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RESEARCH ARTICLE

DEVELOPMENT AND OPTIMIZATION OF SPICED COCONUT MILK USING RESPONSE SURFACE METHODOLOGY

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ABSTRACT

The consumption of beverages and ready to drink products have emphasized the need to enhance the research and development of beverage industry. This research work aims at development of a ready to drink Spiced Coconut Milk (SCM) thereby replacing the dairy beverages. From a detailed research on the coconut based products available in the market, this new product have been developed with the incorporation of spices and jaggery. In this research, the Response Surface Methodology (RSM) is applied to optimize the composition and process conditions of the Spiced Coconut Milk. This method is a collection of statistical and mathematical techniques for empirical model building.

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INTRODUCTION

Coconut has the greatest importance in the national economy as a potential source of employment and income generation among the plantation crops. The usage and the adaptability of coconut palm to grow under various climatic and soil conditions increase its demand. Value addition of coconut has a vital role to develop new products for increasing the income of the people. Coconut products and by-products can be commercially exploited for multiple purposes (Sangamithra *et al.,* 2013). Coconut milk is derived from the coconut meat. It is one of the major ingredient in the Indian recipes and taken as a base for the cuisines. The taste and the health benefits of the coconut milk increase its usage in day to day life. Coconut milk contains vitamin C, vitamin E, vitamin K, vitamin B6, niacin, folate and thiamine. Apart from this, coconut milk is rich in fat content in which saturated fat level is high that provides instant energy to the body. The lauric acid is present as a major fat in coconut milk. It exhibits antibacterial, antifungal and antiviral properties. 22% of the recommended daily allowance of iron is available in the coconut milk. Addition of spices, such as nutmeg and cardamom enhances the flavour of the drink. The product composition and process conditions are optimized using RSM. The retort process improves the shelf life of the drink.

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Nowadays a wide varieties of milkshakes and milk products are available in the market with distinguish flavours. The development of SCM could be an alternative to dairy based beverages. And it also helps to utilize the various nutrients present in coconut, nutmeg, cardamom and jaggery. In this research, the preparation of the coconut milk with spices and jaggery as sweetener may increase good market value and provides a healthier drink to the people.

LITERATURE REVIEW

Nurul Azizah, 2014 have conducted a study on the use of coconut milk versus dairy milk in Malaysian dishes and found that coconut milk dishes were better accepted than dairy milk dishes. Banzon *et al.,* 1990 have stated that the survey reports of United Nations in 1978 shows the lesser heart disease in coconut eating people of Srilanka, one in 100,000 and a higher rate of 18 to 187 per 100,000 in other countries where there is less amount of coconut is consumed. Mithila Jayasundera and Kanthi Fernando, 2014 had developed Coconut milk based soft ice cream by replacing dairy milk with coconut milk with 37.3% total solids and 9.32% fat at an acceptable limits of Sri Lankan standards. Dawane *et al.,* 2010 carried out an experiment on Utilization of tender coconut (*Cocosnucifera L.*) milk in the preparation of pudding found that coconut milk was richer in fat content than dairy (buffalo) milk. Gunathllake *et al.,* 2005 studied that Fat is the major nutrient in coconut and thus serves as the main source of energy. Box and Draper, 1987 developed RSM to model experimental responses and it became the modelling of numerical experiments. Thompson, 1982 described that considers of interaction among the test factors in RSM can be used to determine how the product changes with changes in the factor level. Pritam G. Bafna, 2012 have done the experiment for the Optimization of Process Parameters for Extraction of Kokum (Garcinia Indica) Fruit Pulp using Response Surface Methodology and obtained the optimized values for pulp recovery and Hydroxycitric acid as 92.15% and 14.50g/100g respectively. Lee *et al.,* stated that RSM has been used extensively for optimizing processes in the tropical fruit juice production. Balasubramanian *et al.,* 2012 have optimized the process conditions for the development of tomato foam by Box-Behnken Design and obtained the values for carboxy methyl cellulose, egg albumin, whipping time as 11.45 %, 0.33 % and 5.21 minutes respectively.

MATERIALS AND METHODS

The processing steps for the formulation and processing of SCM are discussed here. Process flow chart are provided in Fig 1.

