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Development of Palmyra Palm (*Borassus flabellifer* Linn.) Fruit Pulp based Ready-to-Serve Beverage using Response Surface Methodology

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Abstract

The present investigation was done to develop ready to serve beverage from Palmyra palm (Borassus flabellifer Linn.) fruit pulp by optimizing the level of palmyra fruit pulp (PFP) and sugar through Central Composite Rotatable Design (CCRD) in Response Surface Methodology (RSM). The responses for optimization were acidity, pH, total soluble solids, total sugar, reducing sugar, non-reducing sugar, color, flavor, taste and after taste. A second order quadratic polynomial regression equation was fitted to the data for all responses to predict the level of PFP and sugar concentration. At linear level, the concentration of PFP significantly influenced the acidity ($p<0.01$), total soluble solids ($p<0.01$) and after taste score of ready to serve (RTS) beverage ($p<0.05$); the level of sugar had significant influence on the sensory attributes such as flavor ($p<0.01$), taste ($p<0.01$) and after taste of RTS beverage ($p<0.05$). The non-reducing sugar content of RTS beverage was negatively influenced (at $p<0.05$) by the interactive effect of PFP and sugar. At quadratic level, PFP had significant influence on acidity ($p<0.01$) and non-reducing sugar content of RTS beverage ($p<0.05$). The optimum level of PFP and sugar for the preparation of 100 ml of RTS beverage determined as per the set goals of 0.3% as maximum titrable acidity, 10% as minimum total soluble solids and 10% as minimum fruit pulp level with the desirability of 0.713 was 13.71 g and 18 g respectively.

Keywords: Central Composite Rotatable Design, Palmyra Fruit Pulp, Ready to Serve Beverage, Response Surface Methodology, Responses, Second Order Quadratic Polynomial Regression Equation

1. Introduction

Palmyrah is a dioecious palm considered to be a native of tropical Africa. It is distributed in Africa, India, Burma and Srilanka. The palm belongs to the family *Arecaceae*, subfamily *Borassoideae* and genus *Borassus*. The palmyrah palms are slow-growing perennials and have no distinguishing features to identify the sex until flowering. The palm commences flowering only after 12–15 years of maturity [1]. The coconut-like fruits are three-sided when young, becoming rounded or more or less oval, 12-15 cm wide and capped at the base with overlapping sepals. The outer covering is smooth, thin, leathery and brown, turning nearly black after harvest. Inside is a juicy mass of long, tough, coarse, white fibers coated with yellow or orange pulp [2]. The soft orange-yellow mesocarp of the ripe fruit is sugary, dense and edible; have excellent flavor and very attractive color which contains gums, albuminoids, fats and is reportedly rich in vitamin A and C [3]. The major reasons for the underutilization of these fruits are separation of the pulp from the fibre and its bitter taste. *Borassus* also contains bitter compound called flabelliferrins, which are steroidal saponins and this bitter principle was identified as tetraglycoside of the steroid isolated

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[3] & [4]. Debittering is a key step for wider utilization of PFP in the form of drinks, jams, cordials etc. There are traditional methods for debittering, including heating the PFP over hot coals as well as scientific methods, using enzymes namely naringinase (mixture of β-glycosidase and β-rhamnosidase) or heat stable α-amylase [4, 5].

The season of availability of palmyra palm fruits are from July to September. RTS beverages have been increasingly gaining popularity throughout the country due to their health and nutritional benefits, apart from pleasant flavor and taste. Fruit based RTS beverages are not only rich in essential minerals, vitamins and other nutritive factors but also are delicious and have a universal appeal [6]. Therefore the preparation of debittered PFP based RTS beverage with its unique flavor may be a convenient alternative for the utilization of PFP and also to mango pulp industry, thus providing a totally new experience for the consumer. In product development and optimisation, response surface methodology (RSM) can be used to model and optimize any response affected by levels of one or more quantitative factors [7]. RSM has been widely applied for optimising processes in the food industry [8–13]. Hence the present study was aimed to extract the palmyra palm fruit pulp (PFP), process to decrease the bitter taste and to develop a ready to serve (RTS) beverage from PFP with optimized level of PFP and sugar.

2. Materials and Methods

2.1 Sample Preparation

Locally grown ripe palm fruits (*Borassus flabelliffer* Linn.) were purchased directly from farmers in Thiruvannamalai district, Tamil Nadu. The ripe palmyra fruits were thoroughly washed with tap water in order to remove any dirt or adhering particles. The fruits were peeled off, pulp with fibrous portions were removed manually using stainless steel knife and crushed in home scale fruit juicer to get fine and thick pulp. The collected pulp was debittered by heating at 90˚C for 15 min; potassium metabisulphite (0.14 g/kg fruit pulp) was added and filled in sterilized glass bottles. Again the filled bottles were pasteurized (80˚C for 20 min) for further use.

