Effect of Carrot Juice and Xylitol on Quality of Low-calorie Roselle-Carrot Juice Mixtures

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Abstract

The investigation on physical and sensory properties of juice mixtures with varying roselle-carrot juice proportion and xylitol concentration revealed a variation for total soluble solids (^{o}Brix), pH, color parameters (L a* b*) and sensory acceptability. The increase in both variables led to higher total soluble solids whereas the carrot juice affected the pH of low-calorie roselle-carrot juices. According to response surface analysis, the model produced the highest percent variation in redness (93.1%) in comparison with either lightness (79.8%) or yellowness (78.9%) and the effect of carrot juice was more pronounced than that of xylitol concentration. The mixture containing roselle-carrot (87.07 : 12.93) juice and 13.41% xylitol resulted in an optimal product having an overall acceptability score of 7.42, while the product with roselle-carrot (70 : 30) juice with 12% xylitol was rated only 4.17 of the same attribute.*

Keywords: *Fruit juice, vegetable juice, low-calorie beverage, vitamin C, carotenoids.*

Introduction

Manufacture of refrigerated fruit and vegetable juice mixtures with inherent health benefits has increased over last 10 years. This is an approach to enrich vitamins in mixed products in which the person who do not eat vegetable can consume. The roselle-carrot juice was selected in this study with the reason that roselle is a good source of vitamin A, vitamin C, niacin, riboflavin and calcium (Morton 1987) while carrot has the highest content of carotenes of fresh foods (Bureau and Bushway 1986). It has been shown that a higher consumption of fruits and vegetables rich in carotenoids and vitamin C can reduce susceptibility to low-density lipoprotein oxidation.

Generally, fruit and/or vegetable juice has 10-30% sugar content; therefore, it causes health problems such as diabetes, obesity and tooth decay (Knecht 1990; Newsome 1993). Xylitol, one of bulking sugar alcohol-type sugar substitutes, is roughly as sweet as sucrose but with two-thirds the food energy. It has virtually no aftertaste, and is advertised as “safe for diabetics and individuals with hyperglycemia”. It also is a “tooth-friendly” sugar which is found in wide assortment of chewing gums and other food products (Newsome 1993).

Good and desirable quality of food products can be produced by a proper choice of ingredients. Response surface methodology (RSM) is an effective tool for optimizing the process conditions when the independent variables have a combined effect on the desired response (Sun *et al*. 2006). It usually uses an experimental design such as a central composite rotatable design (CCRD) to fit a first- or second-order polynomial by a least significance technique. An equation is used to describe how the test variables affect the response, and to determine the interrelationship among the test variables in the response.

The objective of this study was to evaluate the simultaneous influence of levels of xylitol and the proportions of roselle and carrot juices on physical and sensory properties of low-calorie roselle-carrot juices.

Materials and Methods

Materials

Dried roselle, fresh carrot, sugar and salt were purchased from the local market. Xylitol was purchased from the Thai Food and Chemical Co., Ltd.

Roselle Juice Preparation

The 100 g dried roselle calyces were washed and soaked in water for 15 min. The rehydrated roselle calyces were added in 1,000 g boiling water and kept boiling for 30 min. After cooling, roselle liquid was poured through a cheese cloth into previously sterilized glass bottles and stored in a refrigerator prior to processing. The carrot juice was prepared by using a juice extractor.

For processing of roselle-carrot juice mixtures, each roselle liquid mixed with carrot juice in a specific proportion was heated until boiling, and then sugar and salt were added. After further boiling for 2 min, the mixture was hot-filled into sterilized bottles and kept in a refrigerator.

Physical Analysis

Total soluble solids (TSS) were determined as ^{O}Brix using a refractometer. Color was evaluated by using a ColorFlex colorimeter (Hunter Associates Laboratory, Reston, VA, USA). Values for L^* (lightness), a^* (redness/greenness) and b^* (yellowness /blueness) were recorded.

Sensory Evaluation

The sensory evaluation for color, taste, flavor and overall acceptability of roselle-carrot juice mixtures was subjected to a panel of 24 judges from the academic staffs and students of University of the Thai Chamber of Commerce (UTCC). A 9-point hedonic scale test (1 = extremely dislike, 9 = extremely like) was used for this judgment as described by Lawless and Heymann (1998).

Table 1. Experimental range and levels of both coded and actual values of the independent variables.

Experimental Number	Roselle juice : Carrot juice		Xylitol	
	Coded value	Actual value	Coded value	Actual value
1	-1	87.07 : 12.93	-1	10.59
2	-1	87.07 : 12.93	+1	13.41
3	+1	72.93 : 27.07	-1	10.59
4	+1	72.93 : 27.07	+1	13.41
5	-1.41	90 : 10	0	12
6	+1.41	70 : 30	0	12
7	0	80 : 20	-1.41	10
8	0	80 : 20	+1.41	14
9	0	80 : 20	0	12
10	0	80 : 20	0	12
11	0	80 : 20	0	12

Statistical Analysis

Physical and sensory results were conducted on completely randomized design (CRD) and randomized complete block design (RCBD), respectively and evaluated significant difference ($p < 0.05$) using an analysis of variance (ANOVA). Treatment means were compared using the Duncan's New Multiple Range Test (Cochran and Cox, 1992). To study color parameters, a five level, two variables, central composite rotatable design (CCRD) was used, as is shown in Table 1. Experimental design were analyzed using the ANOVA to validate the model (F-test). The statistical package SPSS version 14.0 for window and

STATISTICA software version 6.0 were used to perform the statistical analysis.

