A refreshing beverage from mature coconut water blended with lemon juice

O. P. Chauhan · B. S. Archana · Asha Singh · P. S. Raju ·
A. S. Bawa

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Abstract Coconut water obtained from the mature coconuts was blended with lemon juice to develop a refreshing beverage. The levels of total soluble solids ($^{\circ}$ Brix) in the coconut beverage and lemon juice (%), were optimized using response surface methodology and considering pH, CIE L* value and sensory attributes (colour, aroma, taste, consistency and overall acceptability) as responses. A number total of 14 experiments were carried out following Central Composite Rotatable Design (CCRD) keeping 6 experiments at centre point. The data obtained were analyzed using multiple regression technique and the quadratic equations (R^2 , 98.14–99.89 %) were found to fit well in describing the effect of variables on responses studied. An optimum condition for the coconut water beverage was obtained at 13.5 $^{\circ}$ Brix blended with 2 % lemon juice. The mature coconut water beverage blended with lemon juice showed a shelf-life of 6 months in packed conditions at low (5 $^{\circ}$ C), ambient (25 $\pm$ 2 $^{\circ}$ C) and high (37 $^{\circ}$ C) temperatures on the basis of physicochemical, microbiological and sensory attributes.

Keywords Coconut water · Beverage · Response surface methodology · Optimization · Storage

Introduction

Coconut (*Cocos nucifera*) is one of the oldest known tropical crops and is referred as the ‘Tree of Life’. It is a primary source of food, water, drink, purifier, fluid re-hydration, isotonic,

energy, tonic, fuel, animal feed and shelter. In India, the use of coconut for food and its applications in the ayurvedic medicine were documented in Sanskrit 4000 years ago. Coconut water is the juice of the endosperm found within the cavity of the coconut, which begins to form around 2 months after the natural opening of the inflorescence (Vigliar et al. 2006) and varies in volume and nutrients depending on the maturity of the nuts. Coconut water (liquid endosperm), with its many applications, is one of the world’s most versatile natural product. This refreshing beverage is consumed worldwide as it is nutritious and beneficial for health. There is increasing scientific evidence that supports the role of coconut water in health and medicinal applications. The wide applications of coconut water can be justified by its unique chemical composition of sugars, vitamins, minerals, amino acids and phyto-hormones. The wide applications of coconut water for health and nutritional benefits can be justified by its unique chemical composition of sugars, vitamins, minerals, amino acids and phyto-hormones (Yong et al. 2009). Total reducing sugar and protein contents increase as coconut matures. However, total sugar content reaches a peak of 2.9 % on the ninth month, and then declines (Anzaldo et al. 1985). This is reason of coconut water from young nuts being substantially sweeter than that from mature nut. The sugars include simple sugars such as glucose, fructose, and sucrose, and sugar alcohols, mainly sorbitol. The concentration of total solids at its earliest stages of development is about 2.5 g/100 ml which increases gradually as the nut ripens, reaching a maximum of about 6 g / 100 ml at about 7 months and then declines (Child 1964). Generally, the pulp of mature coconuts is used for making coconut chips, chutneys etc. and the water is discarded as waste (Yong et al. 2009). Some attempts have been made to develop beverage out of this coconut water. Del Rosario and Rubico (1979) formulated coconut water beverage from mature nuts, whereas, Chauhan et al. (2007 and 2008) developed beverages from tender coconut water by addition

O. P. Chauhan (✉) · B. S. Archana · A. Singh · P. S. Raju ·
A. S. Bawa
Defence Food Research Laboratory,
Siddarthanagar, Mysore 570011, India
e-mail: opchauhan@gmail.com

of various fruit juices. Non-carbonated and carbonated coconut water beverages have also been developed utilizing coconut water. Non-carbonated and carbonated coconut water beverages possess the characteristic flavor of coconut water, but this is slightly masked by the acid-sweetish taste imparted by the different additives. Both products were found to be highly acceptable and preferred to other artificial fruit drinks. Large quantities of coconut water are produced in coconut industries, which if left unused; its nutritional value will just go waste and contribute to environmental pollution (Banzon and Escarda 1988). This coconut water can be made use for the production of value added products like Nata-de-coco, therapeutic drink, refreshment drink, vinegar, sparkling wine, coconut champagne, components for tissue culture media for plants (e.g., banana, orchids), fermentation media for enzyme production, growth regulator, biogas generation and coconut water concentrates (Child 1964).