Collection of matured coconuts
↓
Shelling and paring of coconut meat
↓
Extraction of coconut milk (200 ml warm water per 306.3g coconut)
↓
Pre-heating at 90-95°C for 5 min & Filtration using 0.18 mm sieve
↓
Addition of FA_1 (1-2g) and FA_2 (0.5-1g)
↓
Addition of Sweetener (5-10g)
↓
Filtration (using muslin cloth)
↓
Addition of Stabilizer (CMC)
↓
Mixing
↓
Filling in Glass bottles
↓
Capping the bottles
↓
Retort processing (110-121.1°C for 1-10.52 min)
↓
Storage (Ambient condition & Refrigerated condition)

Fig. 1. Flow diagram for SCM preparation and processing

The optimization of composition and process were done using RSM. Design expert 6.0.8 software was used for this.

Extraction of coconut milk

The matured coconut was selected for the extraction of coconut milk. 306.3 g grated coconut is mixed with 200 ml of warm water to extract the milk (Sarah, 2014). The pH of fresh coconut milk varies from 5.5 to 6.2. The sieve of 0.18 mm size is employed for the filtration of coconut milk. The residue obtained is discarded. The extracted coconut milk was preheated at 95°C for 5min to inactivate the microbes initially.

Experimental design

RSM design helps to estimate interaction and quadratic effects to the given idea of the (local) shape of response surface under investigation. Box-Behnken Design (BBD) is having the maximum efficiency for an RSM problem involving three factors and three levels. After determining the preliminary range of the various ingredients used in the preparation of spiced coconut milk, a Box and Behnken experimental design, with three variables, was used to study the response pattern and to determine the optimum combination of variables. The coding level for the optimization of composition and for process parameters were given ino.2 and 3 respectively. Design expert software 6.0.8 was used to design the experiment and randomize the runs. The test factors were coded according to the equation (1)

$$x_i = \frac{Xi - Xo}{\Delta Xi} \times 100 \qquad (1)$$

where, x_i is dimensionless value of an independent variable, X_i is level or value of controllable factor i in original units of measurement, X_o is midpoint of the range of values for factor i, ΔX_i is the range of factor i will vary. Low and high levels of each factor were coded as -1 and +1 keeping 0 as midpoint (E.del Castillo, 2007). Since the different responses were the interaction of independent variables, therefore the following second order polynomial regression equation (2) was fitted to the experimental data of all responses,

$$y = \beta_0 + \sum_{j=1}^{k} \beta_j X_j + \sum_{j=1}^{k} \beta_{jj} X_j^2 + \sum_{i=1}^{j=1} \times \sum_{j=2}^{k} \beta_{ij} X_i X_j + \varepsilon \qquad (2)$$

where y is predicted response, β_0 is a constant, β_i is linear coefficient, β_{ii} is squared coefficient and β_{ij} is interaction coefficient, X_i and X_j are the independent variables and ε is noise or error.

Retort processing

Retort processing was done in a forced steam/ air type retort. It is one of the types of "overpressure" retort of 50 pouch capacity producing a pressure of 2kg/cm^2. The bottled samples were subjected to thermal treatment at various temperature and time as per the values obtained in the RSM. The samples after each process conditions were tested for pH readings. The optimized process condition was selected based on the responses and results obtained in RSM.

RESULTS AND DISCUSSION

The optimization of the SCM depends on the concentration of various ingredients and processing conditions. The results of optimization of SCM in terms of its composition and process conditions are discussed in this section. The average of response obtained for each experimental combination was fitted in the general form of quadratic polynomial model.

Composition and Process Optimization

The composition varies for each run of the experimental design with the ingredients jaggery, FA_1, and FA_2 .Based on these independent variables the response changes i.e., the results of sensory evaluation. The processing parameters were optimized using the response obtained during the various runs carried out. This depends on the nature and concentration of ingredients used in SCM preparation. The word lack of fit refers to the fact that the simple linear regression model may not adequately fit the data. While the goodness of fit for quadratic model implies that the lack of fit of model is not significant. Fisher's value and p- value indicates that the model system was statistically significant. The multiple coefficients calculated by the software are shown in table 3 and 4.The response fit analysis, regression coefficient estimations, and model significance were conducted. The adequacy of the models was tested using F-ratio and coefficient of determination (R^2). Seventeen runs were carried out to select the best composition of SCM and process condition.

