Process optimization for the manufacture of *angoori petha*

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Abstract *Angoori petha* (AP) is delicacy which is relished by large section of Indian population. Fully ripened ash gourd fruits were osmotically dehydrated at different lime water concentration, lime water treatment time and sugar concentration for the manufacture of AP. The response variables consisted of sensory parameter for flavour, body and texture, colour and appearance and overall acceptability and physico-chemical properties. A central composite rotatable design (CCRD) was used as experimental design to predict the optimum conditions for manufacture of *petha*. The interaction of lime water concentration and lime water treatment time had significant ($P < 0.05$) effect for flavour, body and texture, colour and appearance and overall acceptability score (OAA) score in AP. The colour and appearance score had declining trend with increase the lime water treatment time and lime water concentration. Reducing sugar varied from 1.0% to 2.0%. The mean values for total invert sugar, sucrose and total sugar were in the range of 31.6–68.3%, 30.6–66.9% and 31.6–68.4%, respectively in different runs of AP samples. The optimum osmotic diffusion treatment consisted of lime water concentration of 12.6%, lime water treatment time of 54.1 min and sugar concentration of 87.9% for maximum acceptability in AP.

Keywords *Angoori petha* · Ash gourd · Osmotic diffusion · Optimization · Response surface methodology

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Ash gourd (*Benincasa hispida*) is an important crops of cucurbitaceae family and is known by several names such as winter gourd, winter melon, white gourd, Chinese preserving melon, pith gourd, Chinese wax gourd etc. In India, ash gourd is cultivated on an area of 2,497 ha with an annual production of 15,326 tonnes having average productivity 6.13 t/hac (Sidhu 2002). Uttar Pradesh occupies maximum area for production of ash gourd as compared to other states. The fruit of ash gourd is a good source of carbohydrates, vitamin A, vitamin C and minerals (Randhawa et al. 1983). Ash gourd fruits contain various mineral elements particularly high level of potassium and low sodium with low caloric value along with various amino acids such as arginine, methyl alanine, threonine, leucine, isoleucine and valine content (Gopalan et al. 2004). Ash gourd fruit juice increased urine volume, reduced the degree of pathological changes in the kidney due to mercuric chloride and significantly decreased blood serum creatine content (Dong et al. 1995).

Ash gourd is valued for its medicinal attributes towards controlling peptic ulcers, to cure blood disorders, urinary troubles and to control headache (Nadkarni 1927; Grover et al. 2001). The fruit juice is used for treating chronic diseases such as insanity and epilepsy (Ramesh et al. 1989). Ash gourd fruit is low in calories as it is particularly recommended for diabetic, obese people and patients suffering from nervousness and debility (Nadkarni 1927). The regular consumption of ash gourd promotes libido and is useful in periodic attacks of hysteria and convulsions (Rachachh and Jain 2008). An enzyme extracted from ash gourd juice can be used in place of calf rennet for producing cheddar cheese (Gupta and Eskin 1977).

Best quality of honey based carrot candy was developed by using 750 g honey along with 1,000 g carrot which remained acceptable during 6 months of storage at room temperature (Durrani and Srivastava 2011). The optimum dehydration parameters were standardized to 62°Brix sucrose solution, 30 °C temperature, 6 h time and 1:6 fruit to solution ratio to obtain water loss of 48.41%, solid gain of 10.9%, water loss/solid gain ratio of 4.4 and water reduction of 37% during osmotic dehydration of fresh pineapple (Singh et al. 2008).

Mature ash gourd fruits can be stored for many months and may be used for the preparation of candy and preserves, locally called *petha* (Eskin and Landman 1975). *Petha*, a sweet dish is boon for patients suffering from hypertension. Apart from the preparation of candy, large quantities of ash gourd fruit is utilized in the manufacture of AP. Srivastava et al. (2006) developed

jaggery based ash gourd candy which can be stored for 45 days under refrigerated condition. AP is manufactured in different parts of the country at cottage scale under unhygienic environment. The quality of AP in terms of sensory and physico-chemical attributes varies from one supplier to another. Very little information is available about the manufacturing processes and quantity of ingredients for the manufacture of acceptable AP. Therefore the present investigation was undertaken to optimize the effect of lime water concentration, lime water treatment time and sugar concentration for the manufacture of good quality AP.

