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Utilization of Cashew Gum in the Production of Pineapple Jam and Cashew Apple Juice Drink

Esther Gyedu-Akoto[1*] • Ibok Oduro[2] • William O. Ellis[2] • Frank M. Amoah[1] • James H. Oldham[1]

[1] Cocoa Research Institute of Ghana, P.O. Box 8, Akim-Tafo, Ghana
[2] Department of Biochemestry, Kwame Nkrumah University of Science and Technology, Private Mail Bag, Kumasi, Ghana

Corresponding author: * **akua_akoto2004@yahoo.co.uk**

ABSTRACT

Cashew tree gum is an exudate polysaccharide produced spontaneously or by deliberately inflicting wounds on the bark of the cashew (*Anacardium occidentale* L.) tree. Its physico-chemical and rheological properties have been found to be similar to those of gum Arabic which finds industrial applications as a thickening agent, emulsifier or stabilizer. This has led to the assessment of cashew gum as a gelling agent and stabilizer in pineapple jam and cashew juice. The optimum formulations for the production of pineapple jam and cashew juice drink with cashew gum were determined using response surface methodology. Significant regression models which explained the effects of cashew gum on the two products were determined. The coefficients of determination, R^2 for all the response variables which were 0.7 or higher were used to generate contour and response surface plots. Based on the results, the possible combinations of ingredients for the production of jam with the desired sensory qualities were in the range 0.53-0.70, 0.05 and 0.25-0.42 for pineapple pulp, cashew gum and sugar, respectively. Cashew gum was found to be suitable as a clarifying agent rather than a stabilizer in cashew juice production with the optimum level being 0.3.

Keywords: gelling agent, stabilizer, response surface, experimental design, sensory analysis

INTRODUCTION

The addition of value to raw agricultural products has been of immense importance to both producers and consumers over the past decades (Wills 1989). The demand for stable, convenient foods such as fruit juice and preserves has increased markedly, especially exotic products (FAO 1999). Cashew apple, which is a by-product of the cashew nut can be processed to generate extra income for the producers and also provide inexpensive vitamin C to the consumer (Barros 2001). Some major problems of cashew apples are their astringent and acrid nature, short production period of about 70 days and high perishability (Augustin 2001). However, they have tremendous potential if exploited commercially by the food industry in Ghana. Therefore, there is a need to develop a product such as a stable cashew juice drink which will be appealing to consumers using cashew gum as a stabilizer.

Fruit preserves such as jams and marmalades are mixtures of fruits and sugar, which have been boiled to produce a stable gel structure with attractive visual and eating qualities and mould-free storage life. The products should have characteristic colours, flavours and textures and be easily spreadable (Teagasc 2005). The basic principle of jam making is to have fruit, pectin, acid and sugar present in the correct proportions. The setting of jam depends on the presence of pectin (Teagasc 2005). However, commercial pectin, which is used in the production of fruit preserves in Ghana, is highly expensive and its supply is limited. The high cost and limited supply of pectin has led to the search for other suitable and cheaper gelling agents in the production of jams and marmalades.

The average production of gum from the cashew tree per year ranges from 13.7 to 1237.1 g depending on the age and location of tree (Gyedu-akoto 2007). Cashew gum has been found to compare favourably to gum arabic (Gyedu-akoto 2008a, 2008b) and therefore has many industrial potentials. Thus, the need to explore its utilization in food products cannot be overemphasized. This paper therefore attempts to develop a stable single strength juice from cashew apples and pineapple jam using cashew gum as a stabilizer and a gelling agent. When successful, it will expand the income-generating base of cashew producers in Ghana as well as ensure the long-term applications in the fruit processing industry.

MATERIALS AND METHODS

Collection and handling of cashew gum

Gum was collected from cashew (*Anacardium occidentale* L.) trees, aged between 4 and 20 years, in the Savanna and Transitional zones of Ghana where cashew production is concentrated. The gum exudates, which oozed out naturally were picked from the trees and sorted to remove pieces of bark and other foreign matter. They were then spread on large size petri dishes and dried in an oven at 30°C for two weeks. The dried and cleaned gum samples were then milled into a powder with a Christy Disintegrator 43740 (Christy and Norris Ltd., Process Engineers, England).

