% moisture content (wet basis) and packaged under vacuum in aluminum laminated package (100 gauge). The dehydrated product was stored at ambient temperature (28-42°C) for 6 months and was utilized for preparation of carrot based condensed milk product. After conducting preliminary trials, a new method was adopted for the preparation of carrot based condensed milk product. The product prepared from osmo-convectively dehydrated pomace had moderate to excellent overall acceptability.

Key words: Carrot pomace • osmotic • convective dehydration • carrot based condensed milk product • gazrella

INTRODUCTION

Food processing wastes are the end products of the food processing industries which can not be recycled or used for other purposes. These are the non-product flows of raw materials whose economic values are less than the cost of collection and recovery for reuse; and therefore discard as a waste. These wastes pose increasing disposal and potential severe pollution problems and represent a loss of valuable biomass and nutrients [1]. The composition of wastes emerging from food processing industries is extremely varied and depend both on nature of the product as well as the production techniques employed. The wastes will be considered valuable, if the value of derived products from these wastes exceed the cost of reprocessing.

Carrots (*Daucus carota* L.) are rather inexpensive and highly nutritious as it contains appreciable amount of vitamins B_1, B_2, B_6 and B_{12} besides being rich in β-carotene [2]. High carotenoid intake is associated with lowering risk of many cancers, especially the prostate cancer. Further, vitamin A is an antioxidant which is key to the growth and repair of tissues and helps the body to fight with infections, keep eyes healthy, nourish epithelial tissues in the lungs, as well as of the skin. Therefore, maximum retention of β-carotene is of utmost importance for the preservation of the attractive appearance and dietary value of the product. Apart from being high in carotenoids, carrots are also high in dietary fiber [3]. Carrots also contain a significant supply of calcium, potassium and phosphorus. Carrots are also a good source of energy because it contains a lot of sucrose. This low cost crop could be converted to a value added products, if processed properly.

Carrot juices and blends thereof are among the most popular non-alcohlic beverages. Despite considerable improvements in processing techniques including the use of depolymerizing enzymes, mash heating and decanter technology, a major part of valuable compounds such as carotenes, uronic acids and natural sugars is still retained in the pomace. Juice yield is reported to be only 60-70% and up to 80% of the carotene may be lost with the pomace. Total carotene content of pomace may be up to 2 g per kg dry matter, depending on processing conditions. The solid waste from carrot juice production is rich in insoluble fiber, could reduce cholesterol levels and should be exploited as a final ingredient. The use of carrot pomace as by product utilization will decrease the environmental load.

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Various attempts have been made at utilizing carrot pomace in food such as bread, cake, dressing and for production of functional drinks. However, consumer acceptance of such products still needs to demonstrated, especially since sensory quality may be adversely affected. Pigments of spray dried carrot pulp waste proved to be prone to degradation during storage, depending on storage time and temperature. Carrot based condensed milk product (gazrella) is a delicious sweet of Indian confectionary. It is a source of concentrated nutrients and is prepared by cooking carrot shreds in milk with sucrose and moderately frying in hydrogenated oil [4]. Nuts and cardamom are added to increase the nutritive value and palatability. Manjunatha *et al*. [2] formulated a kheer mix based on dehydrated carrot, skim milk powder, sugar and other ingredients. Gazrella is perishable and can be stored for 3-5 days at room temperature. Sourness, drying up and rancidity development decrease the shelf life and quality of this product. It is not available throughout the year because carrot is a seasonal crop of perishable nature [5]. Due to the difficulty of safe storage of Gazrella even at low temperature, it will be more useful if we preserve the raw material (i.e. carrot shreds) of this product. The shelf life of carrot shreds/pomace can however, be increased by either osmotic or convective dehydration or a combination of both. Osmotic dehydration is the process in which water is partially removed from the cellular materials when these are placed in a concentrated solution of soluble solute. It preserves the color, flavor and texture of food from heat and is used as a pretreatment to improve the nutritional, sensorial and functional properties of food [5].

The objectives of this study were to investigate the osmo-convective dehydration kinetics of carrot pomace and to explore the possibility of its subsequent use for preparation of carrot based condensed milk product (gazrella).

MATERIALS AND METHODS

Preparation of pomace: Fresh carrots were procured, manually peeled, washed with potable water and placed on a sieve to drain out surface water and were further used for juice expression by juicer. The recovery of carrot juice and pulp (pomace) varied from 60.0 to 63.87% and 35-37.2%, respectively. The carrot juice and carrot pomace were processed separately. The average particle size of carrot pomace was in the range of 2-3 mm.