Materials and methods

Ash gourd Fully matured ash gourd fruits genotype “Kashi Dhawal” were obtained from vegetable research

Fig. 1 Flow diagram for the manufacture of 10 kg *Angoori Petha*

Table 1 Coded and uncoded values of variables and their level

Independent variable	Coded levels	−1	0	+1
Lime water concentration,% (w/v)	A	5	10	15
Lime water treatment time, min	B	30	75	120
Sugar concentration,% (w/v)	C	50	75	100

farm of Indian Institute of Vegetable Research, Varanasi. The fruits were cut horizontally with sharp edged knife and were moulded into 25×25×15 mm size and 10 kg fruits were taken for each set of experiment. The ash gourd pieces were treated with lime water for 90–100 min with occasional stirring. The ash gourd pieces were thoroughly washed in water followed by dipping in chilled water for 1 h. The ash gourd pieces were cooked in boiled water for 5 min. The cooked ash gourd pieces were mixed with sugar syrup and were concentrated to 64–65°B followed by cooling to room temperature and were packaged in polypropylene (PP, 75 µm) pouches along with sugar syrup and stored at refrigerated temperature (5–7 °C).

Standardization of levels of lime water concentration, lime water treatment time and sugar concentration The different

levels of lime water concentration, lime water treatment time and sugar concentration were standardized and their influence was judged on the basis of sensory and physico-chemical properties of AP. The flow diagram for the manufacture of AP is presented in Fig. 1.

Experimental design Response surface methodology (RSM) was adopted in the experimental design. A CCRD of three variables of three variables at three levels was used in D6 Hokes' response surface design (Thompson 1982) and design matrix is shown in Table 1.

Sensory evaluation The AP was served in chilled condition to a panel of ten trained judges. The AP was evaluated for flavor, body and texture, colour and appearance and OAA on 9-point Hedonic scale (Lawless and Haymann 1998).

Table 2 Effect of lime water concentration, lime water treatment time and sugar concentration on mean sensory score (n=10) in *Angoori Petha*

Experimental run	Lime water concentration (%)	Lime water treatment time (min)	Sugar concentration (%)	Flavour	Body and texture	Colour and appearance	Overall acceptability
1.	7.5	120	70	7.8	7.5	7.4	7.5
2.	7.5	100	70	8.0	8.0	7.4	7.8
3.	7.5	60	70	7.0	6.64	6.6	6.6
4.	5	30	90	6.85	6.14	6.0	6.3
5.	3.3	65	70	6.71	6.4	6.5	6.5
6.	7.5	70	75	6.4	7.6	7.6	7.2
7.	10	100	90	6.9	7.3	7.0	7.0
8.	10	100	50	5.18	6.3	5.9	5.7
9.	5	30	50	5.5	5.5	5.9	5.6
10.	10	30	90	7.8	6.8	7.6	7.4
11.	5	100	90	7.7	8.0	7.1	7.6
12.	5	100	50	6.3	7.03	7.1	6.8
13.	11.7	65	70	7.5	7.3	7.5	7.4
14.	9	65	70	6.2	6.0	6.2	6.1
15.	8	65	70	7.1	6.7	6.8	6.8
16.	7.5	65	36.5	6.0	7.3	7.5	6.9
17.	7.5	65	70	7.7	7.6	7.7	7.6
18.	10	30	50	6.9	6.2	7.8	6.9
19.	6.5	65	105	7.6	6.8	6.8	7.06
20.	12	65	70	7.84	7.04	7.02	7.2

Analytical techniques The total solids in AP was estimated by gravimetric method as per IS: 1479 (part II) 1961 and total soluble solids were estimated by hand refractometer and the values were expressed as °Brix at 20 °C. The ascorbic acid content in AP was estimated by as per the method of Sadasivam and Manickam (1996). The sugar content in AP was estimated as per the method described by Ranganna (1997). The extent of browning in AP was determined by alcohol extraction method (Klin and Nagy 1988).