2.2 Preparation of Ready to Serve Beverage

The sugar syrup was prepared from sugar, citric acid and water (100 ml) in a sterile stainless steel vessel. The homogenized pulp (minimum 10%) was added in the sugar syrup, heated at 85˚C for 20 minutes and removed from the fire, filtered through tea filter and added potassium meta-bi sulfite (70 ppm/litre) as preservative. The beverage was filled into bottles leaving a head space of 1", crown corked and processed in water for 15-20 min at 85˚C and air cooled.

2.3 Experimental Design

The level of palmyra fruit pulp (X_1:10–18 g) and sugar (X_2:10–18 g) for the preparation of PFP based RTS beverage was optimized using Central Composite Rotational Design (CCRD) matrix of 2^2 factorial designs comprising 13 experimental runs combined with four factorial points, four axial points and five central points (Table 1). The data was fitted to second order polynomial regression equation to study the combined effect of two independent variables such as palmyra palm fruit pulp and sugar concentration on quality of RTS beverage.

2.4 Responses for Optimization

The RTS beverage prepared from PFP as per the combination prescribed by CCRD of 13 runs were analyzed for its properties as responses for optimization such as acidity, pH, total soluble solids [14], total sugar, reducing sugar [15] and non-reducing sugar (subtraction of reducing sugar from total sugar).

Descriptive sensory analyses are the most sophisticated tools in the arsenal of the sensory scientist [16]. The developed PFP based RTS beverage was analyzed for its descriptive profile on colour (5-bright orange, 4-light orange, 3-yellowish orange, 2- golden yellow, 1-light

Table 1. Experimental design and independent variable levels in CCRD

Levels of independent variables					
Variables	Coded levels				
	-2	-1	0	1	2
Palmyra fruit pulp (X_1)	10	12	14	16	18
Sugar (X_2)	10	12	14	16	18

Experimental plan		
X_1	X_2	Number of Experiments
±1	±1	4
±2	0	2
0	±2	2
0	0	5

yellow), flavour (5-fruity, 4-sugary and fruity, 3-sugary, 2-fermented, 1-pungent), taste (5-juicy, 4-sweet and juicy, 3- sweet, 2-astringent, 1-bitter) and after taste (5-sweet and fruity, 4-sweet, 3-slightly bitter, 2-alcoholic, 1-sour) through an attribute scale (5 point scale) designed by the investigator for 50 semi trained panel members in the Department of Food Science and Nutrition, Periyar University, Salem.

2.5 Numerical Optimization and Point Prediction

The levels of each independent variable were predicted into current model by calculating the expected responses and associated confidence intervals (95%) based on prediction equation. A second order quadratic polynomial regression equation model was fitted to the data of all responses for prediction. The proposed model was

$$Y=\beta_0+\beta_1X_1+\beta_2X_2+\beta_{12}X_1X_2+\beta_{11}X_1X_1+\beta_{22}X_2X_2$$

Where β_0, β_1, β_2, β_{12}, β_{11}, β_{22} were the regression coefficients, X_1 and X_2 were independent variables and Y was the dependent variable. The optimum level of independent variables for RTS preparation was obtained by combining set goals of quality parameters of commercial RTS (Mango Juice) with maximum importance of 5. To determine the effect of independent variables on the quality of RTS beverage, contour plots and its three dimension surface graphs for each quality parameters were generated as a function of two variables. The quality of fit of second order quadratic polynomial regression equation was expressed by the coefficient of variation (CV %), R^2 and its statistical significance were determined by the F test. The individual and interactive effect of each variable was also determined. The predicted response levels for optimized levels of independent variables were validated through experimentation.

2.6 Cost of Production of PFP based RTS Beverage

The total cost of the product was calculated by including the cost of raw materials and consumables, salary and wages, power and fuel, repair and maintenance, administrative and marketing expenses, interest on term loan, interest on working capital loan, depreciation and 10% as net profit ratio.

2.7 Statistical Analysis

All responses were determined in triplicates and the average was considered for optimization. The experimental data were analyzed statistically using Design Expert Software 8.0.3.1 and SPSS version 17.0.

