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Effect of concentration and temperature of osmotic solution on mass transfer kinetics and its influence on quality of aonla (*Emblica officinalis*) segments

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ABSTRACT

An experiment was conducted to find out the optimum osmotic concentration and temperature for the preparation of osmo-vac dehydrated aonla segments. Blanched segments were dipped in various sugar concentration, viz. 40^0B, 50^0B, 60^0B and 70^0B with the temperature viz., 40°C, 50°C, 60°C and 70°C for six hours without any agitation. At the end of osmosis, segments were analyzed for various quality parameters and sensory attributes. It was indicated that water loss (WL) and solid gain (SG) increased with the increase in sugar concentrations and temperatures of the solution during osmosis process. The regression analysis showed that the process variables have significant effect on osmosis. Sensory attributes revealed that 60° B sugar concentration with 60°C temperature gave better results than the rest of the treatments.

Key words: Aonla segments, Ascorbic acid, Mass reduction, Osmotic dehydration, Solid gain, Water loss

Minor fruits play a vital role in the national economy as they have high scope for exporting both as fresh and in processed form. Among the minor fruits aonla (*Emblica officinalis,* Suresh Kumar and Sagar 2009) has commercial significance. It has wide popularity due to its therapeutic and nutritive value. Aonla is relished as fresh fruit and in processed forms and occupies significant place in the fruit processing industry. But its production is seasonal and lack of knowledge about its proper preservation leads to huge loss. Quality improvement is related not only to the water removal without thermal stress but also to the impregnated solutes. With the correct choice of solutes and a controlled and equilibrated ratio of water removal and impregnation, it is possible to retain natural flavour and colour in fruit products (Barat *et al.* 1998, Suresh Kumar and Sagar 2009). Processing of aonla by osm-vac dehydration (OVD) in the form of segments makes it light in weight and can be easily converted into fresh-like form. Keeping these points in view, the present investigation was carried out to standardize the concentration and temperature of osmotic solution for the preparation of better quality of osmo-vac dehydrated aonla segments.

MATERIALS AND METHODS

The fruits of aonla (*Emblica officinalis*) cv 'Chakkaiya' were obtained from the Division of Fruits and Horticulture Technology, IARI, New Delhi during 2006–07and brought to Division of Post Harvest Technology, IARI, New Delhi for conducting the experiment. The fruits were blanched in boiled alkali (2% NaOH) solution for 5–8 min. Lye treated fruits were washed thrice in tap water and then soaked in citric acid (0.1%) for 20 min. to neutralize the alkali treatment and to remove the astringency. The blanched fruits were dipped in cold water for 2 min. for easy separation of segments manually and removal of seeds.

Osmotic treatment: The weighed amount of aonla segments were suspended in sugar solution containing 0.05% potassium meta bisulphite (KMS) and 0.1% citric acid in 4 different concentration of (40, 50, 60 and 70° Brix) sugar syrup in the vessel. The temperature of the solution was maintained at pre-set value of 40, 50, 60 and 70 °C. The ratio of the aonla segments and osmotic solution was maintained as 1:4 in order to ensure proper soaking of the samples without any agitation. Samples were withdrawn at regular interval (1.5, 3, 4.5 and 6 hr), drained quickly and were wiped gently with tissue paper.

The samples were withdrawn from osmotic solution at the end of immersion period, washed, and blotted with tissue paper to remove the adhering water and values for MR, WL and SG were calculated as percentage by following formulae. (Rahman and Lamb 1990)

$$MR(\%) = \frac{Wi - Wf}{Wi} \times 100 \quad (1)$$

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$$SG(\%) = \frac{WSf - WSi}{Wi} \times 100 \quad (2)$$

$$WL(\%) = SG + WR \quad (3)$$

where W_i = initial weight of the sample (g), W_f = final weight of the sample (g), WS_i = initial total solids content (%), WS_f = final total solids content (%). Total solids content was determined by drying the sample to a constant weight.

The moisture content was determined by drying a known weight of the sample in a hot air oven at 60 ± 5°C to a constant weight. Acidity, ascorbic acid, total sugars, reducing sugars was determined according to Ranganna (1986).