As such, the literature is scarce with regards to beverage made out of mature coconut water. Therefore, the present study was undertaken to develop mature coconut water beverage having good consumer acceptability. Lemon juice as such is a rich source of nutrients, including flavonoids, citric acid, vitamin C and minerals (e.g. potassium), which provide numerous health promoting properties (Del Rio et al. 2004; Gonzalez-Molina et al. 2008) and is widely used as an antioxidant natural substitute for the synthetic ascorbic or citric acids (E300 and E330, respectively) (Marti et al. 2001). It can also prevent browning reactions and colour deterioration of mature coconut water. Therefore, blending of mature coconut water with lemon juice has been done to get a refreshing beverage.

Materials and methods

Fruits

Lemon (*Citrus aurantifolia* swing var. *Kagzi*) and mature coconuts (*Cocos nucifera*, var. *Kappadam*) were procured from the local Mysore (India) market for the study. The fruits were sorted and graded and the ones with visible infections and mechanical injuries were rejected. The selected fruits were subjected to surface sanitation wash in chlorinated water. Lemon fruit was cut into halves and the juice was extracted using a domestic squeezer and rapidly strained through a muslin cloth to accomplish the separation of suspended particles from the juice. The mature nuts were cut using a special knife on a sanitized board, checked for signs of spoilage and the water was passed through the muslin cloth and collected in sanitized container. The coconut water and the lemon juice was stored frozen (−18 °C) until processed.

Experimental design

Response surface methodology was used for designing the experiment (Khuri and Cornell 1987) to develop lemon juice blended mature coconut water beverage. A Central Composite Rotatable Design (CCRD) was used taking 2 variables at 5 levels each with 6 points at centre. The data pertaining to the coded and uncoded parameter values of the design have been presented in Tables 1 and 2. The effect of independent variables (lemon juice, and TSS) was investigated on dependent responses i.e. pH, sensory attributes (colour, aroma, taste, consistency and overall acceptability) and CIE L* value. The TSS was beverage was set at desired level by addition of sugar.

Optimization

The data obtained for pH, CIE L* value and sensory attributes (colour, aroma, taste, consistency and overall acceptability) under different experimental conditions were analyzed using multiple regression analyses. Response surface model was developed to represent the data thus collected and to determine the optimal conditions for various parameters. A quadratic polynomial regression model was assumed for predicting the response variable (Y) and the data were fitted to the following second order polynomial equation:

$$Y = \beta_0 + \sum_{i=1}^3 \beta_i X_i + \sum_{i=1}^3 \beta_{ii} X_i^2 + \sum_{\substack{i,j=1 \\ i \neq j}}^3 \beta_{ij} X_i X_j$$

Where, β_0 is the value for the fixed response at the central point of the experiment, β_i , β_j , β_{ii} and β_{ij} are the linear, quadratic and cross product coefficients, respectively.

Physico-chemical analyses

Ascorbic acid was estimated using 2, 6-dichlorophenol-indophenol dye reduction method, whereas, titratable acidity was estimated using 0.1 N NaOH solution and phenolphthalein indicator as described by Ranganna (1999). Reducing and total sugar contents were determined using Lane and Eynon method as described by Ranganna (1999). TSS of the beverage was measured using a hand refractometer (ERMA, Japan) whereas pH was determined using a

Table 1 Process variables and their coded and uncoded levels

Factors	Process variable	−1.414	−1.00	0.00	+1.00	+1.414
X ₁	TSS (°Brix)	11.59	12.0	13.0	14.0	14.41
X ₂	Lemon juice (%)	0.79	1.0	1.5	2.0	2.21

*TSS total soluble solids

Table 2 Response surface design showing number of experiments at different levels of variables

X_1	X_2	Runs
0	0	6
± 1.414	0	2
± 1	± 1	4
0	± 1.414	2

microprocessor based pH meter (Century, Model CP931, Bangalore, India). The CIE (Commission Internationale de l'Eclairage) colour values (L^* , a^* , b^*) were measured using D-65 illuminant and 10° observer using a colour meter (MiniScan XE Plus, Model No. 45/0-S, Hunter Associates Laboratory, Inc., Reston, VA, USA). The equipment was calibrated using white and black standard ceramic tiles and the readings were recorded with inbuilt software (Easy Match QC, Hunter Associates Laboratory, Inc., Reston, VA, USA).

