DOI : 10.5958/0974-0112.2017.00123.2

Indian J. Hort. 74(4), December 2017: 631-634

Short communication

Optimization of *aonla*-blended juice based on antioxidants and sensory qualities using response surface methodology

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ABSTRACT

Present research investigation was aimed to determine the optimum combination of *aonla* (*Emblica officinalis* Gaertn.), pomegranate and aloe vera juices, which were mixed together in various proportions to obtain a suitable blend. Box Behnken design was adopted with three factors at five levels of each. The responses were analysed to fit a polynomial model by least square technique. Optimized blend was observed to contain *aonla* juice (71.6%), pomegranate juice (15.6%) and aloe vera (12.7%). Resulted with the responses of TSS 8.91°Brix, acidity 0.40%, ascorbic acid 80.1 mg/ 100 ml, colour *L* 23.55 and overall sensory score of 7.9. Regression models for TSS, ascorbic acid and sensory were found significant and the coefficients of determination R^2 were found in the range up to 0.93 for these dependent variables. Results showed that the optimized blend of *aonla*-pomegranate-aloe vera juice is acceptable for further development of premium beverages and can be preserved for 6 months with good quality attributes.

Key words: *Aonla*, juice blending, optimization, vitamin C.

Among fruits, *aonla* commonly known as Indian gooseberry (*Emblica officinalis* Gaertn syn. *Phyllanthus emblica* L.) finds a special place in India as it has got tremendous medicinal values, rich source of vitamins C (400-600 mg/ 100 g), pectins & tannins. Although, consumption of raw *aonla* fruit is considered to be good or human health, but because of the inherent high astringency it has little table value (Jain and Khurdiya, 5). *Aonla* juice is the preferred product, due to easily digestible, highly refreshing, thirst-quenching, appetizing and nutritionally far superior than much synthetic and aerated drink (Nayak *et al*., 6). Various workers have reported that two or more fruit juices/ pulps may be blended in various proportions for preparation of RTS, nectar and other beverages (Bhardwaj and Mukherjee, 3; Deka *et al*., 4; Ram *et al*., 7). Sasi Kumar *et al.* (7) reported that RTS beverage developed by blending aloe vera, *aonla* and ginger in ratio of 70:15:15 recorded the highest sensory scores, taste, flavour and overall acceptability. Optimization of composition of blend juice ingredients is essential to obtain a product with good taste, flavour and colour. The purpose of present work was to study the effect of blending ratio of various fruit juices on quality and optimization to obtain higher quality juice with improved physico-chemical and sensory characteristics.

The experiment was conducted during 2014-15 at ICAR-CIPHET, Abohar, Punjab. The fully matured, well-developed and uniform sized *aonla* fruits of cv. Chakaiya, aloe vera leaf (*Aloe barbadensis*) and pomegranate cv. Mridula were harvested from orchard of the institute. Selected fruits were thoroughly washed in running tap water to remove dirt, dust particles and insecticidal residues. *Aonla* fruit was first shredded with the help of *aonla* shredder machine; juice was obtained by hydraulic press and stored in controlled storage conditions (4 ± 2°C). Selected aloe vera leaves were subjected for pre-processing (cut of tip and edge), gel was extracted and juice was filtered through muslin cloth. The fully ripe fruits of pomegranate were cut and arils were separated. These arils were passed through juicer to extract the juice. The juices so obtained were kept for 24 h in refrigerator (4 ± 2°C) for sedimentation. The calculated juice blends as per design were filled in pre-sterilized 200 ml opaque white glass bottles. The bottles were sealed air tight and pasteurized in hot water at 85°C for 15 min. and cooled. Juice blends were stored in two lots at room temperature (28 ± 4°C) and refrigerators (4 ± 2°C) and evaluated periodically for physico-chemical, and sensory characteristics.

The colour of juices was measured using handy colorimeter NR 3000 (Nippon Deshkhon, Japan). The degree of browning was expressed by the changes in the colour (*L*, *a* and *b*) values. The titratable acidity were determined by the standard methods (AOAC and ascorbic acid, 2). The blended beverages were evaluated for sensory qualities on the basis of colour (appearance), taste and aroma, palatability and

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overall acceptability by a panel of 10 judges on a 9-point Hedonic scale (Amerine *et al.*, 1). Response, surface methodology (RSM) using Design expert package (Statease Inc. Minneapolis, USA) was used to investigate the effect of different juice ratio on its quality and acceptability. Box-Behnken design with 20 treatments (Table 1) including five centre point experiments was applied to establish and evaluate the relationship of responses (TSS, acidity, colour, and overall sensory acceptability) with respect to the independent variables (*aonla*, pomegranate and aloe vera juice).