Sensory analysis: Overall acceptability, colour, flavour, texture of the product were evaluated by experienced panel of seven judges on 9-point Hedonic scale as mentioned by Amerine *et. al.* (1965).

Statistical analysis: The data for various physico-chemical attributes were analyzed by using completely randomized design (CRD) and regression analysis was performed to find out significance on MR, WL, SG and processed data. The ANOVA was performed by SPSS software (Version 10.0).

RESULTS AND DISCUSSION

Regression analysis was applied to correlate the WL, SG and MR with the independent variables like time, concentration and temperature. The resulting regression coefficient is shown in Table 1. It was observed that the regression models for the dehydration parameters were statistically significant. The dipping time, temperature and concentration of sugar syrup had more effect on WL than SG with respective of different concentration of sugar syrup. The R^2 value of 0.92, 0.96 and 0.94 for WL,SG, and MR respectively were recorded.

The water loss (WL) increased with the increase in dip period (Fig 1). However, the rate of water removal slowed down after 4.5 hr. Increase in concentration of sugar and temperature correspondingly increased with the water loss. Maximum WL of 31.8% was observed after 6 hr in 70° B sugar concentration at 70° C temperatures. Increase in WL was very less in 40° B sugar concentration and 40° C temperatures. This may be due to the fact that the low concentration (40° B) of sugar syrup may get diluted and reach the near saturation point quickly which would not help in removing more water during the osmosis process. Similar results were reported by Suresh Kumar and Devi (2011) in osmotic dehydration of banana slices. The dehydration rate was faster in higher concentration of syrup. This may be due to increased osmotic pressure of the sugar at higher concentrations, which increased the drying force available for water transport. Similar results has been reported by Barat *et al*. (2001) in fruit tissues. The sugar penetration was maximum in first two hours and then slowed down (Fig 2). This may be due to high temperature which might have caused tissue damage and a dramatic decrease in dehydration efficiency through increased solute and decreased moisture diffusivities. Similar findings have been reported by Kayamak Ertekin and Sultangulu (2000) in apple ring slices and Sagar and Suresh Kumar (2009) in mango slices.

The solid gain increased with increase in sugar concentration and temperature of the solution. A maximum SG of 9.7% was recorded after 6 hr in 70° B sugar concentrations at 70° C temperature. This is attributed to longer time by osmosis to approach equilibrium between cellular fluid and osmotic solute along with volume of solution and compactness of fruit segments (Morrera and Sereno 2001, Suresh Kumar and Sagar 2012).

Maximum and minimum values for MR were 19.4 and 16.3% in 70° B and 40° B sugar syrup respectively, after 6 hr of dip (Fig 3). The MR is attributed to osmosis, which might be a cause of variation in MR rate among different concentration of sugars. (Sharma and Kausal 1999).

The osmosis decreased the moisture content of the product linearly with increase in sugar concentration up to 60%. Further increase of sugar concentration might have