Sensory evaluation

The sensory evaluation of the beverage was carried out in terms of colour, aroma, taste, consistency and overall acceptability by a semi-trained panel consisting of 30 members from the scientific staff of the laboratory with knowledge of consumer preferences using a nine point hedonic scale having a score of 9 for extreme liking and 1 for extreme disliking (Larmond 1977). The samples were served to the panelists at 11 am during each time after duly coding them in a sensory cubical illuminated with white light and maintained at 20°C .

Preparation of beverage and storage studies

The beverage was prepared at optimized conditions of the variables by mixing lemon juice with mature coconut water, added with sodium benzoate (120 ppm) and packed (200 ml pack size) in laminated standup pouches (12 μ polyester, 9 μ aluminium foil, 15 μ nylon and 70 μ CPP) followed by in-pack pasteurization in boiling water for 15 min. The samples were kept at 5, 25 and 37°C for 6 months and were periodically analyzed for physico-chemical, microbiological and sensory attributes. All the analyses were done in triplicate.

Microbiological evaluation

The microbiological analysis of the beverage was carried out during storage for standard plate count, yeast and molds and total coliform count as per the APHA (1992) procedures.

Optimization and statistical analysis

Contour plotting was carried out to visualize the effect of variables on responses using response surface equation. A

series of contour plots were developed to interpret the effect of variables on the responses investigated. A second order polynomial was fitted to the mean data values to obtain regression equations and statistical significance was examined using statistical software (Design Expert Software, version 7.1, Statease, USA). The experimental and computed values were analyzed for coefficient of determination (R^2), standard error and scattered plot. The levels of independent variables were optimized using the same software considering the sensory responses at maximum values. Physico-chemical data and sensory scores of the beverage during storage were analyzed statistically for analysis of variance (ANOVA) at $P < 0.05$ using Statistica 7 software (Stat Soft, Tulsa, OK, USA).

Results and discussions

Effect of variables on pH

Mature coconut water as such has a pH value of 5.6. The values for pH ranged from 4.36 to 4.78 among various experimental conditions of variables (Table 3). Addition of lemon juice significantly ($p < 0.0001$) decreased the pH of the beverage, whereas, the effect of TSS was found to be non-significant (Table 4). The variables i.e. lemon juice and TSS affected the pH values at linear, quadratic and interactive levels. Polynomial model was found to fit well in describing the effect of both the variables on pH showing a R^2 value of 99.89 % depicting the fitness of the model employed (Table 5). The effect of TSS was not significant at linear level, but at quadratic level it showed significant ($p < 0.001$) effect. The effect of variables on interactive level was also found significant ($p < 0.01$). The effect of variables on pH can be predicted by following equation:

$$Y_1 = 4.42 + 0.02X_1 - 0.15X_2 + 0.013X_1X_2 + 0.075X_1^2 + 0.075X_2^2$$

The effect of variables on pH value has been presented in Fig. 1(a). Addition of citric acid to the tender coconut water beverage showed similar results where increase in citric acid resulted in decrease in pH of the beverage (Chauhan et al. 2008). In the present study also, addition of lemon juice decreased the pH of the mature coconut water beverage significantly. Lemon, being highly acidic in nature is the reason of this decrease in pH. Carvalho et al. (2007) also reported similar trend in the case of coconut water-cashew apple juice beverage.

Effect of variables on sensory responses

Mature coconut water has a bland taste and not liked as such as a beverage as it has very low amount of sweetness and the pH is also towards neutral side. Addition of lemon juice and

Table 3 Experimental design showing level of variables and values of responses

SN	X ₁ , TSS(°Brix)	X ₂ , Lemon juice (%)	Y ₁ , pH	Y ₂ , Colour	Y ₃ , Aroma	Y ₄ , Taste	Y ₅ , Consistency	Y ₆ , OAA	Y ₇ , L* value
1	12	1	4.7	7.6	7.4	7.3	7.32	7.31	11.07
2	14	1	4.71	7.2	7.38	7.04	7.14	7.32	10.08
3	12	2	4.39	8.04	7.56	7.68	7.32	7.91	11.85
4	14	2	4.45	8.12	8.14	7.97	7.82	7.96	11.19
5	11.59	1.5	4.54	7.8	7.2	7.46	7.31	7.82	11.79
6	14.41	1.5	4.60	7.6	7.7	7.45	7.54	7.74	10.57
7	13	0.79	4.78	7.3	7.5	7.14	7.21	6.97	10.31
8	13	2.21	4.36	8.03	8.04	7.94	7.62	7.89	11.53
9	13	1.5	4.42	8.1	8.2	7.97	8.12	8.36	10.79
10	13	1.5	4.41	8.2	8.21	8.02	8.14	8.32	10.91
11	13	1.5	4.42	8.14	8.23	8.05	8.14	8.34	10.78
12	13	1.5	4.42	8.12	8.24	8.07	8.12	8.32	10.77
13	13	1.5	4.41	8.12	8.26	8.02	8.14	8.36	10.76
14	13	1.5	4.42	8.12	8.25	8.03	8.13	8.35	10.76

