Effect of Process Parameters on Extraction of Pulp from Tamarind Fruit

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Abstract—*Box-Behnken design was employed to design the experiments for tamarind pulp extraction. The independent variables chosen were water to tamarind fruit ratio, soaking time and soaking temperature, varied between 2:1 – 3:1, 20 – 40 min and 25 - 55°C respectively. The responses for the experimental design were pulp yield and overall acceptability. The results showed that pulp yield increased with the increase in water to fruit ratio, soaking time and temperature. At higher values of water to fruit ratio there was no further increase in pulp yield. Soaking time and temperature alone are the only two variables which affected the overall acceptability of pulp. The optimum conditions derived for pulp extraction were 2.5:1 water to fruit ratio, 31min soaking time and 38°C soaking temperature. Characterization of the pulp made under optimized conditions revealed 28.23 ± 2.45 L^*-value, 8.32 ± 1.2 a^*-value and 16.89 ± 1.9 b^*-value for color analysis. Total solids, total soluble solids, acidity and pH of the pulp were 10g/100g ± 0.3, 8.4 ± 0.2°B, 11.86 ± 0.4% and 2.24 ± 0.2 respectively.*

Keywords: *tamarind pulp, water to tamarind fruit ratio, soaking time, soaking temperature, pulp yield, overall acceptability*

1. INTRODUCTION

Tamarind (*Tamarindicus indica* L.) a type of tree is a member of dicotyledonous family leguminosae, which is the third largest family of flowering plants [1]. Tamarind is native to Eastern Africa, including parts of the Madagascar dry deciduous forests. The tree grows wild throughout the Sudan and introduced into most tropical areas around the world. Tamarind has become naturalized in many areas particularly in India, Southeast Asia, tropical America, the Pacific Islands and the Caribbean [2]. India is the world's largest producer of tamarind. Indian states like Madhya Pradesh, Bihar, Andhra Pradesh, Karnataka, Tamilnadu and West Bengal are major producers of tamarind. In the year 2012-2013 production of tamarind in India was about 189980 Tonnes [3]. *Tamarindus indica* is one of the most common and important cash trees of India. Each part of the tree finds some use, but the most useful part is the fruit, which yields acidic pulpy material. The pulp of tamarind (*Tamarindus indica* L.) fruit contains tartaric acid, which renders it acidic in taste. The pulp also contains reducing sugars, pectin, protein, fiber, and cellulosic materials [4]. Because of its pleasant acidic taste and rich aroma, it is used as the chief souring agent for curries, sauces, and certain beverages. Tamarind pulp has been reported to be used as a raw material for the preparation of wine-like beverages [5]. The tamarind pulp also claims some medicinal uses, as it was regarded as a digestive, carminative, laxative, expectorant and blood tonic [6] and found to possess hypolipidemic activity [7] and hypoglycemic activity [8].

Tamarind fruits are rarely used directly. Instead, they are deshelled, soaked in water for some time and then pulp is extracted manually. The yield and the quality characteristics of the pulp vary with process conditions. The process parameters include Water to fruit ratio, soaking time and soaking temperature. The aim of the present study was to study the effect of process parameters on the extraction of tamarind pulp and to optimize process parameters for pulp extraction and its characterization.

2. MATERIAL AND METHODS

2.1. Materials

Fresh and fully ripened tamarind pods were procured from Pune, India.

2.2. Sample preparation

The shell of the tamarind fruit was removed manually and then deshelled fruit was soaked in water according to an experimental design described at the item number 2.5. For every experimental run after a known soaking time, the mixture was blended with a laboratory type blender and sieved to separate fiber, rags and seeds from the pulp. The pulp was then filtered through three layers of muslin cloth to obtain fine pulp and weighed.

2.3. Pulp yield

Pulp yield for each experimental run was calculated according to the formula given below:

$$ulp\ yield\ (\%) = \frac{Weight\ of\ extracted\ pulp - Weight\ of\ water\ added}{Weight\ of\ deshelled\ tamarind\ fruit} \times 100$$

2.4. Overall acceptability

Over acceptability of pulp was done on the basis of color, taste, odour and sourness of the pulp using a nine point hedonic scale. Fresh tamarind pulp prepared under different experimental conditions was evaluated by the sensory panel consisted of 10 trained members. Panelists evaluated the overall acceptability of samples based on the given characteristics.

2.5. Experimental design

A three factorial three level Box-Behnken design consisting of 17 experimental runs including five replicates at centre point was employed to design the tests for the extraction of pulp (Table 1). The independent variables chosen were water to fruit ratio, soaking time and soaking temperature, varied between 2:1 to 3:1, 20 to 40min and 25-55°C, respectively. The responses for the experimental design were pulp yield and overall acceptability.

The significant terms in the model were found by analysis of variance (ANOVA). The adequacy of the model was checked by calculating the R^2. The response surface methodology (RSM) was applied using a commercial statistical package, Design expert version 8.0.2 (Statease Inc., Minneapolis, USA), to identify the optimum levels of the process variables viz. water to fruit ratio, soaking time and soaking temperature regarding two responses pulp yield and overall acceptability. The numerical optimization techniques of the design expert software were used for simultaneous optimization of multiple responses. The desired goals for each variable and response were chosen. All the independent variables were kept within range, while the responses were maximized.

Table. 1: Experimental Design for extraction of tamarind pulp with their corresponding response values.