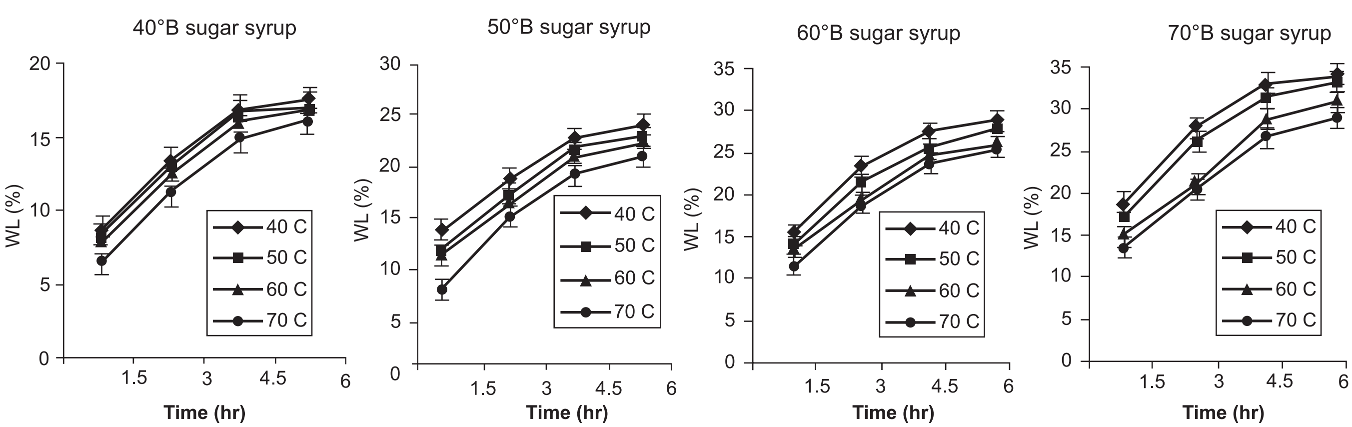

Fig 1 Effect of different osmotic concentrations and temperatures on water loss (WL) from *aonla* segments

Table 1 Regression coefficient and variance analysis on osmotic dehydration of aonla slices

Response	Coefficients		SE±	t-stat
WL	b_0	–34.91	5.260	
	b_1	5.31	.554	9.597
	b_2	1.054	.125	8.463
	b_3	0.007	.125	.056
	b_{12}	0.023	.006	4.323
	b_{13}	0.003	.006	–1.185
	b_{23}	0.004	.001	3.900
	b_{11}	–0.493	.046	–10.732
	b_{22}	–0.0088	.001	–8.555
	b_{33}	–0.00034	.001	–.363
ANOVA source	SS	df	MS	F
Model	2280.75	9	264.53	481.85
Residual	18.87	54	0.535	
R^2 = 0.92				
SG	b_0	–18.977	1.925	
	b_1	0.35	.175	–9.857
	b_2	0.464	.046	2.073
	b_3	0.103	.046	10.176
	b_{12}	0.01	.002	3.569
	b_{13}	0.0021	.001	5.534
	b_{23}	0.0003	.000	2.057
	b_{11}	0.063	.017	1.024
	b_{22}	0.003	.000	–3.799
	b_{33}	0.001	.000	–2.8
ANOVA source	SS	df	MS	F
Model	301.62	9	33.51	365.79
Residual	4.94	54	0.009	
R^2 = 0.96				
MR	b_0	–15.94	4.930	
	b_1	4.96	.519	9.563
	b_2	0.59	.117	5.056
	b_3	–1.56	.067	2.633
	b_{12}	.012	.005	2.451
	b_{13}	–0.0086	.005	–1.677
	b_{23}	.002	.001	3.761
	b_{11}	–0.429	.043	–9.966
	b_{22}	–0.005	.001	–5.612
	b_{33}	0.0006	.001	.645
ANOVA source	SS	df	MS	F
Model	301.622	9	33.514	365.796
Residual	4.947	54	0.0916	
R^2 = 0.94				

lead to the more sugar gain by the fruits which was not desirable as confirmed by Rahman and Lamb (1990) (Table 2). Osmosis of fruits also resulted in reduction of titratable acidity with increase in sugar concentration. The reduction might be attributed to the leaching of acid from fruits to hypertonic solution through a semi-permeable membrane which might have caused decrease in titratable acidity

Table 2 Effect of osmosis on chemical attributes of mango slices (dry weight basis)

Treatment	Moisture (%)	Acidity (%)	Ascorbic acid (mg/100g)	Reducing sugar (%)	Total sugar (%)
40^0 B+ 40^0 C	63.4	0.53	60.6	10.71	38.34
40^0 B+ 50^0 C	62.9	0.46	58.4	10.79	40.46
40^0 B+ 60^0 C	60.4	0.41	57.5	10.85	40.72
40^0 B+ 70^0 C	60.3	0.39	57.1	11.12	41.01
50^0 B+ 40^0 C	62.8	0.44	61.3	10.72	39.58
50^0 B+ 50^0 C	61.4	0.42	61.0	10.86	40.89
50^0 B+ 60^0 C	60.0	0.40	58.5	10.89	40.97
50^0 B+ 70^0 C	59.6	0.38	58.0	11.16	41.15
60^0 B+ 40^0 C	62.4	0.43	62.1	10.93	39.76
60^0 B+ 50^0 C	61.0	0.40	61.7	10.99	41.02
60^0 B+ 60^0 C	58.7	0.38	61.6	11.17	42.03
60^0 B+ 70^0 C	58.5	0.37	59.7	11.19	42.02
70^0 B+ 40^0 C	62.0	0.40	62.3	10.30	39.81
70^0 B+ 50^0 C	60.8	0.38	61.9	10.25	39.99
70^0 B+ 60^0 C	58.6	0.36	61.7	10.19	41.87
70^0 B+ 70^0 C	58.5	0.34	59.8	10.11	41.83
SEd±					
Concentration	0.90	0.01	0.78	0.26	0.82
Temperature	0.90	0.01	0.75	0.26	0.85
Conc × temp	1.80	0.02	1.52	0.51	1.62
CD (P = 0.05)					
Concentration	1.82	0.02	1.60	0.52	1.66
Temperature	NS	0.02	1.54	0.48	1.62
Conc × temp	3.64	0.04	3.13	0.98	3.27