Development of cashew juice using cashew gum as stabilizer

1. Harvesting, handling and extraction of juice from cashew apples

Cashew apples, which were about 60 days old, were harvested daily by picking them from the fields of experimental cashew tree plots of the Cocoa Research Institute of Ghana (CRIG). The nuts were detached from the apples by hand and sent to the processing site in trays for sorting to remove unwholesome fruits. The apples were quickly immersed in cold water and washed. Sample fruits

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were then cut into eight pieces to extract as much juice as possible. The cut apples were then filled into a polyethylene sack which was placed in a screw press extractor to squeeze out the juice.

2. Experimental design for the formulation of cashew juice

The central composite design (CCD) was used in the formulation. The independent parameters used were cashew juice (X_1) and cashew gum (X_2). Five levels of each of the parameters were used (**Table 1**). Since the design is a two factor design with five levels, a value (α) of -1.414 was assigned to the lowest level, 0 to the middle level and +1.414 to the highest level. Altogether 9 combinations were chosen (**Table 2**) (Cochran 1992).

Sample calculation

$\alpha = [2^k]^{1/4}$
$\alpha = [2^2]^{1/4}$
$\alpha = 1.414$

where k is the number of factors

1. Processing of cashew juice and its physico-chemical analysis

Cashew gum was mixed with fresh cashew juice in the various proportions (**Table 2**) and boiled for about 15 to 20 min until a brown colour was obtained. Sodium metabisulphite was added at 0.01%. The boiled juice was then filled into 250 ml polyethylene bottles, which were pre-sterilized by rinsing in hot sodium metabisulphite solution (0.01%) at 80 ± 5°C. Turbidity was determined by measuring the absorbance of each product using Phillips PU8620 UV/VIS/NIR (Pye Unican Ltd, England) spectrophotometer. The pH of each product was also measured using a Mettler Toledo pH meter (Mettler Toledo Ltd, Switzerland).

Development of pineapple jams using cashew gum as gelling agent

1. Preparation of pineapple pulp

Mature and ripe pineapples (smooth cayenne cultivar) were bought from the open market and brought to the processing site for washing. The washed pineapples were peeled and cut into four to remove the hard central cord. They were then diced and blended into pulp using a Moulinex blender.

2. Experimental design for the formulation of pineapple jam

A three-component constrained simplex lattice design was used (Cornell 1983). Design mixtures consisted of coordinates of the vertices and uniformly spaced distribution of points on the face and sides of the constrained region of the simplex factor space. Pineapple pulp (K_1), cashew gum (K_2) and sugar (K_3) were the ingredients (variables) for jam formulation. The sum of the component proportions was one. The proportions of K_1 and K_2 were limited to the range of 0.20-0.70 and 0-0.10, respectively, based on preliminary studies. To support a second or higher-order polynomial equation that represents response behaviour over the restricted simplex region (Cornell 1983) 12 blends (**Table 3**) were identified. The location of each blend in the simplex coordinate system was plotted (**Fig. 1**).

Sample calculation

a. Since the sum of component proportions was one, then

$K_1 + K_2 + K_3 = 1$

i. If K_1 and K_2 are 0.70 and 0 respectively, then

$K_3 = 0.30$

ii. If K_1 and K_2 are 0.20 and 0 respectively, then

$K_3 = 0.80$

b. Since the points are uniformly distributed on the face and sides of the constrained region, then for K_1 and K_3, the difference between each point will be 0.17 while that of K_2 will be 0.05

Table 1 Central Composite Design with levels of components used for juice production.

CCD code (α}	-1.414	-1	0	+1	+1.414
Cashew juice (X_1)	8.75	8.95	9.00	9.05	10.0
Cashew gum (X_2)	0.00	0.05	0.10	0.15	0.20

Table 2 Combinations of components of the various blends.

Blend no.	Cashew juice (X_1)		Cashew gum (X_2)	
	Code	Actual value	Code	Actual value
1	1	9.05	-1	0.05
2	-1	8.95	-1	0.05
3	1	9.05	1	0.15
4	-1	8.95	1	0.15
5	+1.414	10.0	0	0.10
6	-1.414	8.75	0	0.10
7	0	9.00	-1.414	0.00
8	0	9.00	1.414	0.20
9	0	9.00	0	0.10

Table 3 Component proportions of the various blends for pineapple jam.