Run	Water: Fruit	Soaking time	Soaking temperature	Pulp yield	Overall acceptability
1	2.50	30	40	49.20	7
2	3.00	30	25	47.52	8
3	3.00	40	40	49.89	6
4	3.00	30	55	51.39	4
5	2.5	30	40	48.9	8
6	2.5	30	40	49.6	8
7	2.00	30	55	36.22	3
8	2.50	20	25	43.17	8
9	2.00	30	25	26.67	8
10	2.50	40	25	45.38	8
11	2.00	40	40	37.60	6
12	2.50	40	55	50.16	2
13	2.50	30	40	49.59	8
14	3.00	20	40	46.41	8
15	2.50	20	55	47.95	4
16	2.50	30	40	51.12	8
17	2.00	20	40	32.68	8

2.6. Characterization of pulp made under optimized conditions

2.6.1. Color

The color of the pulp was determined using a color spectrophotometer (CM-3600d, Konica Minolta). The results were expressed in terms of Hunter color values of L*, a*, and b*, where L* denotes lightness and darkness, a* redness and greenness, and b* yellowness and blueness. Triplicate samples were analysed for color values and the mean was recorded.

2.6.2. Total solids

Approximately 5g of extracted pulp was taken in a petriplate and dried in vacuum oven at a temperature of 70 ^{o}C until a constant weight was obtained. The total solid content (%) of the pulps was calculated by using the formula:

$$TS\ (\%) = 100 - \text{moisture content}$$

2.6.3. Total soluble solids

The total soluble solids of the pulp was measured by refractometry using an Atago hand held refractometer and the results were expressed in °Brix. All the measurements were done at ambient temperature and the readings were corrected for a standard temperature of 20°C by adding the correction factor of 0.00023/°C.

2.6.4. Tritable acidity

Tritable acidity as tartaric acid was measured according to AOAC [9]. The pulp was treated with 0.1N NaOH solution using titration kit, where 3 to 5 drops of phenolphthalein indicator were used.

2.6.5. pH

For pH determination of the sample, pH meter was used. The instrument was calibrated with standard buffer solutions of pH 7 and pH 4, prior to measuring the pH of samples. Triplicate samples were analysed for pH and the mean was recorded.

3. RESULTS AND DISCUSSION

To determine the effect of process variables 17 experimental runs were conducted. The percentage of pulp varied from 26.67% to 51.39% with respect to different combinations of independent variable. All the independendent variables showed significant effect on the percent yield and overall acceptability of pulp. The experimental data was used to calculate the coefficients of the quadratic equation. The corresponding R^2 of each response is shown in Table 2. ANOVA showed coefficients of multiple determinations (R^2) of 0.98 for the responses of pulp yield and overall acceptability.

3.1. Percent yield and overall acceptability

The coefficients of second order polynomials showed the effect of process conditions on the pulp yield and overall acceptability (Table. 2). The pulp yield increased with the increase in fruit to water ratio, soaking time and temperature. The overall acceptability of the pulp was not affected by the water to fruit ratio. However soaking time and temperature affected the overall acceptability, with temperature showing maximum effect on overall acceptability. Increase in temperature darkens color, increases sourness and negatively influences taste and aroma, which are not the quality attributes of pulp, thereby reducing overall acceptability.

Table 2: Regression coefficients and R^2 for two dependent variables for tamarind pulp extraction

P > F	Pulp Yield (%)	Overall acceptability
Model	< 0.0001	< 0.0001
b1= Water to Fruit ratio	7.76	0.12
b2= Soaking time	1.60	–0.75
b3=Soaking temperature	2.87	–2.38
b12	–7.13	–0.27
b22	–0.91	–0.52
b32	–2.11	–1.77
b1b2	–0.36	0.00
b1b3	–1.42	0.25
b2b3	+0.00	–0.50
R2	0.977	0.977

3.2. Optimization

Optimization conditions for pulp extraction were determined to obtain maximum pulp yield and overall acceptability. Optimization was applied for selected ranges of water to fruit ratio, soaking time and temperature as 2:1 to 3:1, 20 to 40min and 25-55°C, respectively. The solutions obtained for optimum condition for pulp extraction were 2.5:1 for water to fruit ratio, 31min soaking time and 38°C soaking temperature. At this condition the predicted value of responses were 49.84 for yield and 8 for overall acceptability, close to the experimental values of 48.12 and 8 respectively.

3.3. Characteristics of the pulp extracted under optimized conditions

The color analysis of the pulp extracted under optimized set of conditions showed L^* value of 28.23 ± 2.45, a^* = 8.32 ± 1.2 and b^* = 16.89 ± 1.9. The total solid of the pulp was 10g/1000g ± 0.3, higher than that of the total soluble solids of the pulp, which is 8.4 ^{o}B ± 0.2. Acidity and pH of the pulp was about 11.86 ± 0.4% and 2.24 ± 0.2 respectively.

4. CONCLUSION

Extraction of pulp from tamarind fruit was significantly affected by process variables. Optimization of tamarind pulp extraction using RSM successfully determined the optimum conditions for higher pulp yield and overall acceptability. The results showed that for maximum pulp yield and overall acceptability, water to fruit ratio, soaking time and temperature should be 2.5:1, 31min and 38°C respectively.

5. ACKNOWLEDGEMENTS

The Ist Author is very much thankful to University Grants Commission for providing Fellowship.

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