(Sharma and Kausal 1999). Ascorbic acid content reduced considerably due to thermal degradation during osmotic process. The loss of ascorbic acid was less at low temperature with high concentration of sugar syrup. This might be due to less degradation of ascorbic acids at low temperature and more protection by the sugars at high concentration of sugar syrup. Reducing sugars and total sugars were higher in osmosed aonla segments than fresh one owing to removal of water leading to concentration of sugars. This might be due to increase in temperature, which hampered the more penetration of sugars during osmosis. The quality attributes and a regression result clearly indicated that 60° B concentration of sugars with 60° C temperature was found to be optimum parameters to get better-osmosed product.

It is apparent from the Fig 4 that sensory score of osmosed slices for the best colour was obtained with 60^0B with 60^0C temperature. This is due to prevention of enzymatic and oxidative browning as the fruit pieces were surrounded by sugar thus making it possible to retain good colour. Similar results were observed by Sagar and Khurdiya (1996) and Sagar and Suresh Kumar (2009) in dehydrated ripe

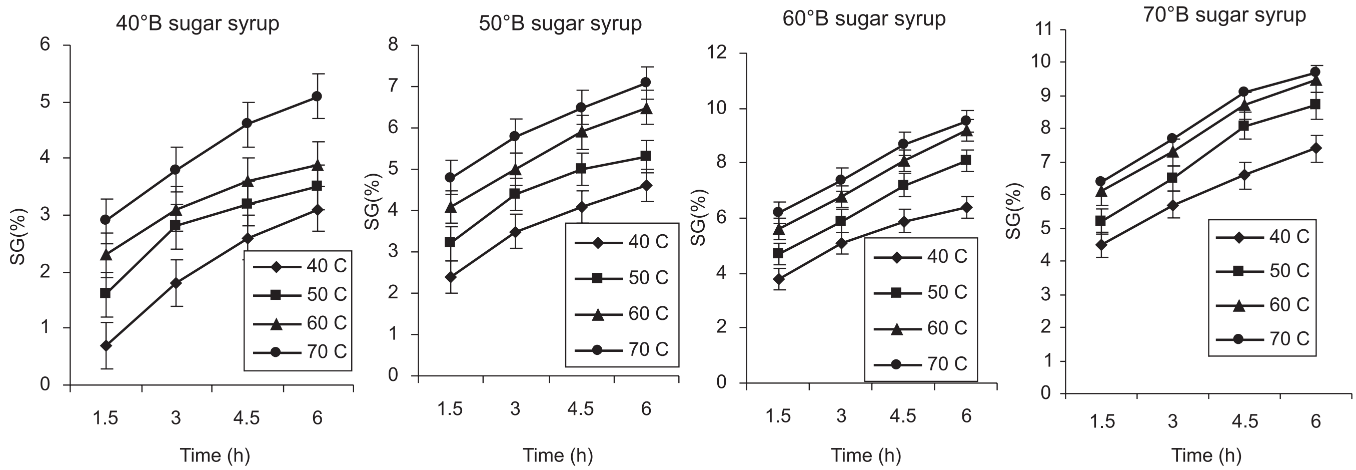

Fig 2 Effect of different osmotic concentrations and temperatures on solid gain (SG) of aonla segments