Results and discussion

Sensory score The effect of lime water concentration, lime water treatment time and sugar concentration on sensory score in AP is described in Table 2. The second order polynomial models were regressed for the manufacture of AP. The flavour score in AP varied from 5.18 to 8 (Table 2). Maximum flavour score (8.0) was attained for experimental run 2 which had 7.5% lime water concentration, lime water treatment time of 100 min and 70% sugar concentration. Maximum body and texture score (8.0) was obtained for experimental run 2 and 11 and minimum body and texture score (5.5) was reflected in experimental run 9. Judges had maximum preference for colour and appearance score (7.8) for the experimental run 18 of AP while minimum colour and appearance score (5.9) for experimental run 8 and 9 in AP. Maximum OAA score (7.8) in AP was obtained for experimental run 2 having 7.5% lime water concentration, 100 min lime water treatment time and 70% sugar concentration and minimum OAA score (5.6) for experimental run 9 which contained 5% lime concentration, lime water treatment time of 30 min and 50% sugar concentration (Table 2). ANOVA studies had shown that the interaction of lime water concentration and lime water treatment time had significant ($P < 0.05$) effect for flavour, colour and appearance and OAA score in AP. Lime water concentration had negative response for body and texture, colour and appearance and OAA in AP. It is evident that flavour score decreased with increase the lime water treatment time, interaction of lime water concentration and lime water treatment time and interaction of lime water concentration and sugar concentration. Similarly, lime water concentration also exhibited negative response for body and texture, colour and appearance and overall acceptability in AP. The calculated adequate precision value was 5.45, 5.18, 4.99 and 5.16 for flavour, body and texture, colour and appearance and OAA score, respec-

tively which was greater than 4.0. A ratio greater than 4 is desirable which indicates that model can be used to navigate the design space.

The model thus developed with coded variables are follows:

$$\begin{aligned}\text{Flavour} = & 7.02 + 0.049*A - 0.53*B + 0.58*C \\ & - 1.37*A*B - 0.068*A*C + 0.13B**C \\ & + 0.039*A^2 + 0.154*B^2 - 0.18*C^2\end{aligned}$$

$$\begin{aligned}\text{Body and texture} = & 7.06 - 0.37*A + 0.18*B + 0.25*C \\ & - 0.90*A*B + 0.07*A*C + 0.12*B*C \\ & - 0.35*A^2 - 0.28*B^2 - 0.01*C^2\end{aligned}$$

$$\begin{aligned}\text{Colour and appearance} = & 7.0 - 0.32*A - 0.67*B \\ & + 0.17*C - 1.54*A*C \\ & + 0.22*A*C + 0.19*B*C \\ & - 0.44*A^2 - 0.02*B^2 + 0.01*C^2\end{aligned}$$

$$\begin{aligned}\text{Overall acceptability} = & 6.96 - 0.24*A - 0.36*B + 0.35*C \\ & - 1.32*A*B + 0.09*A*C \\ & + 0.14*B*C - 0.24*A^2 - 0.04*B^2 \\ & - 0.05*C^2\end{aligned}$$

The flavour score in AP had decreasing trend with increase the lime water treatment time (30–120 min) and lime water concentration (5–12%). However, the flavour score was increased with increase the sugar concentration of 50–90% (Fig. 2a). Body and texture score, colour and appearance and OAA score in AP decreased with increasing the lime water treatment time (30–120 min), lime water concentration (5–12%) and sugar concentration of 50–90% (Fig 2b, c and d).

Physico-chemical properties The effect of lime water concentration, lime water treatment time and sugar concentration on physicochemical properties on AP is described in Table 3. The mean reducing sugar varied from 1.0% to 2.0%. The mean values for total invert sugar, sucrose and total sugar were in the range of 31.6–68.3%, 30.6–66.9% and 31.6–68.4%, respectively in AP samples.

Fig. 2 Response surface plots on effect of processing variables on sensory scores of attributes **(a)** flavour **(b)** body and texture **(c)** colour and appearance **(d)** over all acceptability

Table 3 Effect of lime water concentration, lime water treatment time and sugar concentration on physico chemical properties ($n=5$) in *Angoori Petha*