X₁ TSS (total soluble solids, °Brix); X₂ lemon juice (%).

increase in TSS of the mature coconut water beverage improved the sensory acceptability of the beverage. The sensory scores for colour, aroma, taste, consistency and overall acceptability at various experimental conditions of variables have been shown in Table 3. Increase in the level of the lemon juice significantly ($p < 0.001$) increased the sensory scores for all the sensory parameters i.e. colour, aroma, taste, consistency and overall acceptability (Table 4). Increase in TSS was also increased the sensory scores except being negative in the case of colour. The effect of TSS on aroma was found to be non-significant, whereas, it was significant for taste ($p < 0.0001$) colour ($p < 0.001$), consistency ($p < 0.001$) and overall acceptability ($p < 0.001$). The high R^2 values (98.14–99.87 %) shows fitness of the polynomial model used for describing the effect of the variables on the sensory scores (Table 5). The effect of variables on

sensory responses can be described by following equations:

$$\begin{aligned}
 Y_2 &= 8.14 - 0.075X_1 + 0.30X_2 + 0.12X_1X_2 - 0.20X_1^2 - 0.22X_2^2 \\
 Y_3 &= 8.23 + 0.16X_1 + 0.21X_2 + 0.15X_1X_2 - 0.39X_1^2 - 0.23X_2^2 \\
 Y_4 &= 8.03 + 0.004X_1 + 0.30X_2 + 0.13X_1X_2 - 0.28X_1^2 - 0.24X_2^2 \\
 Y_5 &= 8.13 + 0.08X_1 + 0.16X_2 + 0.17X_1X_2 - 0.36X_1^2 - 0.36X_2^2 \\
 Y_6 &= 8.34 - 0.006X_1 + 0.32X_2 + 0.01X_1X_2 - 0.28X_1^2 - 0.45X_2^2
 \end{aligned}$$

Figure 1 (b) shows a representative idea about effect of lemon juice and TSS on overall acceptability of the mature coconut water beverage. Similar results have also been reported by Chauhan et al. (2008) in the case of pomegranate juice blended tender coconut water and by Lima et al. (2009) in the case of acerola fruit juice blended tender coconut water beverage. Chauhan et al. (2007) also developed tender coconut water beverage blended with lemon, pineapple and mango juices and reported that addition of

Table 4 Coefficient of second order polynomial regression model for response values

Coefficient	Y ₁ , pH	Y ₂ , Colour	Y ₃ , Aroma	Y ₄ , Taste	Y ₅ , Consistency	Y ₆ , OAA	Y ₇ , L* value
Intercept	4.42****	8.14****	8.23****	8.03****	8.13****	8.34****	10.80****
X ₁	0.02	−0.075***	0.16	0.004****	0.08***	−0.006***	−0.42***
X ₂	−0.15****	0.30***	0.21***	0.30****	0.16**	0.32***	0.45**
X ₁ X ₂	0.013**	0.12***	0.15***	0.13***	0.17**	0.01**	0.08**
X ₁ ²	0.075***	−0.20**	−0.39	−0.28***	−0.36**	−0.28**	0.19**
X ₂ ²	0.075**	−0.22**	−0.23**	−0.24***	−0.36**	−0.45**	0.058**

****Significant ($p < 0.0001$), ***significant ($p < 0.001$), **significant ($p < 0.01$). X₁ TSS (total soluble solids, °Brix); X₂ lemon juice (%).