Blend no.	Component proportions		
	Pineapple pulp (K_1)	Gum (K_2)	Sugar (K_3)
1	0.70	0	0.30
2	0.53	0	0.47
3	0.37	0	0.63
4	0.20	0	0.80
5	0.70	0.05	0.25
6	0.53	0.05	0.42
7	0.37	0.05	0.58
8	0.20	0.05	0.75
9	0.70	0.10	0.20
10	0.53	0.10	0.37
11	0.37	0.10	0.53
12	0.20	0.10	0.70

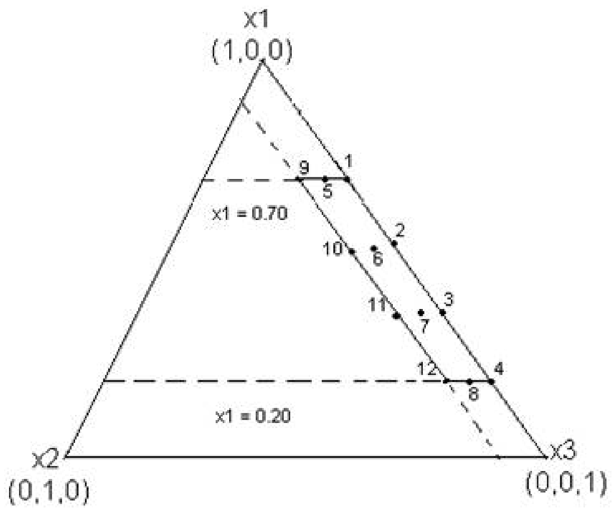

Fig. 1 Constrained region in the simplex coordinate system defined by the restrictions $0.20 < x_1 < 0.70$ and $0 < x_2 < 0.10$.

Processing of pineapple jam and its physico-chemical analysis

Pineapple pulp was mixed with sugar and cashew gum in the above proportions and boiled to set. Sodium metabisulphite was added at 0.01%. Then the set jam was filled into jars, which were pre-sterilized in hot water. Total ash content and pH were measured on each experimental product. The ash content was determined by weighing 2 g of each sample into porcelain crucibles and incinerating in a muffle furnace at 600°C for 1 h until carbon-free ash was obtained. The weight of the ash was expressed as a percentage of the weight of milled gum. Aqueous solution of each

Table 4 Mean sensory scores for juice blends and mean values of their physical determinations.

Blend no.	Sweetness	Flavour	Astringency	Colour	Acceptability	pH	Turbidity
1	9.1	8.3	7.5	10.5	5.7	5.48	2.64
2	6.5	6.6	7.4	4.0	5.1	5.40	2.02
3	7.6	7.6	5.7	7.7	5.8	5.44	2.16
4	7.9	7.6	7.3	5.7	5.2	5.41	2.30
5	6.6	6.8	6.5	8.3	4.7	5.36	2.25
6	6.9	7.3	6.3	7.2	5.5	5.39	2.33
7	5.8	7.8	8.0	1.8	5.2	5.39	1.17
8	7.3	7.5	5.5	7.3	5.4	5.36	1.01
9	6.6	8.7	7.0	6.2	5.8	5.37	2.24

product was made by dissolving 2 g of each sample in 50 ml distilled water and the pH measured with a glass electrode fitted to a Jenway 3020 pH meter (UK).

Sensory analysis

This was done by presenting 33 consumer panelists with sets of coded samples of cashew juice to rank in order of preference for color, sweetness, flavor and astringency. The panelists consisted of National Service Personel at CRIG whose ages were between 20 and 25 years. They were also asked to determine the overall acceptability of the products using a 9 point hedonic scale where 1 = dislike and 9 = like extremely (Pangborn 1980).

Statistical analysis

Data obtained for each product was analyzed using Statgraphics Plus program (Ver. 3.0) package (Statistical Graphics Corp., US) for analysis of variance and regression. Regression analysis was used to fit a relation to the data of all dependent sensory and physical variables evaluated ($P < 0.05$). Lack-of-Fit tests were conducted to detect whether the models generated fitted well.