Corresponding values of various responses of dependent variables are given in Table 1. A wide variation in all the responses was observed for different juice blending proportion combinations, *viz*. colour value L^* (16.2 to 34.8), a^* (8.15 to 28), b^* (2.1 to 9.12), TSS (6.1 to 10.5°Brix), acidity (0.3 to 1.8%) overall sensory (5.5 to 7.9) and ascorbic acid (20 to 210 mg/ 100 ml). Juice percent had significant effects on overall acceptability ($p < 0.01$). The 3D response (Fig.1) was generated for the fitted model to visualize the combined effect of two variables on each dependent variable like TSS, acidity and ascorbic acid, while keeping third variable at its central value. A second order polynomial fitted for all the data performed, regression coefficients for each response and the fitted equations are given in eq.1-4.

Ascorbic acid ranged from 20 to 210 mg/ 100 g (Fig. 1) reveals that independent variable (X_1) affected the ascorbic acid content significantly. The interaction effect (*aonla* × aloe vera juice) and (*aonla* × pomegranate juice) were negatively related. The changes in ascorbic acid with respect to the juice ratios could be predicted using the quadratic model as given in eq.1. TSS varied from 6.1° to 10.5°Brix for different blends. The *aonla* juice and pomegranate juice had their significant effects on TSS ($p < 0.01$) of the final blend. The results revealed that out of all independent factors, pomegranate juice plays a major role in deciding the TSS of final product since it contains higher amount of sugars. The positive coefficients on linear term between *aonla* and pomegranate juice indicated that TSS increased with the increase in pomegranate juice (Fig.1). Similar results were obtained by Ram *et al.* (7). While, negative coefficients for aloe vera indicated that TSS decreased with increase in aloe vera juice. There was also significant interaction ($p < 0.01$) between *aonla* and pomegranate variable, while TSS was negatively

Table 1. Experimental design and responses with respect to *aonla*-pomegranate-aloe vera juice blends.

Run	Uncoded variable			Response						
	X_1	X_2	X_3	*L*	*a*	*b*	TSS	Acidity	Sensory	AA
1	50	10	10	23.09	11.96	3.95	9.2	0.91	6.9	105
2	100	0	0	18.59	9.05	3.52	6.1	1.12	6.1	145
3	0	20	0	22.71	22.39	2.75	10.2	0.52	6.2	60
4	0	0	0	21.96	13.81	4.09	9	0.56	6.3	52
5	50	10	0	22	12	5.56	10.5	0.92	7.12	95
6	0	0	20	19	11.97	4.09	6.2	0.52	6.1	49
7	50	20	10	22.49	20.33	3.1	9.5	1.12	6.3	110
8	0	10	10	26.42	13.49	3.24	6.4	0.3	5.5	10
9	50	10	10	27.94	23.52	9.59	9.5	0.98	6.5	62
10	50	10	10	22	8.17	11.27	9.6	1	6.5	63
11	100	20	20	31	8.15	10.2	9.6	1.22	7.5	150
12	50	10	10	29.2	28	17.25	10.4	1.02	7	104
13	100	0	20	32.66	25	8.02	9.1	1.4	7.8	140
14	0	20	20	22.79	17.5	2.1	8.1	0.6	6.9	68
15	50	10	20	34.88	23.22	15.98	6.2	0.96	6.7	110
16	100	20	0	16.2	13.36	7.8	9.9	1.5	7.9	160
17	50	0	10	17.07	14.58	14.25	8.9	0.8	6.8	100
18	100	10	10	26	16	19.12	9.6	1.8	7	210
19	50	10	10	20.18	13.7	11.3	9.7	1.2	6.6	65
20	50	10	10	17.83	13.6	3.6	9.6	1.18	6.4	64