3. Results and Discussion

3.1 Estimated Response Levels

The TSS, acidity, pH, total sugar, reducing sugar, non-reducing sugar and sensory attributes (color, flavor, taste and after taste) were determined as responses for predicting best combination of PFP and sugar in the preparation of RTS beverage. The estimated levels of responses for 13 experimental runs as per CCRD matrix are presented in Table 2.

The total soluble solids ranged between 14.58-19.66°Brix; acidity between 0.22-0.33%; pH between 3.44-3.61; total sugar between 13.66-21.00 %; reducing sugar between 8.00-16.66%; non reducing sugar between 4.00-6.33% and total sensory score between 12.36-15.08 (sum of scores for color, flavor, taste and after taste). Descriptive sensory analysis revealed that the developed PFP based RTS beverage was light to bright orange in color, sugary and fruity flavor, sweet taste and slightly bitter after taste. Similar result on titrable acidity ranges between 0.28-0.32% citric acid equivalent; pH as 3.12 to 3.17; TSS as 15°Brix; total sugar ranges between 16.6 to 21.9 % of PFP based RTS beverage was noted by Nilugin and Mahendran (2010) [17]. The pH of the developed RTS beverages was below 4. This was supported by Cole *et al.* (2000) that the pH of most soft drinks and juices is less than 4 [18].

3.2 Influence of Independent Variables on Responses

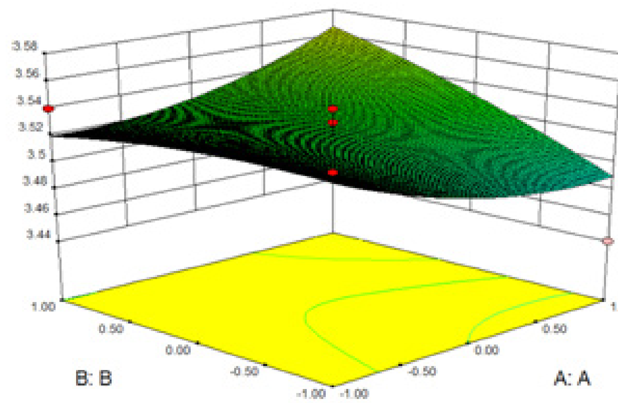
The magnitude of the terms indicates the order of influence on each response and the difference in magnitude of the quadratic terms explains which variable was dominant for response. The sign and magnitude of coefficients indicate the effect of variable on the response. Negative sign of the coefficient means decrease in response when the level of the variable is increased, while positive sign indicates increase in the response. Significant interaction suggests that the level of one of the interactive variable can be increased while the other decreased for constant value of the response [19].