RESULTS AND DISCUSSION

Visual observation of cashew juice produced showed that sediments formed in the juice after heat treatment could not remain suspended indefinitely indicating that cashew gum did not have any stabilizing effect on the juice. However, turbidity of the juices showed that the addition of cashew gum caused more sedimentation at all levels (**Table 4**). Thus the products were rather clarified by cashew gum and this may be due to the galactopyranosyl units in its structure. It has been reported by Baker and Cameron (1999) that the addition of base-solubilized polygalacturonic acid to fruit juices yielded immediate and relatively complete clarification. All the juice blends, with the exception of blend 8, had higher turbidity than blend 7 which contained no cashew gum (**Table 4**). The addition of cashew gum to the juices also reduced astringency and this may be because most of the tannins, which are the main cause of astringency, might have precipitated out with the gum.

Regression analysis of the results indicated that second order polynomial models were adequate to determine the effects of cashew gum on astringency and turbidity of the products. The coefficients of determination (R^2) of astringency and turbidity for polynomial regression were 0.77 and 0.82, respectively (**Table 5**). The closer the R^2 value is to unity the better the empirical model fits the actual values. The models generated are expressed as follows:

Table 5 Coefficients of determination and p-values for dependent variables.

Variable	R^{2*}	p-value	R^{2**}	p-value
Sensory				
Colour	0.22	0.48	0.30	0.342
Astringency	0.71	0.03	0.77	0.03
Flavour	0.11	0.70	0.33	0.31
Acceptability	0.40	0.21	0.55	0.09
Sweetness	0.09	0.75	0.25	0.48
Physical				
Turbidity	0.07	0.81	0.82	0.005
pH	0.17	0.58	0.13	0.66

*Multiple linear regression
**Polynomial regression (2nd order)

$$Y_1 = 8.7-23.5(X_2) + 46.0(X_2)^2$$

$$Y_2 = 1.4 + 17.2(X_2)-76.0(X_2)^2$$

Y_1 and Y_2 are astringency and turbidity respectively and X_2 is cashew gum.

They were found to be statistically significant ($p<0.05$) as determined using ANOVA (**Table 5**). Thus, for all the variables monitored astringency and turbidity are the components to observe and work on if one has to achieve optimum quality products. Lack-of-Fit test conducted on the two models showed that the models were adequate to describe the observed data since their P-values were greater than 0.10. Response surface plots, which are helpful in understanding the main and interaction effects of the independent variables (Kenneth 1995) were plotted for turbidity and astringency (**Figs 2A, 2B**). Both plots depicted nonlinear trends for turbidity and astringency. The distribution of the response surface showed that increasing cashew gum levels increased turbidity but this however reduced astringency.

Results on sensory analysis of pineapple jam produced with cashew gum showed that sweetness, flavour, consis-

Table 6 Mean sensory scores for jam blends and mean values of their physical determinations.

Blend no.	Sweetness	Flavour	Consistency	Colour	Acceptability	pH	Ash (%)
1	6.9	8.3	5.7	6.0	5.6	3.56	0.41
2	8.3	9.6	6.3	7.5	4.9	3.51	0.38
3	7.2	6.6	6.0	8.2	4.5	3.56	0.36
4	12.4	7.4	11.0	5.0	2.6	3.82	0.04
5	7.5	7.4	10.6	9.5	6.7	3.52	0.22
6	8.4	11.2	8.2	10.5	7.0	3.53	0.21
7	8.9	9.8	9.2	10.5	6.5	3.55	0.18
8	11.8	5.2	11.3	4.1	2.9	3.75	0.16
9	8.2	7.6	10.6	8.3	6.5	3.47	0.17
10	9.8	9.8	9.8	7.9	5.9	3.57	0.10
11	10.6	7.5	11.8	6.5	5.2	3.62	0.18
12	10.2	7.2	10.0	6.6	3.5	3.70	0.14