Pretreatment of carrot pomace: After the extraction of juice, the carrot pomace was osmotically pretreated by two methods. Firstly, the pomace was put in sucrose solution of 65°Brix containing 0.1% (w/w) sodium metabisulphite [5, 6]. Secondly, powdered sucrose @ 35% (w/w) of weight of Carrot pomace and 0.1% sodium metabisulfite were added. No blanching was done prior to osmosis as it has been reported to be detrimental to osmotic dehydration processes due to loss of semi-permeability of the cell membranes and reduction of β-carotene [7, 8].

Convective dehydration: The convective dehydration was performed at 60°C temperature with direction of airflow over the product in blind Aluminum Trays. The product was turned up after a regular interval of 30 min for proper dehydration and to avoid sticking to the base of the tray. The drying was done up to a final moisture content of 4-5% (wet basis). The dried product was packaged in aluminum-laminated envelopes under vacuum and stored at ambient temperature (28-42°C). The dehydrated pomace was used for the preparation of gazrella at regular interval of 60 days duration.

Validation of convective drying models: The following empirical models have been used to describe convective drying kinetics of thin layer drying [7, 9, 10].

Page Model

$$MR = Exp(-K*t^N) \quad (1)$$

Generalized Exponential Model

$$MR = A*Exp(-K*t) \quad (2)$$

Logarithmic Model

$$MR = A*Exp(-K*t)+C \quad (3)$$

Two Term Exponential

$$MR = A*Exp(-K_0*t)+B*Exp(-K_1*t) \quad (4)$$

Midilli *et al*. (2002)

$$MR = A*Exp(-K*t^N)+C*t \quad (5)$$

Where, K, N, A, B and C are model constants, t is the time in minutes and

$$MR = \text{Moisture ratio} = \frac{M_t - M_e}{M_o - M_e}$$

Drying curves were fitted to the experimental data using these moisture ratio equations. However, moisture ratio (MR) was simplified to M_t/M_o instead of $(M_t\text{-}M_e)/(M_o\text{-}M_e)$ [11-13]. M_t is the moisture content at time t, M_o is the initial moisture content and M_e is the equilibrium moisture content (dry basis).

Statistical analysis: The non-linear regression analysis of the experimental data was carried out by the software Statistica, 1995 for checking the validity of empirical models for all the dehydration processes.

Adequacy of fit of empirical models: The main criterion for the checking of adequacy of the model was coefficient of determination (R^2). The percent mean relative deviation modulus (E%) was also used to select the best equation to account for variation in the drying curves of the dried samples as recommended by several authors recently in their drying studies [14] that indicate the deviation of the observed data from the predicted line. Therefore, the best model was chosen as one with the highest coefficient of correlation (R^2); and the least mean relative deviation modulus (E).

The average percent difference between the experimental and predicted values mean relative deviation modulus, E, defined by following equation.

$$E(\%) = \frac{100}{n}\sum_{i=1}^{n}\left|\frac{\text{Experimental Value} - \text{predicted value}}{\text{Experimental value}}\right| \quad (6)$$

The values of E less than 5.0 indicate an excellent fit, while values greater than 10 are indicative of a poor fit. Where n are the numbers of observations.

Preparation of carrot based condensed milk product (Gazrella): In the present study, a new method was adopted for the preparation of carrot based condensed milk product (gazrella, an Indian sweetmeat) after conducting a number of trials by different methods for for preparation of gazrella. Gazrella was prepared by rehydrating the osmotically dehydrated carrot pomace in limited volume (1:1) hot/boiling water for 10-15 minutes. After proper rehydration the carrot pomace was cooked in desi ghee (clarified butter @ 60 g/100 g dried mixture of carrot pomace and sucrose), till the appearance of brown colour. After cooling the mixture, desired quantity of khoa (evaporated/condensed milk @ 100 g/100 g dried mixture of carrot pomace and sucrose) and dry fruits (raisins, cashew nuts etc. @ 15 g/100 g dried mixture of carrot pomace and sucrose) were mixed and served for sensory evaluation. The gazrella was prepared at regular interval of 2 months and was sensory evaluated by panel of experts.

Sensory evaluation: Organoleptic quality of finished product was determined with the help of a ten-member panel of judges using a 9-point hedonic scale. The aspects considered were colour, appearance, taste, flavour and overall acceptability. In between testing different samples, the panel members were served bland puffed rice and fresh water to rinse the mouth. The average scores of all the 10 panelists were computed for texture, flavour, appearance and overall acceptability.

