

Process Optimization for Tamarindus Indica. L Pulp Extraction Using Response Surface Methodology



Food science

KEYWORDS : Hot water extraction, Tamarind pulp, Response surface methodology, optimization

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ABSTRACT

A central composite design was developed to optimize the extraction conditions of Tamarindus indica. L pulp. Time (15-30 min) and temperature (40oC-100oC) were the independent variables. Pulp yield, odour, taste and sourness were the dependent variables, for which the combined effect of independent variables was analyzed. Obtained results depicted the data variation and significant relationship between the independent variables and dependent variables. The results depicted that extraction temperature is an important factor because it affects the odour, which made the pulp less acceptable. Increase in temperature increases the pulp yield but it also increases the sourness which affected the quality of the pulp. The relationship between the dependent and independent variable where shown by the contour plots and the responses were developed. Superimposing of the contour plots gave an optimum condition of 40oC for 15min for hot water extraction of Tamarindus indica. L pulp.

Introduction:

Ready to use pulp has become an important part of culinary throughout the world. With the increase in market size, a wide variety of new fruit products are supplied to the consumers. India ranks top among the countries of the world in production of tamarind products (1). Tartaric acid, which is the main acidulant in the preparation of foods in India and other Asian countries, is the major composition of tamarind (2). Traditional methods of tamarind pulp preparation are commonly used but commercial preparation is not developed properly. It is used mainly for food preparation and for medicinal purposes (3). It was reported that extraction of food substance using hot water method could make the enzymes inactive (4). Hence an experiment was done in this study for the production of tamarind pulp using hot water extraction for a better yield. Sensory consumer test has always been an important criteria for modern food industries for the development of new product, as well as in the optimization of existing process. In order to model the responses of consumers to generate predictive equations which correlate the consumer response with the variables, response surface methodology is used (5). The study was aimed to find the combined effect of extraction time and temperature on the organoleptic properties of tamarind pulp using RSM.

2. Materials and methods

2.1. Tamarind pods

The fruits were procured from Krishnagiri district, Tamilnadu, India with a high fruit flesh composition (30%). Fruits were separated from pods and seeds, dried under sun. Dried fruits were stored in HDPE bags under room temperature.

2.2. Sample preparation

Fruits were weighed and soaked in hot water at different temperature in the ratio 1:3(w/w) for different duration (Table.1). The temperature of the water was maintained using a hot water bath. After the soaking time the mixture was blended with a hand blender for 10 min. The pulp was extracted and filtered through a perforated stainless steel sieve. The pulp obtained from each sample was weighed and packed.

2.3. Experimental Design

Face centred central composite design of response surface methodology was used to optimise the extraction process of pulp from tamarind, after determining the preliminary range of the extraction variables through single-factor tests. Extraction time (X1) and extraction temperature (X2) were the variables whose effect on the responses was studied. The range of the extraction time and extraction temperature was set between 15-45 min and 40- 100°C respectively. The effect of the independent variables was studied with respect to pulp yield, odour, taste and sourness of the pulp. To represent the levels of the

experimental design three coded factor levels were fixed -1, 0, +1 in which -1 corresponds to the low level of each factor, 1 to the high level and 0 to the mid-level. The trial version of Design Expert version 8.0.7.1 (Stat-Ease Inc., Minneapolis, MN, USA) software was used to develop the experimental design, to evaluate the results and to plot the three-dimensional response surface curves. An experimental design with 14 combinations consisting of six replicate runs at the centre of the points was obtained (Table.1). To estimate the pure error six replicate runs were performed at the centre point. Randomized order was followed in performing experiments in order to avoid the effect of unexplained variability in the observed responses due to extraneous factors(A1)(6). Linear, quadratic and interactive were the partitioned components of reponse function (Y) (7).

Table A.1 Responses with respect to extraction time and temperature

Factor 1	Factor 2	Response 1	Response 2	Response 3	Response 4			
Std Run	Block	A:Time	B:Temp	Yield	Taste	Odour		
Sourness		Min	°C	%				
7	1	Block 1	30.00	70.00	79.04	3	3	
1	2	Block 1	15.00	40.00	87.02	4	4	4
2	3	Block 1	45.00	40.00	76.4	3.5	3.5	3.5
6	4	Block 1	30.00	70.00	77.77	3	3	3
4	5	Block 1	45.00	100.00	76.9	2.5	2	2
3	6	Block 1	15.00	100.00	76.88	3	2	2.5
5	7	Block 1	30.00	70.00	77.72	3	3	3.5
8	8	Block 2	15.00	70.00	82.12	3.5	3	3.5
10	9	Block 2	30.00	40.00	85.04	4	3.5	4
13	10	Block 2	30.00	70.00	79.64	3	3	3

2.4. Percentage of pulp yield

The weight of tamarind pulp obtained from each sample was obtained using a weighing balance. The sample was placed in a beaker, whose weight was known and weighed. The percentage yield of pulp obtained was then calculated using the equation below:

$$\% \text{ Yield} = \{ \text{weight of the pulp} / (\text{weight of the raw pulp} + \text{water}) - \text{waste} \} * 100$$

2.5. Sensory evaluation

Sensory laboratory, Department of food science and technology, Pondicherry University was used to evaluate the samples for sensory characteristics. Fresh tamarind pulp were prepared with designed treatments and evaluated by the sensory panel.