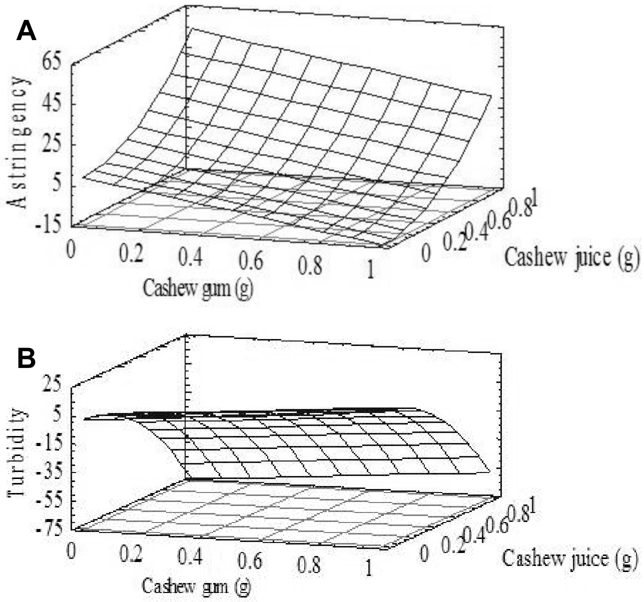

Fig. 2 (**A**) Distribution of the response surface for turbidity. (**B**) Distribution of the response surface for astringency.

Table 7 Coefficients of determination and p-values for dependent variables.

Variable	R^{2*}	p-value	R^{2**}	p-value
Sensory				
Colour	0.25	0.27	0.46	0.06
Consistency	0.54	0.03	0.06	0.76
Flavour	0.16	0.46	0.62	0.01
Acceptability	0.70	0.004	0.77	0.01
Sweetness	0.69	0.01	0.69	0.01
Physical				
Ash	0.53	0.03	0.07	0.71
pH	0.71	0.004	0.86	0.00

*Multiple linear regression
**Polynomial regression (2nd order)

tency, colour and acceptability generally increased with an increase in gum proportion (**Table 6**). However, pH and ash contents of the products decreased with an increase in cashew gum. An increase in the proportion of pineapple pulp also increased flavour, colour, acceptability and ash content but decreased pH. The lowest pH was with blend 9 and the highest with blend 4. For ash blend 1 gave the highest level while blend 4 gave the lowest. Reducing pineapple pulp proportion also increased sweetness and this is due to the increase in sugar content (**Table 6**). An increase in the pineapple pulp proportion increased the fruity flavour of the jam. The p-values and the coefficients of determination (R^2) of the dependent variables are presented in **Table 7**. Regression analysis of the data indicated that multiple regressions gave very high and significant coefficients for acceptability (R^2 = 0.70), sweetness (R^2 = 0.69) and pH (R^2 = 0.71). Regression of the second order polynomial also gave very high and significant coefficients for acceptability (R^2 = 0.77), sweetness (R^2 = 0.69), pH (R^2 = 0.86) and flavour (R^2 = 0.62). From these results, it implies that pH and sweetness are the most important factors influencing product quality.

Response surface plot was generated for consumer acceptability because its coefficient of determination was above 0.7 and also because the consumer is the ultimate judge. The model used is as follows:

$$Y_1 = -0.75 + 22.81(K_1) - 18.42(K_2)^2$$

Y is acceptability and K_1 and K_2 are levels of pineapple pulp and sugar respectively.

This model was found to be statistically significant ($P < 0.05$) (**Table 7**) and the Lack-of-Fit test showed that the model was adequate to describe the observed data. The distribution of the response surface for acceptability showed that increase in pineapple pulp proportion increased acceptability (**Fig. 3**). In order to predict optimum levels of pineapple pulp, cashew gum and sugar, contour plots were drawn at the constant levels of cashew gum K_2 (0, 0.05, and 0.10). At the 0 level of cashew gum acceptance was high for products with pineapple pulp proportion of 0.65-0.85 (**Fig. 4A**) while at the 0.05 level it was high for products with pineapple pulp proportion of 0.53-0.95 (**Fig. 4B**). At the 0.10 level, acceptance was high for products of 0.53-0.85