Results and Discussion

Total Soluble Solid (TSS) and pH

Table 2 shows the results for TSS (as °Brix) and pH, indicating that the level of TSS could be increased from the variations in carrot juice proportion and the xylitol concentration whereas the carrot juice had effected on the pH of low-calorie roselle-carrot juice. The increase in both variables led to higher TSS samples, because of the replacement of roselle juice (lower °Brix) with carrot juice (higher °Brix) and more amount of xylitol used. Moreover, the juice mixture having more roselle juice being replaced with carrot juice produced less acidic product, because of the replacement of higher acidic roselle juice with lower acidic carrot juice.

Table 2. Physical characteristics of low-calorie roselle-carrot juices.

Experimental number	Total soluble solid (°Brix)	pH
1	12.13	2.83
2	14.60	2.83
3	13.00	3.50
4	16.20	3.15
5	13.20	2.71
6	16.20	3.26
7	11.80	3.00
8	16.40	3.01
9	13.40	2.94
10	13.30	2.94
11	13.40	2.95

Color

By using the STATISTICA program, three fitted second-order polynomial equations can be obtained as follows:

$$L^* = 2.236 + 5.206 X_1^* + 0.085X_2 + 2.228 X_1^2 + 4.964 X_2^{2*} - 0.053X_1X_2 \quad (R^2 = 0.798,\ sig = 0.079), \qquad (1)$$

$$a^* = 1.578 + 4.233 X_1^* + 0.524X_2 + 1.956 X_1^2 + 3.674 X_2^{2*} - 0.023X_1X_2 \quad (R^2 = 0.931,\ sig = 0.006), \qquad (2)$$

$$b^* = 1.964 + 6.559 X_1^* + 0.555X_2 + 2.767 X_1^2 + 6.439 X_2^{2*} + 0.135X_1X_2 \quad (R^2 = 0.789,\ sig = 0.087), \qquad (3)$$

where: X_1 is the carrot juice proportion; X_2 is the xylitol concentration; *significant at 5%.

Comparing their R^2 values, it is clear that redness (a^*) had the highest value indicating presumably that the model was a better fit than for lightness (L^*) and yellowness (b^*). According to the significance of regression coefficient for color parameters (L^*, a^*, b^*), it can seen that the variable with the largest effect was the linear term of carrot juice proportion (X_1), followed by the quadratic of the xylitol concentration (X_2). The highest total determination coefficient R^2 is for redness (a^*) (93.1%) implies that the sample variation of 93.1% for redness is attributable to the carrot juice proportion and xylitol concentration and the effect of carrot juice was more pronounced than the influence of xylitol concentration on these parameters.

Response surface plots of data on color parameters are presented in Fig. 1a–c, showing the same changes as a function of roselle-carrot juice proportion and xylitol concentration. The increase in carrot juice proportion led to lighter sample (higher L^*) in accordance with increased intensity of redness and yellowness.

Sensory Evaluation

As shown in Table 3, there were significant differences ($p < 0.05$) in all sensory attributes among all roselle-carrot juices. Results for sensory evaluation of low-calorie roselle-carrot juice mixtures show that sensory color, sweetness, flavor and overall acceptability scores of these products varied from 2.92 to 7.75, 4.08 to 7.25, 4.67 to 6.75 and 4.00 to 7.42, respectively. The low-calorie roselle-carrot juices with higher amount of carrot juice or with higher xylitol concentration were rated in lower sensory scores, because most panelists did not prefer more intense sweetness of products. Moreover, some panelists would not like the cloudy of roselle-carrot mixtures, resulting from cloud carrot juice added. The more carrot juice used, the more cloudy mixture occurred. This was more affected the appearance of the mixtured product and may be attributed to the decrease in sensory preference.

The optimum formulation was obtained for the mixed roselle and carrot juice at 87.07:12.93 with 13.41% xylitol, scoring 7.42 of overall acceptability (moderately liking). On the other hand, the product with roselle-carrot juice (70 : 30) with 12% xylitol was rated only 4.17 score of overall acceptability, showing that the carrot juice was the main factor on panelists preference. Based on sensory evaluation, there is a potential to use carrot juice and xylitol in roselle-carrot mixture with specific amount, producing a product with less calorie and tooth decay.

Conclusion

The quality of low-calorie roselle-carrot juice mixtures were influenced by roselle-carrot juice proportion and xylitol concentration, showing a variation of TSS and pH with increased carrot juice proportion and xylitol. The model for redness (a*) was a better fit than for lightness (L*) and yellowness (b*). The increase in carrot juice proportion led to lighter sample (higher L*). The mixture containing roselle-carrot juice (87.07 : 12.93) with 13.41% xylitol was more acceptable than other products.