Table 1. Coding level for composition optimization

Source	Sum of squares	DF	Mean square	F value	p-value prob>F	R^2
Linear	43.42	3	14.47	39.43	0.0001*	0.9010*
2FI	0.51	3	0.17	0.40	0.7554	0.9116
Quadratic	2.83	3	0.94	4.63	0.0436*	0.9323*
Cubic	1.43	3	0.48	6.366	0.0001	1.0000

Table 2. Coding level for process condition optimization

Actual values	*Coded values*	*Unit*	*Lower limit*	*Upper limit*
Jaggery	A	g	5	10
FA_1	B	g	1	2
FA_2	C	g	0.5	1

Table 3. Goodness of Fit test for Composition Optimization

Actual values	*Coded values*	*Unit*	*Lower limit*	*Upper limit*
Jaggery	A	g	5	10
FA_1	B	g	1	2
FA_2	C	g	0.5	1

* Terms significant at 5% level of significance

Table 4. Goodness of Fit test for Process Optimization

Source	Sum of squares	DF	Mean square	F value	p-value prob>F	R^2
Linear	1.47	6	0.24	43.44	<0.0001	0.5191
2FI	1.44	5	0.29	51.33	<0.0001	0.5263
Quadratic	0.21	3	0.068	12.16	0.0024*	0.9204*
Cubic	0.13	1	0.13	22.92	0.0014	0.9446

* Terms significant at 5% level of significance

The final equation for composition and process condition in terms of coded factors are given in equation 3 and 4 respectively.

$$y = + 7.50 + 2.24 *A - 0.59 * B + 0.28 * C - 0.51 * A^2 - 0.56 * B^2 - 0.19 * C^2 - 0.075 * A*B - 0.35 *A*C - 0.000 *B*C \quad (3)$$

where y = sensory evaluation, A = Jaggery, B = FA_1, C = FA_2

$$y = + 5.97 + 0.037 *A + 0.45 *B + 0.53 *A^2 + 0.059 *B^2 + 0.075 *A* B \quad (4)$$

where y = pH, A = Temperature, B = Time

Goodness of fit tests for composition

The coefficient of determination (R^2) is defined as the ratio of the explained variation to the total variation and is a measure of the degree of fit. The goodness of fit is indicated by the value of coefficient of determination, $R^2 = 0.945$ (J.Lee *et al.,* 2000). The R^2 value obtained in the quadratic model as 0.9323 which indicates the goodness of fit for the designed experiment. It means that the composition for the preparation of SCM is significant in the quadratic model with varying ingredients as inputs and sensory evaluation as response.

From the above data, it can be interpreted that the selected model can help us to optimize the composition levels with significant relationship among the parameters chosen. The response surface plot showing the effect of varying jaggery, FA_1, and FA_2 concentration with constant 100 ml of coconut milk on sensory evaluation in the Figure 2. From the plot it can be seen that the increase in jaggery concentration increases the sensory evaluation value with a concentration of FA_1 as 1.72 and FA_2 as actual factor with a value of 0.93.