Table 2. Estimated response levels of experimental runs

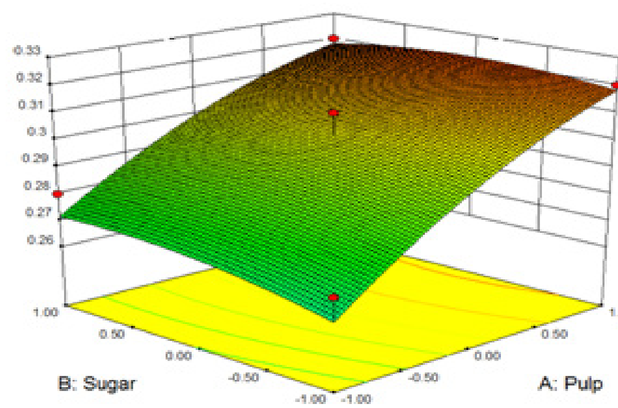
Runs	pH	Acidity (%)	TSS (°Brix)	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)	Color	Flavor	Taste	After Taste	Total Sensory Score
1	3.54±0.01	0.27±0	14.58±0.25	9.33±2.06	4.00±1.26	13.66±1.2	4.13±0.95	3.52±1	2.80±1	2.60±1.2	13.22±2.78
2	3.44±0.02	0.32±0	15.83±0.6	8.00±1.26	5.83±0.98	13.66±1.5	4.21±0.78	3.60±0.98	2.86±0.87	2.66±1.19	13.44±2.63
3	3.54±0.02	0.28±0	16.75±0.4	9.66±1.5	6.00±1.78	16.00±1.26	3.98±0.98	3.96±0.74	3.13±0.95	3.17±1.14	14.22±2.65
4	3.53±0.04	0.32±0	17.33±0.41	10.33±1.5	4.66±2.06	15.00±1.09	4.62±0.63	3.66±0.79	3.15±1	2.76±1.25	14.16±2.47
5	3.55±0.03	0.22±0	15.75±0.25	8.66±1.03	6.33±1.5	15.00±1.09	4.25±0.77	3.94±0.81	3.54±0.85	3.31±0.96	14.96±2.17
6	3.61±0.02	0.33±0	15.83±0.37	9.66±1.5	5.66±1.5	15.00±1.09	4.66±0.58	3.64±0.84	2.76±1.06	2.37±1.18	13.22±2.21
7	3.48±0.01	0.28±0	14.66±0.4	9.33±1.63	4.66±1.63	14.00±0.78	4.27±0.89	3.50±0.94	2.68±1.17	2.27±1.18	12.36±2.53
8	3.53±0.01	0.29±0	18.83±0.4	11.66±1.5	5.00±1.09	16.33±1.5	4.47±0.8	3.98±0.88	3.70±1.15	3.29±1.34	15.08±2.46
9	3.54±0.02	0.31±0	19.00±0	16.66±1.63	4.33±1.5	19.66±1.5	4.60±0.91	3.96±0.89	3.23±1.25	2.98±1.31	14.36±2.22
10	3.51±0.01	0.31±0	19.66 ±0.49	15.00±2.09	6.00±1.78	21.00±1.09	4.31±1.08	3.76±1.19	3.17±1.22	2.74±1.45	13.44±2.32
11	3.53±0.01	0.3±0	16.58±0.54	13.00±1.09	4.00±1.216	17.00±1.09	4.58±1.25	3.74±1.29	3.15±1.5	2.80±1.61	13.68±2.55
12	3.54±0.01	0.29±0	18.5±0.37	14.33±2.33	4.33±1.5	18.66±2.06	4.70±1.18	3.86±1.34	3.11±1.55	2.98±1.69	13.98±2.14
13	3.51±0.01	0.29±0	18.75±0.25	10.00±1.78	4.33±0.81	14.33±1.05	4.31±1.5	3.88±1.46	3.25±1.75	2.94±1.79	13.64±2.52

The values are the average of six determinants. TSS- Total Soluble Solids

According to the coefficients for the proposed second order quadratic polynomial regression equation in terms of actual variables indicated in Table 3, at linear level the TSS, acidity and total sensory score were increased significantly ($p<0.01$) with increase in level of PFP while addition of sugar revealed significant ($p<0.05$) change in flavor, taste and after taste of RTS beverage. At interactive level (Figure1a – j), the non reducing sugar



1(a)



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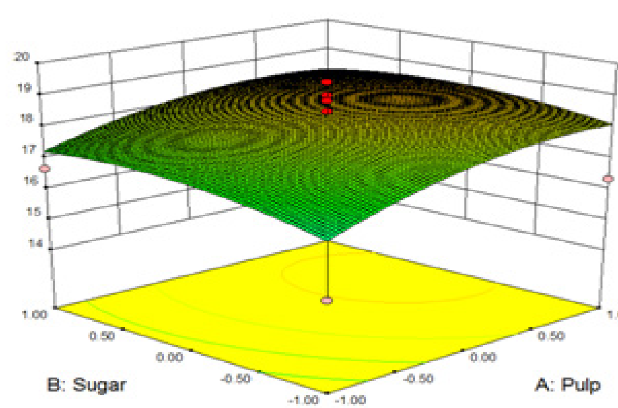

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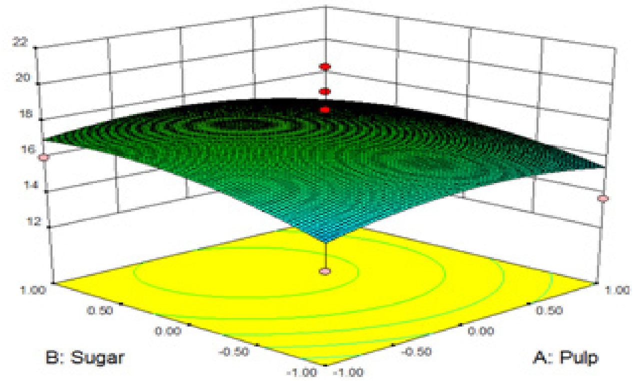

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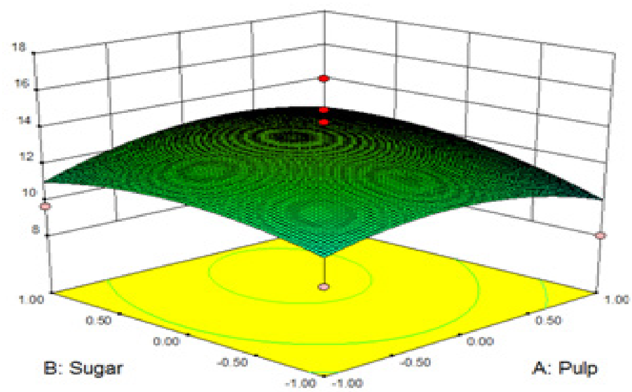