Table 5 Analysis of variance data for response variables

Source	Sum of square						
	Y ₁ , pH	Y ₂ , Colour	Y ₃ , Aroma	Y ₄ , Taste	Y ₅ , Consistency	Y ₆ , OAA	Y ₇ , L* value
Model	0.242****	1.375****	1.904****	1.662****	1.970****	2.548****	3.342***
X ₁	0.003***	0.045****	0.201****	0.000***	0.052***	0.0004***	1.434**
X ₂	0.169***	0.715**	0.354**	0.733**	0.198***	0.807****	1.629**
X ₁ X ₂	0.001**	0.058**	0.090***	0.070***	0.116**	0.0004**	0.026***
X ₁ ²	0.039***	0.288**	1.039**	0.562**	0.894***	0.526**	0.244**
X ₂ ²	0.039**	0.340**	0.357***	0.407***	0.919***	1.409**	0.024**
Combined effect of variables							
Linear	0.172***	0.761***	0.555***	0.733***	0.250***	0.808***	3.06***
Interactive	0.001***	0.058**	0.090***	0.070***	0.116**	0.0004**	0.026***
Quadratic	0.069****	0.56**	1.26**	0.86****	1.60**	1.74***	0.252**
R ² (%)	99.89 %	98.14 %	99.57 %	99.44 %	99.87 %	99.74 %	99.43 %

****Significant ($p < 0.0001$), ***significant ($p < 0.001$), **significant ($p < 0.01$). X₁ TSS (total soluble solids, °Brix); X₂ lemon juice (%)

fruit juices increased the sensory acceptability of the tender coconut water. Increase in TSS and acidity by means of addition of sugar and lemon juice, respectively, resulted in better sensory acceptability of the mature coconut water beverage in the present study also. Addition of fruit juice has positive effect in increasing the sensory acceptability of the developed beverage.

Effect of variable on CIE L* value

The data pertaining to CIE L* values at experimental combinations of TSS and lemon juice level is given in Table 3. The L* value varied from 10.08 to 11.85 at various combinations. Addition of lemon juice to the mature coconut water increased the L* values significantly ($p < 0.01$), whereas, the effect of TSS was found to be on negative side ($p < 0.001$) (Table 4). The results showed that increase in the lemon juice increased the lightness of the product whereas addition of sugar reduced the lightness. The effect of variables on L* values is shown graphically in Fig. 1(c). The effects of variables on L* value can be given by the following equation:

$$Y_7 = 10.80 - 0.42X_1 + 0.45X_2 + 0.08X_1X_2 + 0.19X_1^2 + 0.058X_2^2$$

A high R² value (99.43 %) was obtained for the polynomial model which shows fitness of the model in describing the effect of the variable on L* value (Table 5). Chauhan et al. (2008) reported negative effect of addition of pomegranate juice on the L* value of the tender coconut water beverage because pomegranate juice decreased the lightness of the product giving a darker shade to the beverage. In the present study, lemon juice was found to increase the L* value making the product lighter in shade.

Optimization of the variables

The levels of variables were optimized for getting optimal values of responses using Design Expert Software (Version 7.1, Statease, USA). The optimization was carried out keeping the variable in range and maximizing the response values for sensory scores. Thus, the compromised optimum values were arrived at 13.5°Brix for TSS and 2 % for lemon juice. The beverage was prepared at optimum levels using 2 % lemon juice in the mature coconut water and the TSS of the beverage was set at 13.5 °Brix using sugar. The responses (i.e. pH, sensory attributes and CIE L* value) showed good correlation between predicted and actual values (>99 %).

Changes in physico-chemical, sensory and microbiological attributes during storage

The Table 6 summarizes the changes in physico-chemical characters of the lemon juice blended mature coconut water beverage prepared at optimized conditions of variables, added sodium benzoate (120 ppm), packed and pasteurized. Significant changes were not observed in the total soluble solids, pH and titratable acidity during storage of the beverage. This is in agreement with the studies done by Lima et al. (2009) on stimulant coconut water-acerola fruit, wherein not much difference was stated in the physico-chemical parameters of the said beverage during storage. A gradual but non-significant increase in reducing sugar content of the beverage was observed. This may be attributed to a slow acid hydrolysis of the non-reducing sugar (sucrose) added to standardize the beverage soluble solids, because the beverage was stabilized at acid pH values and weak acids easily hydrolyze sucrose (Carvalho

Fig. 1 Representative response surface plots showing effect of levels of lemon juice and TSS (total soluble solids) on pH (a), overall acceptability (b) and L* value (c)

Table 6 Changes in physico-chemical, sensory and microbiological parameters of lemon juice blended mature coconut water beverage during storage ($n=3$)