RESULTS AND DISCUSSION

Pretreatment of carrot pomace: The carrot pomace was osmotically pre-treated with sucrose solution of 65°Brix as reported by Singh (2001) containing 0.1% sodium metabisulphite. The osmotic pretreatment with 65°B sucrose solution resulted in very less reduction of moisture content of product from 85 to 83.2% (wet basis) only, whereas in such type of osmotic pretreatment, there will be a lot of wastage of the valuable sucrose syrup. The less reduction in moisture content might be due to very small size of carrot fines consequently, to eradicate this drawback; the carrot pomace was directly mixed with dry sucrose powder, in the pomace to sucrose ratio 1: 0.35. This amount of sucrose addition was decided on the basis of amount required at the time of preparation of gazrella. No supplementary sucrose was added at the time of preparation of gazrella. The addition of dry sucrose however did not remove water from carrot fines, but it increased the amount of dry matter, thus indirectly decreased the moisture of the carrot pomace from 85 to 62% (wet basis).

Convective dehydration: The drying of un-osmosed carrot pomace had been started at relatively high moisture content (approximately 85% wet basis) whereas the drying of sucrose pretreated samples began at relatively lower moisture content of about 62% (w.b.).The mixture of carrot pomace and sucrose took about 18 h to dry up to 4-5% moisture content (w.b.) in a hot air cabinet dryer with the direction of airflow over the product at a drying air temperature of 60°C as compared to only 6 h at the same temperature for carrot pomace without addition of sucrose. Therefore osmotic pretreatment with sucrose added approximately 520 minutes to the convective dehydration time when compared to un-osmosed carrot

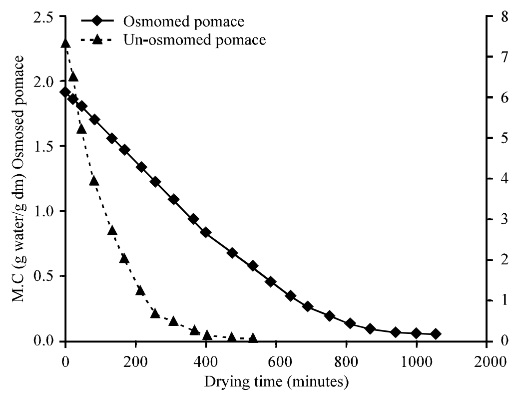

Fig. 1: Drying behavior of osmotically pretreated and un-osmosed carrot pomace at 60°C temperature with the air flow over the product

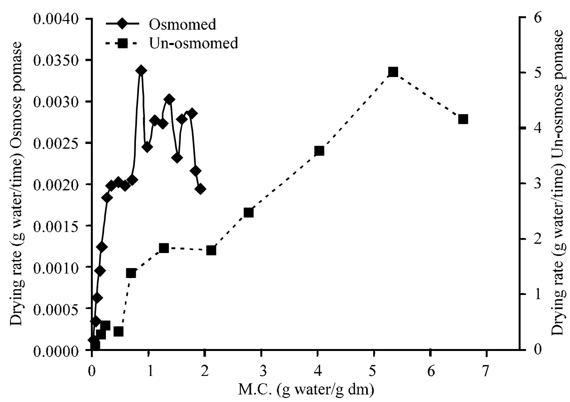

Fig. 2: Drying rate of carrot pomace at 60°C temperature with the air flow over the product

Table 1: Values of regression coefficients and statistical parameters for different models

Model	Regression coefficients and staistical parameters	Pre-osmosed	Un-osmosed
PAGE MODEL	K	0.00013	0.00445
	N	1.46917	1.11621
	E (%)	9.14323	11.37705
	R^2	99.85601	99.87902
GEM MODEL	A	1.08706	1.02552
	N	0.00247	0.0081
	E	46.13937	35.46266
	R^2	97.40901	99.70201
LOG MODEL	A	1.35787	1.04547
	K	0.00146	0.00754
	C	-0.31586	-0.02877
	E (%)	23.57233	34.68651
	R^2	99.36201	99.82901
TWO TERM EXPONENTIAL MODEL	A	0.54362	-47.34650
	K_0	0.00248	0.01205
	B	0.54344	48.34731
	K_1	0.00247	0.01192
	E	46.13960	8.86050
	R^2	97.40901	99.88901
MIDDILI MODEL	A	0.98504	0.99906
	K	0.00013	0.00471
	N	1.45633	1.10219
	C	-0.00003	-0.00002
	E	9.304424	16.86510
	R^2	99.88801	99.89021

pomace at 60°C drying air temperature. The increase in supplementary convective dehydration might be due to the binding properties of sucrose which caused lumping of the pomace. These lumps reduced the exposed surface area for hot air drying and consequently reduced the heat transfer rate. The increase in total convective dehydration might also be due to the resistance offered to water removal by the sucrose gained during osmotic pretreatment, which is accordance to Lenart and Cerkowniak [15], Kaleemullah *et al.* [6] also reported that, even a simple immersion of raw material into an osmotic solution, caused a substantial decrease of water removal rates in convective dehydration. However, some workershave reported that the osmotic dehydration spectacularly shortened the total convective drying time [5, 16, 17]. The reduction in convective dehydration time may only be possible, if osmo-convective drying has to be performed to prepare intermediate moisture foods (IMF) having high final moisture content. The drying behaviour of osmotically pretreated and unosmosed carrot pomace is shown in Fig. 1.