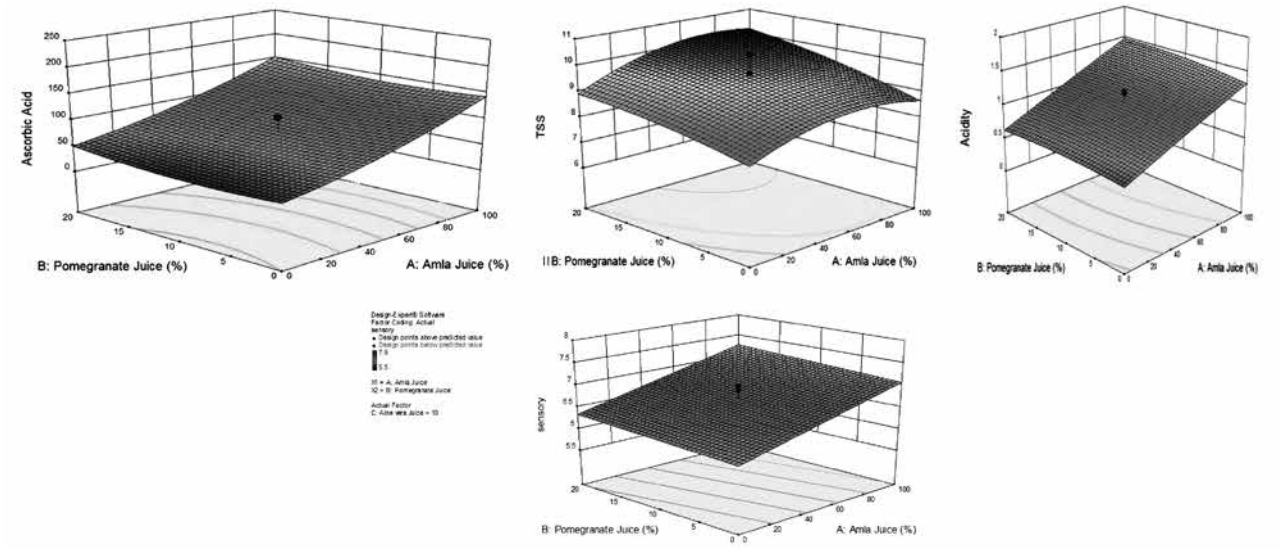

Fig. 1. 3D Response surface plots of with respect to change in pomegranate: *aonla* juice ratio, a. ascorbic acid; b. TSS; c. acidity, and d. overall sensory

influenced with aloe vera. The TSS content increased rapidly with increase in pomegranate juice per cent and while less during aloe vera juice per cent. The P values indicated that concentration of pomegranate juice was the most influencing factor followed by *aonla* juice and aloe vera was least effective over TSS gain. As it can explain for TSS, pomegranate juice has an effect on the total carbohydrates content that could increase total solids in blended juice. Second-order polynomial equation for TSS seems quite adequate to fit model (Equation 2).

$$\textit{Ascorbic acid} = 77.31 + 51.43X_1 + 5.04X_2 + 1.11X_3 - 0.25\,X_1X_2 - 2.50\,X_1X_3 + 0.75\,X_2X_3 + 10.64X_1^2 + 8.88X_2^2 + 7.99X_3^2\ (R^2 = 0.93) \quad (\ldots 1)$$

$$\text{TSS} = 9.66 + 0.48X_1 + 0.62X_2 - 0.69X_3 + 0.15\,X_1X_2 + 0.95\,X_1X_3 - 0.32X_2X_3 - 0.57X_1^2 - 0.042 - 0.15X_2^2 - 0.049 - 0.45X_3^2\ (R^2{=}0.84) \quad (\ldots 2)$$

$$\textit{Acidity} = 1.05 + 0.41X_1 + 0.057X_2 + 0.0078X_3 + 0.02X_1X_2 - 0.005X_1X_3 - 0.055X_2X_3 - 0.00983X_1^2 - 0.042X_2^2 - 0.049X_3^2\ (R^2 = 0.87) \quad (\ldots 3)$$

$$\textit{Overall Sensory} = 6.64 + 0.46X_1 + 0.100X_2 + 0.080X_3 + 0.10X_1X_2 + 0.10X_1X_3 - 0.15X_2X_3 - 0.081X_1^2 + 0.025X_2^2 + 0.15X_3^2\ (R^2 = 0.87) \quad (\ldots 4)$$