Parameters	Initial	3 months			6 months		
		RT	5 °C	37 °C	RT	5 °C	37 °C
TSS (°Brix)	13.50 ^a	13.50 ^a	13.50 ^a	13.50 ^a	13.47 ^a	13.50 ^a	13.45 ^a
pH	4.40 ^a	4.39 ^a	4.40 ^a	4.39 ^a	4.38 ^a	4.40 ^a	4.37 ^b
Acidity (% citric acid)	1.68 ^a	1.68 ^a	1.68 ^a	1.68 ^a	1.65 ^a	1.67 ^a	1.65 ^b
Total Sugar (%)	11.65 ^a	11.65 ^a	11.65 ^a	11.63 ^a	11.63 ^a	11.65 ^a	11.61 ^b
Reducing Sugar (%)	3.96 ^a	3.96 ^a	3.96 ^a	3.98 ^a	3.99 ^a	3.97 ^a	3.99 ^a
Ascorbic acid (mg/100 ml)	7.15 ^a	7.10 ^a	7.14 ^a	7.05 ^b	6.95 ^c	7.02 ^b	6.65 ^d
L* value	10.28 ^a	9.65 ^c	9.87 ^b	9.60 ^c	9.40 ^e	9.54 ^d	9.32 ^f
a* value	0.23 ^a	0.42 ^c	0.36 ^b	0.46 ^d	0.57 ^e	0.40 ^c	0.65 ^f
b* value	−0.42 ^a	−0.38 ^b	−0.40 ^a	−0.38 ^b	−0.35 ^c	−0.40 ^a	−0.29 ^d
Overall acceptability	8.50 ^a	8.50 ^a	8.50 ^a	8.20 ^c	7.80 ^d	8.40 ^b	7.50 ^e

*The values with different superscripts in the same row differ significantly ($p<0.05$), RT: Room temperature (25 ± 2 °C); TSS total soluble solids

et al. 2007). Ascorbic acid content of the beverage decreased during the storage period (Table 6). Studies done by Huelin (1953) showed the oxidation of ascorbic acid during processing of fruit juices. In thermally preserved fruit juices anaerobic degradation of the ascorbic acid takes place during storage (Solomon et al. 1995). Degradation of vitamin C results in the formation of several decomposition products (Eskin 1990) leading to the formation of brown pigments (Larisch et al. 1998). Studies have shown that the content of vitamin C decreases during storage depending on varying conditions, such as temperature, oxygen and light access (Kabasakalis et al. 2000; Zerdin et al. 2003). The changes in various physico-chemical parameters were found to be more in the samples stored at higher temperatures compared to the samples stored at low temperature which is in agreement with the studies conducted by Chauhan et al. (2008) in the case of pomegranate juice blended tender coconut water beverage.

The CIE L* and b* values of the beverage were found to decrease significantly ($p<0.05$), whereas, a* value showed increasing trend during storage. This may be due to the non-enzymatic browning reactions taking place in the beverage during storage. Non-enzymatic browning results from several reactions, including Maillard reaction, caramelization and ascorbic acid browning processes and degradation of pigments (Lima et al. 2009). Carvalho et al. (2007) detected darkening of a beverage composed of coconut water and cashew apple juice during storage. In the case of present study, some oxidation reactions are expected during the storage period because of the headspace in the pouch, which contains oxygen, as well as the oxygen dissolved into the beverage as air present in the headspace results in browning of the beverage (Carvalho et al. 2007).

The beverage added with sodium benzoate (120 ppm) as chemical preservative was found to acceptable on the basis of sensory attributes after 6 months of storage at all the three temperatures, however, the sensory scores decreased significantly ($p<0.05$) during storage, but the scores remained in

the acceptable limit (Table 6). The decreases in sensory scores were found to be higher at higher temperatures. The beverage showed no sign of microbial proliferation in terms of standard plate, coliform and yeast and molds counts in all the samples showing that beverage was fit for consumption even after 6 months.

Conclusion

A refreshing beverage could be prepared from mature coconut water by blending with lemon juice. The polynomial regression equations, obtained during optimization of the variables using response surface methodology, fit well in describing the effects of variables on various responses studied. The beverage prepared under optimized conditions showed a shelf-life of 6 months under different storage conditions which is sufficient for domestic and export marketing of the product. The formulated beverage is unique in the sense that it comes under byproduct utilization and falls under the current trend of world market, where there is a quest for beverages of mixed fruits, especially tropical fruits with good sensory, nutritional, functional and therapeutic properties.

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