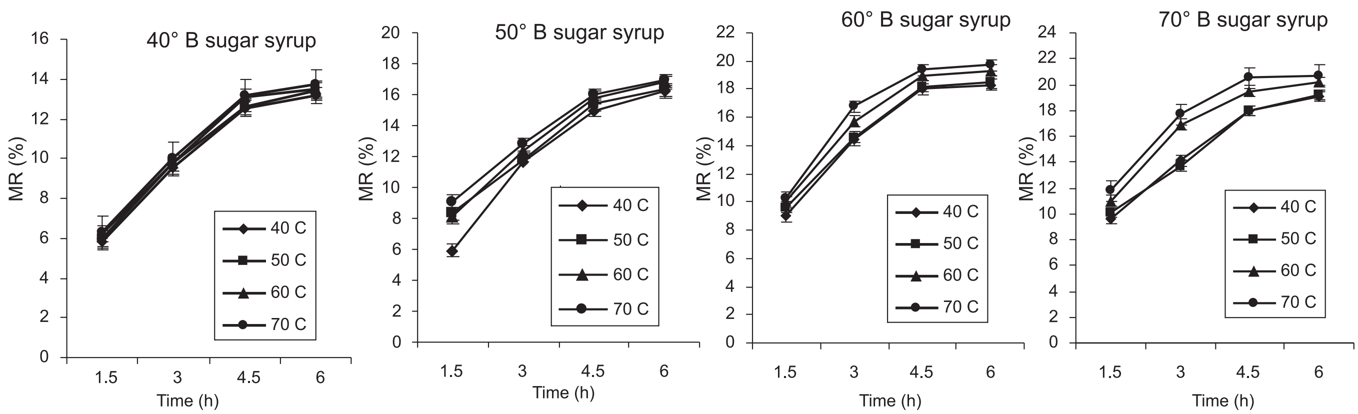

Fig.3 Effect of different osmotic concentrations and temperatures on mass reduction (MR) from aonla segments

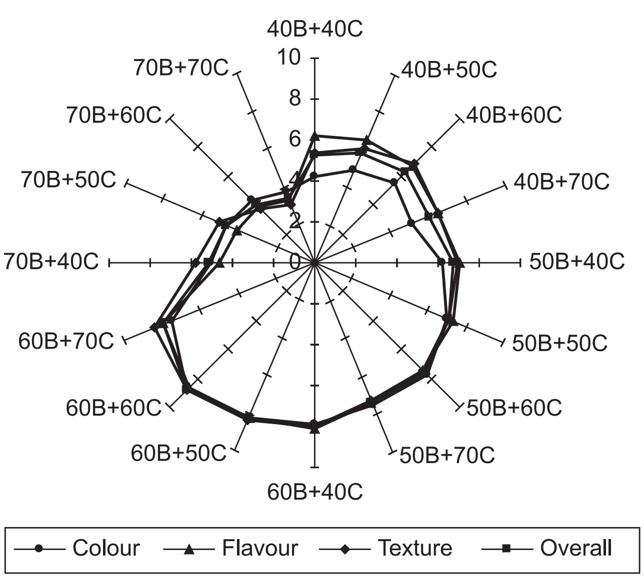

Fig 4 Descriptive analysis on sensory score of osmosed aonla segments

mango slices. However, high concentration and high temperature hinders the solid gain and there by render poor colour score. Higher score for flavour was noticed in 60°B sugar syrup with 60°C temperature. This is attributed mainly to optimum level of osmosis at 60°B and protective effect of sugar syrup on retention of fresh fruit flavour during osmosis. Similar result has been reported by Sagar and Khurdiya (1996) in dehydrated mango slices. Very low score on texture was observed with very low concentration of sugar. This could be due to better solid gain and optimum water loss at 60°B concentration then low concentration of sugar which might cause less solid gain in the product. Overall acceptability was also higher (8.2) with 60°B with 60°C than other combinations which is due to better colour, texture and flavour of the osmosed fruits. This is in conformity with the results of Suresh Kumar and Devi (2011).

From the above results it can be concluded that sensory score in respect of colour, flavour, texture of osmosed aonla segments was significantly better in 60 ^{0}B sugar concentrate at 60 °C.

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