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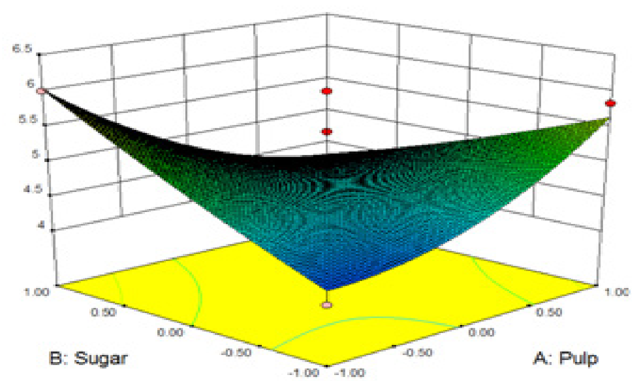

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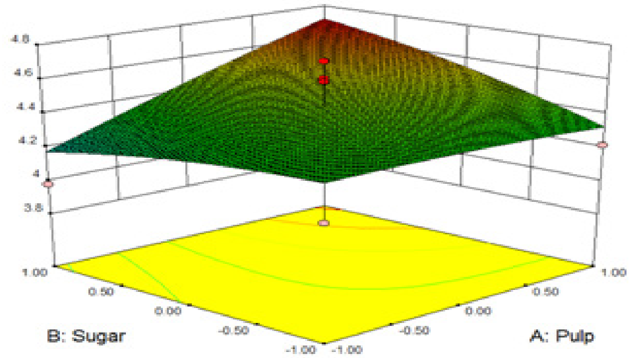

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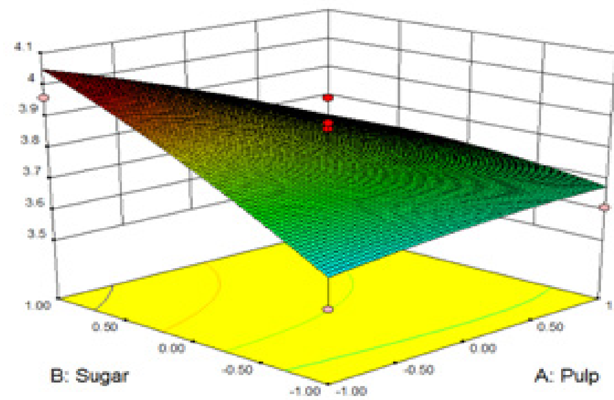

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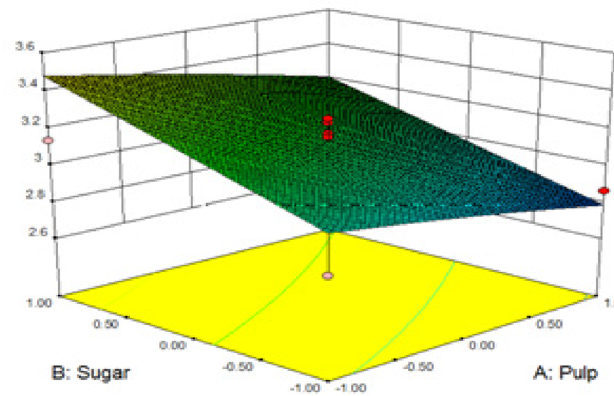
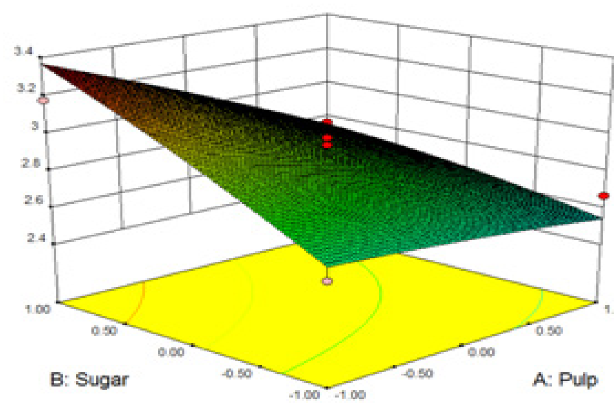


1(i)



1(j)

Figure 1. Response surface plots for different quality parameters of PFP based RTS beverage. 1a) pH, 1b) Acidity, 1c) TSS, 1d) Total sugar, 1e) Reducing sugar, 1f) Non reducing sugar, 1g) Color, 1h) Flavor, 1i) Taste, 1j) After taste.

of RTS beverage was significantly negatively influenced at $p<0.05$. At quadratic level the palmyra fruit pulp had significant negative influence on acidity ($p<0.01$) and significant positive influence on non reducing sugar content ($p<0.05$) of the RTS beverage.