The panel consisted of 10 trained members, to evaluate the samples based on the given characteristics. The sensory panel evaluated the sample for odour, taste and sourness using a five point hedonic scale and the mean scores were computed.

3. Results and discussion

3.1. Model fitting

For optimising two parameters 14 trial runs were designed. The percentage of pulp extracted using hot water bath method was 75.04% to 87.02% with respect to different combinations of independent variable. The pulp yield mainly depends on the extraction time but extraction temperature also equally affects the same. With the extraction temperature of 40°C and time 15 min a maximum yield of 87% was observed. The corresponding R^2 of each response is shown in Table A.2. Adequate response surface models were developed with respect to yield, taste, odour and sourness. R^2 should be at least 0.80 for a good fit of a model (8). The responses had R^2 values higher than 0.80, indicating that the regression models explained the reaction well. The responses such as pulp yield, taste, odour and sourness had R^2 values of 0.8958, 0.8864, 0.9894 and 0.9372 respectively for pulp yield, odour, taste and sourness. The probability (p) values of all regression models were less than 0.001 except for taste and sourness ($p < 0.01$), which had no lack of fit.

Table A.2 Regression co-efficients, R^2 , adjusted R^2 and p or probability values for four dependent variables for tamarind pulp extract

	Pulp yield%	Odour (panel)	Taste (panel)	Sourness (panel)
Intercept b_0	79.19	2.99	2.99	3.11
b_1	-2.50**	-0.33**	-0.083*	-0.25*
b_2	-3.37***	-0.67***	-0.83***	-0.83***
b_1^2	0.000	0.10	0.050	0.083*
b_2^2	0.000	0.10	-0.20**	-0.17
b_{12}	2.66	0.000	0.13**	0.000
R^2	0.8958	0.9894	0.8864	0.9372
Adjusted R^2	0.8611	0.9818	0.8053	0.8923
P or probability	<0.0001	0.0033	<0.0001	0.0004

Subscripts: 1 = extraction time; 2 = extraction temperature.

*Significant at 0.05 level.

**Significant at 0.01 level

***Significant at 0.001 level.

3.2. Effect of extraction time and temperature

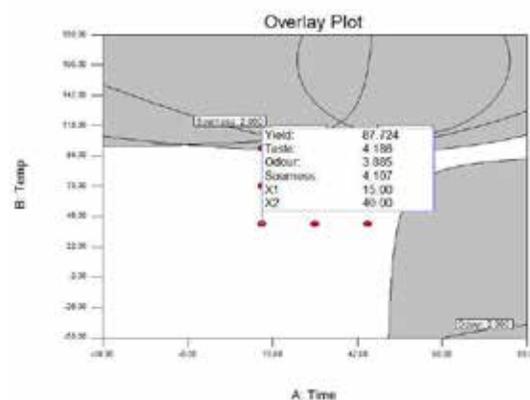
The coefficient of second order polynomials reveals the effect of extraction conditions on the pulp yield, odour, taste and sourness (Table A.2). The pulp yield was significantly affected by the by the linear ($p < 0.001$) and quadratic ($p < 0.01$) effect of the extraction temperature as shown in Table A.2. There was a significant ($p < 0.01$) effect on pulp yield with respect to the interaction between the variables. Results suggest that the primary determining factors for pulp yield were linear and quadratic effects of the extraction temperature. Increase in temperature resulted in decrease of pulp yield. Therefore through the experiments it was studied that high yield was obtained at low extraction temperature. With higher extraction temperature the taste decreased. The temperature had a significant effect of $p < 0.001$ on odour. Even though the terms were negative, the interaction among the variables had good influence on the odour. Longer time and higher temperature decreases the characteris-

tic odour of the pulp. High temperature which also contributes to high sourness may influence the taste score value. Extraction temperature significantly influenced the sourness. The linear terms were more significant at $p < 0.001$ and quadratic terms significant at $p < 0.05$ level. Hence, high sourness is not a desirable character of pulp. Time did not show profound effect on sourness.

3.3. Optimization of extraction condition Superimposing the

contour plots of all response determined the optimum extraction conditions. Consumer's perception of the pulp was determined using QDA test. Contour plots using predicted equation were generated and acceptance limits were set for each attribute. The contour plot for pulp yield and odour showed that with increase in time and temperature decreased the yield and characteristic odour. Hence lower temperature was significant to obtain high score value. Taste and sourness decreased significantly with increase in temperature. High temperature results in high sourness. The contour plots with respect to taste showed a high score at a range of 40°C – 60°C, which reduced as the temperature increased. Hence the tamarind pulp would be considered the best with maximum pulp yield of 87%, maximum odour of 4.0, taste of 4.0 and sourness score of 4.0. It was graphically optimized with the criteria (a) maximum pulp yield, (b) maximum taste, (c) maximum odour (d) maximum sourness. The superimposed plot of the above criteria gave an optimum region (Fig A.1).

Fig A.1 showing the optimized extraction conditions with overlay plot



The optimum condition, by overlapping all the responses was found to be 40°C for 15min.

4. Conclusion

Optimization of tamarind pulp extraction using RSM produced pulp with stronger taste, odour and higher pulp yield but lower sourness. The overall acceptability of the pulp does not depend much on the time but lesser extraction time may improve it. The results suggest that for maximal pulp extraction, the soaking should be carried out at 40°C for 15 min since a higher extraction temperature may cause the pulp to be sourer and lose its characteristic odour and taste.

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