During convective dehydration, the drying rates were higher in the beginning of the process and later decreased with decrease of moisture for un-osmosed and osmotically pretreated samples during convective dehydration.The reason for reduction of drying rate might be due to reduction in porosity of the material due to shrinkage with the advancement of drying process, which increased the resistance to movement of water leading to further fall in drying rates. The decrease in drying rates with time may also be due to non-availability of free moisture in the later stages of dehydration. The sudden rise in drying rate might be due to the exposure of fresh surface to hot air because of turning of material at regular intervals.

It was expected that a vegetable like carrot having high moisture content should have constant rate of

Table 2: Mean sensory score of carrot based condensed milk product prepared from osmosed and un-osmosed dried carrot pomace

Duration (Days)	Pre-treatment	Texture	Flavour	Appearance	Overall acceptability
0	Osmosed	8.0	7.0	7.5	8.0
	Un-osmosed	7.0	5.0	5.0	6.0
60	Osmosed	8.0	7.0	7.2	8.0
	Un-osmosed	5.0	4.5	4.5	5.5
90	Osmosed	7.5	6.5	7.0	7.5
	Un-osmosed	4.0	4.0	4.0	5.0
120	Osmosed	7.0	6.0	6.0	7.0
	Un-osmosed	4.0	3.5	3.0	4.0
150	Osmosed	7.0	6.0	6.0	6.0
	Un-osmosed	2.0	2.0	1.5	1.5
180	Osmosed	6.5	6.0	6.0	6.0
	Un-osmosed	1.5	1.0	1.0	1.5

drying, because initially evaporation took place at the surface or near the surface. However, when drying proceeds, evaporation occurs from inside the solid and water vapour had to be transported to the surface by diffusion. The drying rate curves for convective dehydration Fig. 2 indicated that, the drying process occurred mainly in falling rate drying period. The absence of constant rate period might also be due to the reason that the product could not provide a constant supply of water for an appreciable period of time because of rapid thin layer drying of the product at initial stages of drying [18-20]. The curves displayed very low drying rates, when the average moisture content of the product approached from 2 to 1 g water/g dm and thereafter. Therefore, a considerably long drying period would be necessary to achieve final moisture content lower than 1 g water/g dm.

Validity of empirical models: The values of various regression coefficients and statistical parameters are shown in Table 1. The statistical analysis of experimental data revealed that the convective dehydration of pre-osmosed pomace could be represented by Midilli *et al.* [21] model and un-osmosed pomace by Two Term exponential Model due to lowest values of E(%) (Table 1). The variation in validity of the fitted models might be due to change in structural and chemical properties of carrot pomace due to addition of sucrose powder prior to convective dehydration.

Evaluation of the finished product: The dried product was vacuum packaged in aluminum-laminated packages of 100 gauge and stored at room temperature (28-42°C). During storage, the protection of dehydrated pomace from rodents was utmost important.

The overall response of acceptability varied between moderate to excellent (6-7 on Hedonic scale). Sensory scores of gazrella indicated that the colour, aroma, taste, texture, as well as overall acceptability were quite high for the gazrella prepared from carrot pomace osmotically pretreated with sucrose and were low for the gazrella prepared from un-osmosed carrot pomace. The high sensory score of gazrella prepared from osmotically pretreated carrot pomace might be due to preservative action of sucrose during storage. Mean sensory score of gazrella prepared from osmosed and un-osmosed dehydrated carrot pomace are presented in Table 2. However, lack of flavour was observed in the finished product, which might be due to the absence of juice in the carrot pomace.

CONCLUSIONS

Osmotic pretreatment of carrot pomace before convective dehydration resulted in increase of convective dehydration time and lowering of drying rates. Among the applied empirical models, the Midilli model was found to be the best model to describe the convective drying characteristics of pre-osmosed and Two-Term exponential model for un-osmosed carrot pomace. The finished product (carrot based condensed milk product, gazrella) prepared from carrot pomace osmotically pretreated with sucrose had moderate overall acceptability even after 6 months of storage at room temperature. Thus the waste from carrot juice could be utilized as raw material for preparation of gazrella during the off season.

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