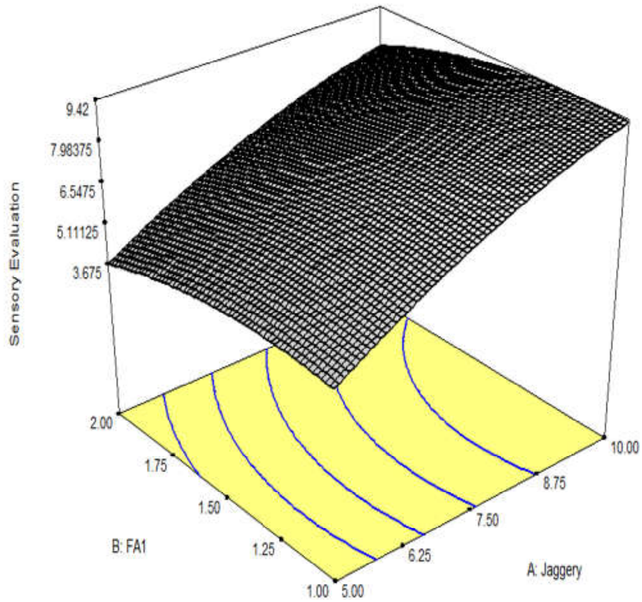

Fig. 2. Response Surface plot for composition optimization as a function of concentration of various ingredients and sensory evaluation as response at constant concentration of 100 ml coconut milk

The possible reason for decrease in FA_1 concentration can be due to the presence of mymiristin. Around 20 – 40 % of the essential oil present in nutmeg (FA_1) may cause the decrease in acceptance level during sensory evaluation process. Adding to that, the consumption of nutmeg in large doses may cause lack of concentration, sweating, palpitations, body pain and in severe cases hallucination and delirium (Orabi KY *et al.,* 2000). The range of FA_1 from 1 - 1.72 g gives a good response with jaggery concentration of 7 - 9.75 g. While the decrease in jaggery concentration and increase in FA_1 results in unacceptable value in sensory evaluation. The concentration of FA_2 is kept as actual factor of 0.93 g.

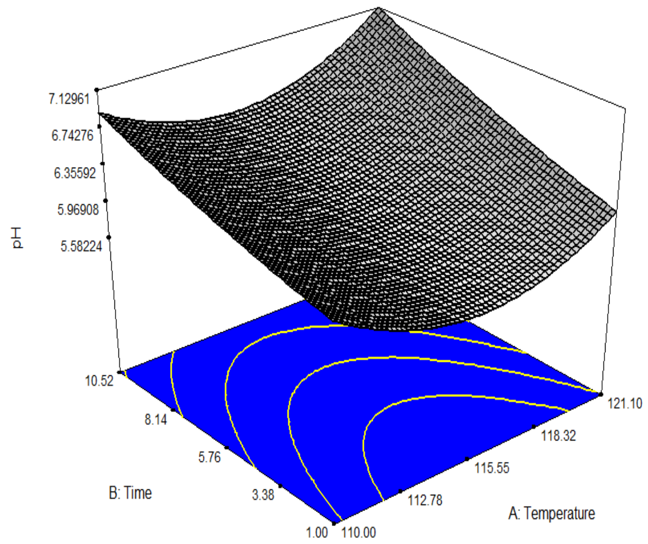

Fig. 3. Response Surface plot for process optimization as a function of time and temperature with pH as response

Goodness of fit tests for process condition

The goodness of fit is determined by the value of coefficient of determination obtained in the quadratic model. Here, the R^2 value for the process conditions is 0.9204. It indicates the goodness of fit. . It means that the process conditions such as temperature and time for the preparation of SCM is significant in the quadratic model. From the above data, it can be interpreted that the selected model can help us to optimize the process conditions with significant relationship among the parameters chosen. The response surface plot showing the effect of varying temperature and time with optimized composition of SCM on pH as response in the Figure 3. From the plot it can be seen that the increase in time increases the pH. Similarly, the increase in temperature causes rise in pH. The possible reason for this can be the pseudo elastic property exhibited by the coconut milk during heat treatment. Seow *et al.*1997, found that the change in pH during heat treatment due to the denaturation of albumins and some globulins. Seoh and Goh, 1994 reported that the resistance of this protein denaturation was increased in the presence of sugars, polyols, and Na Cl. In addition, the CMC can also reduce the denaturation of these proteins.

Conclusion

The coconut milk was prepared by the addition of spices and jaggery as sweetener. The nutrients from the various ingredients can be utilized by the consumption of this ready to drink milk. The Spiced Coconut Milk was formulated using RSM and the processing conditions were determined. This drink can be a good alternative to dairy based beverages. The optimized composition of SCM were 7.50g, 1 g and 0.5 g of jaggery, nutmeg, and cardamom respectively. While the process condition optimized were 121.1 ˚C and 1 minute. The developed product can be stored for further studies.

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