The magnitude of terms revealed that the palmyra fruit pulp had greater influence on pH, acidity, total soluble solids, reducing sugar, color and after taste of RTS beverage while sugar had greater influence on total sugar, non reducing sugar, flavor and taste of RTS beverage. Nilugin and Mahendran (2010) reported the same results that acidity and sugar value of PFP beverage increased with the increase in the concentration of palmyra pulp. As suggested by Nilugin and Mahendran (2010), this can be attributed partly to the contribution of the inherent acid naturally present in the palmyra fruit pulp [17]. According to Theivendirarajah (1992), the inherent acidity of palmyra fruit pulp is mainly attributed to tartaric acid at the concentration of 2.35 g/litre [20]. Similarly Nilugin and Mahendran (2010) also reported that addition of palmyra fruit pulp did not impart significant changes in aroma of RTS beverage [17].

3.3 Response Surface Model Evaluation

The coefficient of determination (R^2), model 'p' value, lack of fit 'p' value, CV% and adequate precision value of the regression model using CCRD for each response are presented in Table 3 and Table 4.

The adjusted R^2 above 0.8 for acidity (0.935) and after taste (0.89) showed good fit of the model with experimental data, while R^2 value between 0.5 and 0.8 for pH (0.604), TSS (0.529), reducing sugar (0.519) and non reducing sugar (0.66), color (0.55), flavor (0.79) and taste (0.74) indicated fair fit of the model with the experimental data.

The CV% value less than 10% for pH (0.91), acidity (3.1) and total soluble solids (6.96), color (4.57), flavor (2.63), taste (6.22) and after taste (4.83) showed that the experiments conducted were precise and reliable. Adequate precision measures the signal to noise ratio. A ratio greater than 4 is desirable. The adequate precision value greater than 4 for pH (4.93), acidity (16.13), non-reducing sugar (4.58), color (4.33), flavor (8.63), taste (6.73) and after taste (11.22) indicated adequate signal for better prediction and optimization. The significance of model indicating fit of the proposed second order quadratic polynomial regression model for proper prediction of data which was significant at $p<0.05$ for non reducing sugar and at $p<0.01$ for acidity.

The insignificant lack of fit 'p' value for all determined responses except for pH and total soluble solids suggested that the proposed second order quadratic polynomial regression model was probably appropriate and adequate for prediction / optimization.

3.4 Optimization and Validation

Numerical multi-response optimization was adopted to determine the optimum level of each independent variable. The respective predicted level of responses as per the set goals (Table 5) with maximum desirability function

Table 3. Regression coefficients for estimated responses

Coefficients and Terms	pH	Acidity	TSS	Reducing Sugar	Non-reducing Sugar	Total Sugar	Color	Flavor	Taste	After taste
β_o	3.52	0.30206	18.38	13.11	4.63	17.57	4.444	3.811	3.135	2.876
β_1	0.0008	0.0258*	0.645*	0.1116	-0.07083	-0.0833	0.1290	-0.0667	-0.1242	0.0396*
β_2	0.0158	0.0025	0.21583	0.61	0.12583	0.695	0.0539	0.119**	0.222**	0.0396*
β_{12}	0.0225	-0.0025	-0.1025	0.5	-0.792**	-0.25	0.1421	-0.0931	-0.0098	0.0687
β_{11}	0.0131	-0.006*	-0.46106	-1.20231	0.351**	-0.8174	-0.0150	-0.0142	-0.0112	0.0287
β_{22}	-0.0056	-0.00362	-0.36731	-0.86856	0.06002	-0.7761	-0.0371	-0.0265	-0.0014	0.0287
R^2	0.6044	0.93574	0.5293	0.5181	0.6645	0.4289	0.5515	0.7997	0.7471	0.8926
Model 'p' value	0.1747	0.0005	0.2819	0.3000	0.1080	0.4582	0.2477	0.216	0.0455	0.0028
Lack of fit 'p' value	0.0284	0.5813	0.0056	0.5027	0.1587	0.6525	0.3335	0.3236	0.0043	0.2098
Predicted R^2	-2.355	0.76021	-2.839	-0.78419	0.21417	-0.7977	-1.0347	0.113	-1.14	0.2602
Adeq. Precision	4.935	16.1378	3.759	3.007688	4.5817	2.825	4.331	8.632	6.7334	11.244
CV (%)	0.91	3.21	6.96	21.98	12.71	14.54	4.57	2.635	6.22	4.838

*Significant at $p<0.01$, **Significant at $p<0.05$.