Experimental run	Lime water concentration (%)	Lime water treatment time (min)	Sugar concentration (%)	Mean reducing sugar (%)	Mean invert sugar (%)	Mean sucrose (%)	Mean total sugar (%)	Mean ascorbic acid (mg/100 g)	Mean titrable acidity (%)	Mean total solids (%)	Mean total soluble solids ($^{\circ}$ Brix)	Mean extent of browning (OD)
1	7.5	120	70	1.3	44.3	40.9	42.2	9.8	0.0	26.2	60.1	0.0
2	7.5	100	70	1.3	42.7	41.4	42.8	9.8	0.0	20.4	60.5	0.0
3	7.5	60	70	1.3	47.1	45.8	47.1	9.8	0.2	39.6	60.1	0.0
4	5	30	90	1.5	68.3	66.9	68.4	7.3	0.1	27.0	60.5	0.1
5	3.3	65	70	1.3	46.1	44.9	46.2	9.7	0.2	36.2	58.5	0.0
6	7.5	70	75	1.3	48.0	46.8	48.1	8.5	0.2	64.6	55.1	0.5
7	10	100	90	1.8	59.1	57.4	59.2	7.8	0.1	60.0	60.4	0.1
8	10	100	50	1.4	45.9	45.9	47.3	7.3	0.2	47.8	45.2	0.1
9	5	30	50	1.4	46.6	45.3	46.6	3.6	0.1	35.1	45.3	0.1
10	10	30	90	1.4	60.3	58.9	60.4	4.3	0.1	11.9	60.1	0.1
11	5	100	90	1.5	68.3	66.9	68.4	3.6	0.2	12.3	60.1	0.1
12	5	100	50	1.1	40.6	39.4	40.5	4.3	0.1	53.4	50.7	0.0
13	11.7	65	70	1.3	49.9	38.6	39.9	9.7	0.1	37.6	60.5	0.0
14	9	65	70	1.3	46.1	44.6	46.9	8.5	0.1	42.5	55.2	0.0
15	8	65	70	1.3	45.2	43.9	45.3	7.8	0.1	41.1	60.0	0.0
16	7.5	65	36.5	1.0	31.6	30.6	31.6	4.9	0.1	60.9	40.3	0.0
17	7.5	65	70	1.3	44.3	43.1	44.4	9.7	0.0	37.6	60.9	0.1
18	10	30	50	1.1	36.6	33.6	36.7	8.5	0.0	52.3	40.3	0.1
19	6.5	65	105	2.0	56.2	54.3	56.3	7.8	0.0	33.1	65.3	0.0
20	12	65	70	1.3	43.5	42.3	43.6	9.7	0.1	44.3	55.3	0.1

Maximum level of total invert sugar (68.3%), sucrose (66.9%) and total sugar (68.4%) were obtained for experimental run 4 and 11 and minimum level for experimental run 16 having 31.6%, 30.6% and 31.6% total invert sugar, sucrose and total sugar, respectively (Table 3). Our studies confirmed that maximum levels of total invert sugar, sucrose and total sugar were obtained in AP samples having sugar concentration 90% and minimum level of total invert sugar, sucrose and total sugar were reflected in the experimental run containing 36.5% sugar concentration in AP. Sagar and Kumar (2006) also reported that reducing and total sugars were increased in dehydrated aonla shreds which may be due to absorption of sugar during osmosis process.

The mean ascorbic acid content ranged from 3.6 to 9.8 mg/100 g in different experimental runs of AP samples. The reduced level of ascorbic acid can be attributed due to extensive heat treatment during the manufacture of AP. Similar decrease in ascorbic acid value was also reported during heat treatment of fruits and vegetables by the other workers (Sethi and Anand 1982; Tripathi et al. 1988). The mean values of total solids and total soluble solids were in the range of 11.9–64.6% and 40.3–65.3%, respectively. The extent of browning varied from 0.0 to 0.5 OD. The low level of extent of browning reflects the minimum browning during manufacture of AP. Sagar and Kumar (2006) also attributed the lower extent of browning of 0.124 OD in dehydrated aonla shreds. The non-enzymatic browning is related to low moisture content and faster biochemical changes at higher temperature (Tripathi et al. 1988).

In linear terms, sugar concentration had significant model term for reducing sugar, total invert sugar, total sugar and total solids except for lime water concentration and lime water treatment time. The values on regression coefficient on the physico-chemical properties in AP reflected that the interaction of lime water concentration and sugar concentration had negative effect on total invert sugar, sucrose, total sugar, ascorbic acid and extent of browning. The coefficient of determination R^2 was between 0.77 and 0.93 for reducing sugar, total invert sugar, sucrose and total sugar. The higher coefficient of regression (R^2) values signified the goodness of the fit of the model.

Optimization In order to optimize the process for the manufacture of AP, the process variable consisted of lime water concentration (5–15%), lime water treatment time (30–120 min) and sugar concentration (50–100%) for manufacture of good OAA of AP. The maximum desirability was obtained with lime water concentration of 12.6%, lime water treatment time of 54.1 min and sugar concentration of 87.9%.

Conclusion

Maximum (7.8–8.0) flavour, body and texture and overall acceptability score was obtained after treatment with 7.5% lime water concentration, 100 min lime water treatment time and 70% sugar concentration while minimum (5.6) overall acceptability was obtained after 5.0% lime water concentration, 30 min lime water treatment time and 50% sugar concentration in AP. The mean values for reducing sugar, total invert sugar, sucrose and total sugar were in the range of 1.0–2.0%, 31.6–68.3%, 30.6–66.9% and 31.6–68.4%, respectively in different experimental runs of AP samples.

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