Juice colour is a key sensory attribute in influencing consumer acceptance. The juice percentage had significant effects on colour value ($p<0.01$). There was some homogeneity in colour parameters (L^*, a^* and b^*) among all the blends. Both a^* and b^* values were non-significantly different among all treatments, while L^* value was significantly increased with blending (p-values of 0.04, 0.045, and 0.74). Concentration of pomegranate juice leads to a decrease in the L^* value, while *aonla* and aloe vera juices increased the L^* value. The calculated colour a value ranged from 16.2 to 34.8. The positive coefficient of the linear term of pomegranate juice percentage indicated that as pomegranate juice content increased, a^* value increased proportionally. Similar finds were obtained by Jain and Khurdiya (4) and Seema *et al*. (9).

Acidity of the juice blend ranged 0.30 to 1.80. Concerning acidity, the intention was to incorporate the sufficient quantity of *aonla* juice in the blended juice with higher sensory scores. There was increase in acidity level when *aonla* juice increased. The *aonla* juice and pomegranate juice has significant effects ($p<0.01$) on acidity. The positive coefficients on linear term between *aonla* juices indicated that acidity increased with the increase in *aonla* juice (Fig. 1). Further, it was observed that when aloe vera juice was blended with *aonla* and pomegranate juice acidity was substantially lowered (negative coefficient of aloe vera juice and pomegranate juice). The three process variables were found non-significant in their respective quadratic terms. Moreover, 3D response (Fig. 1) was generated for the fitted model to visualize the combined effect of two variables on acidity, was found non-linear except pomegranate juice and aloe vera juice blending. The acidity content increased rapidly with increase in *aonla* juice per cent and pomegranate juice, while less during aloe vera juice per cent.

The combined effect of all variables was significant at quadratic level ($p = 0.001$) for key responses. Linear terms of all the three variables affected the sensory attributes of juice significantly ($p = 0.001$), whereas, interaction among variables for sensory attributes was not significant. The equation pertaining to overall sensory score of the blend is given in eq. 4. Earlier, Bhardwaj and Mukherjee

(3), Ram *et al.* (7) and Sasi Kumar *et al*. (9) found that the blending of fruit juice gave the best result on the basis of overall sensory quality and vitamin C content. Numerical optimization technique was adopted to find the optimum combination of juice blend ratio. The constraints were set such that the selected variables (X1, X2 and X3) would be minimum from economical point of view for the most important product attribute and close to the optimum for the others. The main criteria for constraints optimization were maximum possible maximum ascorbic acid and targeted TSS and colour were most important quality parameters. The process parameters for juice blending were numerically optimized for desirability function having equal importance (+) to all the three process parameters and equal importance (+++++) to two responses. The goal setting begins at a random starting point and proceeds up the steepest slope on the response surface for a maximum value of ascorbic acid. Table 2 shows the software generated optimum conditions of independent variables with the predicted values of responses. A graphical multi response optimization technique was adapted to determine the workable optimum conditions for the seasonal juice blending. The model equation for the response variables predicted values under the identified optimum conditions, which were experimentally verified to be in general agreement in the model. The 3D plots for all responses were superimposed and regions that best satisfy all the constraints were selected as optimum conditions. The optimized blending ratio was *aonla* juice, 15.6 per cent pomegranate juice and 12.7 per cent aloe vera juice to obtain optimum sensory and other chemical quality factors.

The RSM was effective in optimizing process parameters for juice percent of in the range of *aonla* juice in range of 71.6 per cent, pomegranate juice percent 15.6 per cent and aloe vera juice 12.7 per cent.

Table 2. Goal for optimization and the optimized values for each variables of *aonla*-based juice blend.

Parameter/ Variable	Goal	Optimized value
X1: *Aonla* juice (%)	Maximize	72.2
X2: Pomegranate juice (%)	in range	15.2
X3: Aloe vera juice	in range	12.6
Colour *L*	in range	23.50
Colour *a*	Maximize	-
Ascorbic acid	Maximize	81.5
Acidity	Minimize	0.41
TSS	Maximize	9.0
Colour *b*	Minimize	-
Overall sensory	Maximize	8.0

ACKNOWLEDGEMENT

Authors are thankful to Director, ICAR-CIPHET, Ludhiana, Punjab for facilities.

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Received : June, 2017; Revised : October, 2017; Accepted : November, 2017