Table 4. Proposed model equation

Response	Equation
pH	$Y= 4.87\beta_0 - 0.17\ \beta_1 - 0.031\beta_2 + 0.005\beta_{12} + 0.003\beta_{11} - 0.001\beta_{22}$
Acidity	$Y= - 4.96\beta_0 + 0.064\beta_1 + 0.035\beta_2 - 0.0006\beta_{12} - 0.001\beta_{11} - 0.0009\beta_{22}$
TSS	$Y= - 33.2608\beta_0 + 3.9090\beta_1 + 3.0378\beta_2 - 0.02563\beta_{12} - 0.1152\beta_{11} - 0.0918\beta_{22}$
TS	$Y= - 77.048\beta_0 + 6.555\beta_1 + 6.655\beta_2 - 0.0625\beta_{12} - 0.2043\beta_{11} - 0.19405\beta_{22}$
RS	$Y= - 68.9108\beta_0 + 6.721\beta_1 + 4.634\beta_2 + 0.125\beta_{12} - 0.3005\beta_{11} - 0.2171\beta_{22}$
NRS	$Y= - 14.4338\beta_0 + 0.2794\beta_1 + 2.4165\beta_2 - 0.1981\beta_{12} + 0.0878\beta_{11} + 0.0150\beta_{22}$
Color	$Y= 7.498\beta_0 - 0.3203\beta_1 - 0.2083\beta_2 + 0.035\beta_{12} - 0.0037\beta_{11} - 0.009\beta_{22}$
Flavor	$Y= - 3.2567\beta_0 + 0.4\beta_1 + 0.5825\beta_2 - 0.0237\beta_{12} - 0.0036\beta_{11} - 0.0067\beta_{22}$
Taste	$Y= 1.334\beta_0 + 0.0523\beta_1 + 0.1548\beta_2 - 0.0025\beta_{12} - 0.0028\beta_{11} - 0.0003\beta_{22}$
After taste	$Y= - 5.1617\beta_0 + 0.4085\beta_1 + 0.7193\beta_2 - 0.02938\beta_{12} - 0.00322\beta_{11} - 0.00697\beta_{22}$

TSS – Total Soluble Solids, TS – Total sugar, RS – Reducing sugar, NRS – Non reducing sugar

Table 5. Set goals and importance of process parameters and responses

Variables	Target	Experimental range		Importance	Mango juice
		Lower Limit	Upper Limit		
Pulp (%)	is in range	10	18	3	-
Sugar (%)	is in range	10	18	3	-
Acidity (%)	is target = 0.3	0.22	0.33	5	0.046
pH	minimum (3.44)	3.44	3.61	5	3.82
TSS (°Brix)	is target = 15	14.83	19.41	5	15.5
Colour	maximum (4.7)	3.98	4.7	5	4
Flavour	maximum (3.98)	3.5	3.98	5	4
Taste	maximum (3.7)	2.68	3.7	5	5
After Taste	maximum (3.31)	2.27	3.31	5	4

TSS- Total Soluble Solids

was validated by preparing RTS beverage using optimum level of independent variables and determining its quality parameters (Table 6). The minimum level for pH and maximum level for sensory parameters were set in the target to get maximum desirability in the RTS beverage. The actual level of quality parameters were statistically on par with predicted levels. For the graphical interpretation of independent variables interactions, the use of an overlay plot of the regression model has been highly recommended [21].

The range of optimum conditions can be visualized by superimposing the contours for the various response surfaces in an overlay plot [22]. It defines a region in which optimum values for all responses, which was evaluated as a function of PFP and sugar. The small shaded area indicates the optimum conditions for the development of PFP based RTS beverage (Figure 2).