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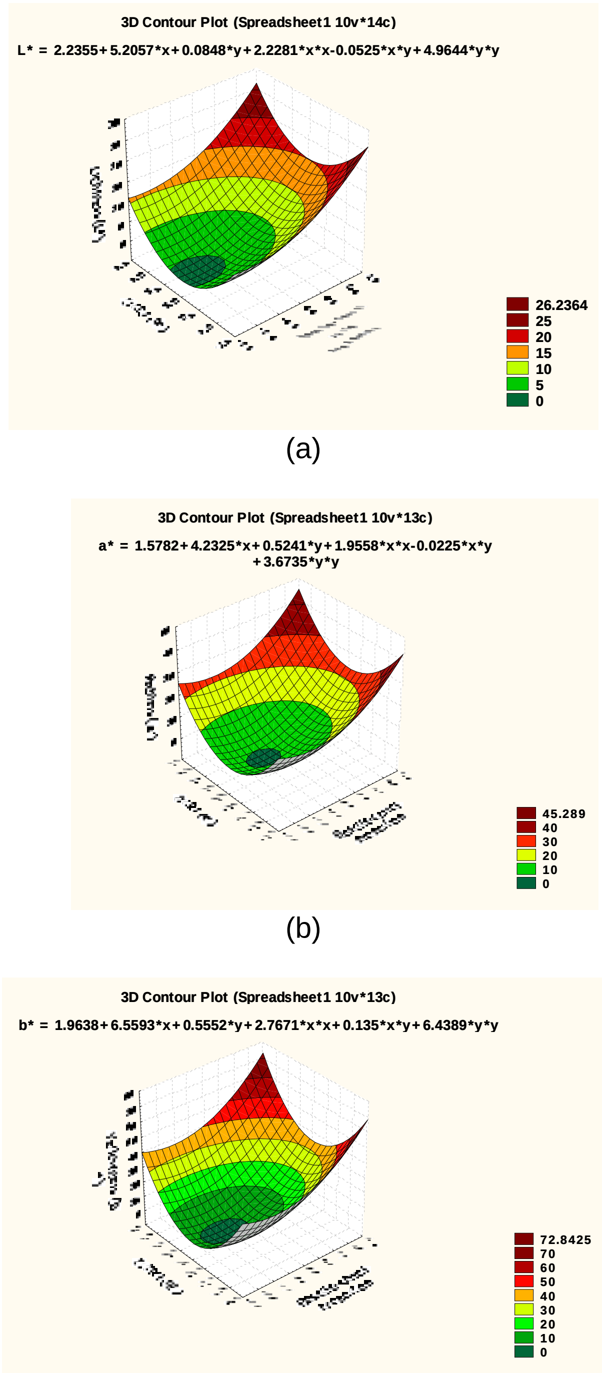

(a)

(b)

(c)

Fig. 1. Response surface of color parameters as a function of carrot juice proportion and xylitol concentration: (a) lightness (L*), (b) redness (a*) and (c) yellowness (b*).

Table 3. Sensory scores of low-calorie roselle-carrot juice mixtures.

Experimental number	Sensory scores*			
	Color	Sweetness	Flavor	Overall acceptability
1	7.17 ± 1.34^{a}	6.00 ± 1.48^{ab}	6.42 ± 1.44^{a}	6.58 ± 1.38^{ab}
2	7.75 ± 1.06^{a}	7.25 ± 1.22^{a}	6.75 ± 1.66^{a}	7.42 ± 1.16^{a}
3	6.58 ± 1.38^{ab}	6.00 ± 1.71^{ab}	6.25 ± 1.05^{ab}	6.17 ± 1.34^{ab}
4	6.50 ± 0.90^{bc}	5.92 ± 2.31^{ab}	6.25 ± 1.65^{ab}	5.92 ± 1.98^{b}
5	7.00 ± 1.35^{ab}	6.33 ± 1.56^{ab}	6.67 ± 1.30^{a}	6.83 ± 1.69^{ab}
6	2.92 ± 1.38^{d}	4.08 ± 2.35^{c}	4.83 ± 2.37^{c}	4.17 ± 2.08^{d}
7	2.92 ± 1.31^{d}	5.17 ± 2.21^{bc}	4.67 ± 1.97^{c}	4.42 ± 1.73^{c}
8	3.00 ± 1.71^{d}	4.17 ± 1.64^{c}	4.67 ± 1.92^{c}	4.00 ± 1.76^{d}
9	6.25 ± 1.48^{bc}	6.50 ± 2.19^{ab}	5.92 ± 1.31^{abc}	6.08 ± 1.38^{b}
10	7.08 ± 1.08^{ab}	6.17 ± 2.48^{ab}	6.50 ± 2.02^{a}	6.42 ± 2.15^{ab}
11	5.83 ± 1.94^{c}	6.08 ± 1.56^{ab}	5.00 ± 1.47^{c}	5.58 ± 1.68^{bc}

[a,b,c,d] Means in the same column with different superscripts are different ($p < 0.05$).
* Based on 9-point hedonic scale test (1 = extremely dislike, 9 = extremely like).

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