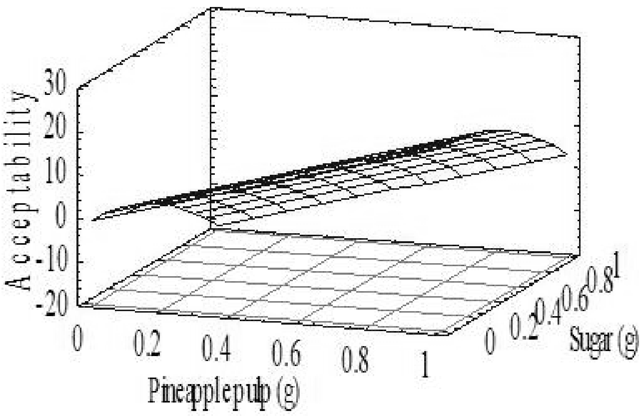

Fig. 3 **Distribution of the response surface for acceptability.**

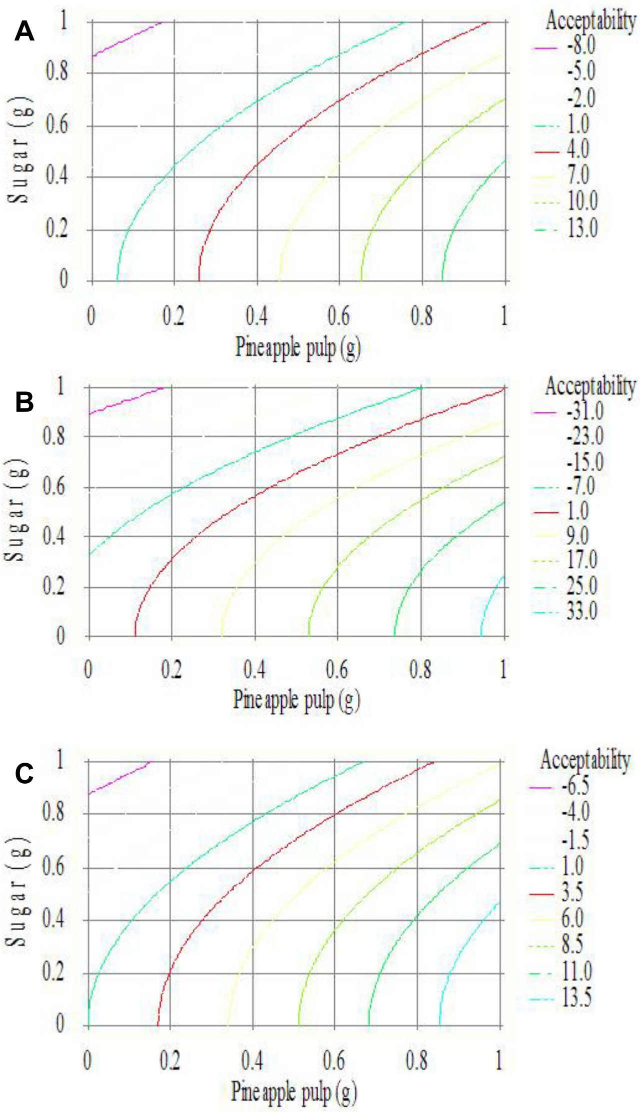

Fig. 4 (**A**) Contour plot at 0 level of cashew gum. (**B**) Contour plot at 0.05 level of cashew gum. (**C**) Contour plot at 0.10 level of cashew gum.

pineapple pulp proportions (**Fig. 4C**). Although acceptance was high at all three levels for high pineapple pulp products it was highest at the 0.05 level of cashew gum inclusion indicating that the optimum level of cashew gum for jam was 0.05 and that for pineapple pulp and sugar were 0.53-0.70 and 0.25-0.42, respectively.

CONCLUDING REMARKS

Addition of cashew gum to cashew juice caused sedimentation of the juice resulting in the clarification of the juice rather than stabilizing its cloudiness. It also reduced the astringency, one of the major problems of cashew apples. The optimum level of cashew gum for juice clarification was found to be 0.3. The study showed that cashew gum has the potential to be used as a substitute for pectin in the production of pineapple jam. High cashew gum and pineapple pulp proportions increased the acceptance of the products but reduced the pH which was the most important factor affecting the quality of pineapple jam. Acceptability was very high in products with 0.05 levels of cashew gum, indicating that the optimum level of the gum in the production of pineapple jam was 0.05. The optimum levels for the other ingredients were found to range from 0.53-0.7 and 0.25-0.42 for pineapple pulp and sugar respectively. Therefore, the commercial application of cashew gum in the clarification of fruit juices and the production of jams should be encouraged to make it one more source of income for cashew growers.

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