Table 6. Validation of optimum level of responses

S.No.	Responses	Predicted	Actual Value
1	pH	3.522	3.53±0.04
2	Acidity (%)	0.2894	0.286±0.02
3	TSS (°Brix)	17.27	17.04±0.19
4	Color	4.34	3.78±0.5
5	Flavor	3.98	4.2±0.63
6	Taste	3.59	3.46±0.93
7	After taste	3.279	3.38±0.92

TSS- Total Soluble Solids

The optimum level of independent variables for RTS beverage preparation with prescribed limit of responses suggested by FPO and FSSAI, 2011 (15 % total soluble solids, 0.3% acidity) and as well as comparable with mango Juice available in the market was 13.71g% of PFP, 18 g% of

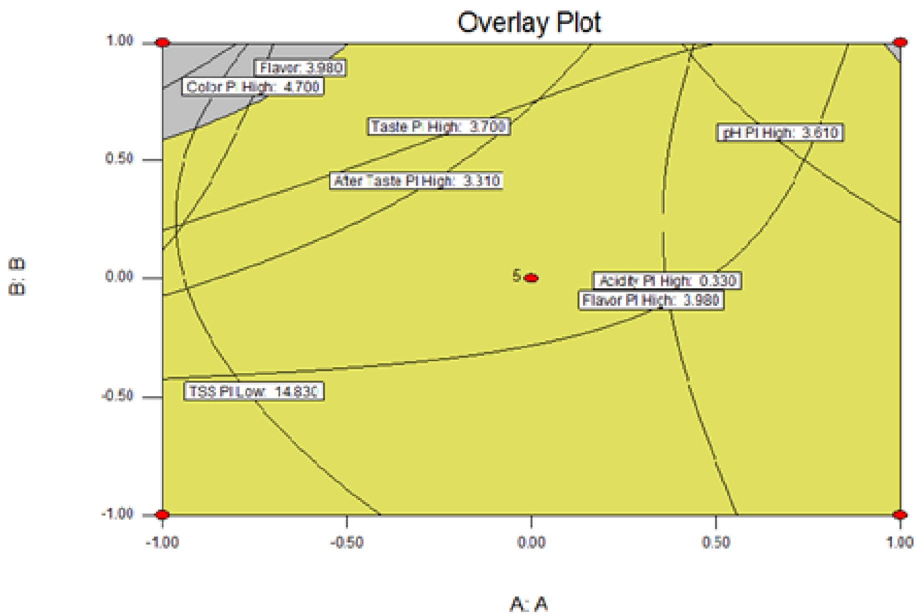


Figure 2. Overlay contour plot of the seven responses; A - Pulp, B – Sugar.

Table 7. Production cost of PFP based RTS beverage

S.No.	Expenses/litre	Cost of Production in Rs.
1	Personnel **Total(A)**	2.00 2.00
2	Raw materials a) Palmyra palm pulp b) Sugar c) Citric acid d) Water **Total(B)**	 2.50 7.00 0.50 2.00 **12.00**
3	Utilities a)Fuel b)Water c)Power **Total(C)**	 0.50 0.50 0.50 **1.50**
4	Contingency expenses a)Transport b)Publicity, Postage, Telephone, Stationary c)Packaging material cost **Total(D)**	 0.50 0.50 3.00 **4.00**
5	Depreciation on building (@5%) for 100L production/day	0.86
6	Depreciation on machine (@1%)	0.69
7	Interest on capital investment (@12%)(Rs.3750000) **Total(E)**	3.13 **4.68**
8	Total cost of production (A+B+C+D+E)	24.18
9	Net profit ratio@10%	2.42
10	Cost of developed production per liter	26.60
11	Valid cost of production per liter	27.00

sugar with the desirability of 0.713. Titrable acidity of the RTS beverage having 12% of palmyra pulp was found to be 0.3% which is similar to the commercial recommendation of acidity (0.3%) for RTS preparation [23]. The optimum level of fruit pulp identified in the present study was little higher than the level suggested by Nilugin and Mahendran (2010) as 12 % in terms of physical, chemical, microbiological and overall acceptability of RTS beverage from palmyra fruit pulp [17].

3.5 Production Cost of PFP Based RTS Beverage

The cost calculation for the production of one litre of developed PFP based RTS beverage with optimum level of fruit pulp and sugar (Table 7) revealed that the total cost of production was Rs. 27/- and comparatively lower than commercial mango fruit drink (Rs.50 – 60/-).

4. Conclusion

The regression equations for each response obtained can be used to predict optimum conditions for desired responses. Thus the mango fruit processing industries can scale up the extraction of palmyra fruit pulp and preparation of RTS beverage from the extracted palmyra fruit pulp in the months of August to October which is out season for mango. This also enables the consumers to purchase indigenous carotenoid rich fruit drink all over the world.

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