

Optimizing Acceptability of Fresh *Moringa oleifera* Beverage

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Abstract
The study was conducted to formulate and optimize a consumer acceptable fresh Moringa leaves (extract) beverage. A constrained three component mixture design consisting of fresh tender Moringa leaves extract, pineapple juice and carrot extract was used to optimize the formulation of the beverage based on sensory acceptability (color, taste, flavor, aftertaste and overall acceptability). A constant amount of ginger root distillate was used to improve the flavor of the beverage. The optimum component proportions consisting of 50-52% Moringa extract, 38-40% Pineapple juice and 10-12% Carrot extract was validated to be adequate and acceptable to consumers. The findings show that fresh Moringa leaves could be processed into acceptable beverage, to extend its beneficial and nutraceutical properties to many consumers.
Keywords: formulate, optimize, validate, Moringa, pineapple, carrot, ginger

1. Introduction

Moringa oleifera, a rapidly growing tree, is native to the sub-Himalayan tracts of India, Pakistan, Bangladesh, Afghanistan (Fahey, 2005). Analyses of the leaf composition have revealed them to have significant quantities of calcium, iron, protein, vitamin A, B, and C (Ramachandran *et. al.,* 1980).

As many as 800 million persons worldwide are affected by malnutrition. More than half the childhood deaths in developing countries are related to malnutrition (Benson, 2004). Furthermore, across the continent increasing numbers of individuals live with or die - prematurely - from stroke, hypertension, diabetes and cancers. In countries such as Ghana a greater number of medical admissions and deaths result from chronic non-communicable diseases than from communicable diseases such as HIV and tuberculosis (Aikins, 2008).

In 2004, the World Health Organization (WHO) adopted the Global Strategy on diet to help prevent or minimize the occurrence of non-communicable diseases. It recommended that individuals achieve energy balance and a healthy weight; limit energy intake from total fats and shift fat consumption away from saturated fats to unsaturated fats and towards the elimination of trans-fatty acids; increase consumption of fruits, vegetables, legumes, whole grains, and nuts; limit the intake of free sugars; and limit salt consumption from all sources and ensure that salt is iodized (Lachat, 2013).

Moringa oleifera leaves have been determined to have high levels of vitamin and minerals among other nutrients, and may provide a simple solution in efforts at minimizing malnutrition and various related ailments. In Ghana, Moringa leaves are popularly distributed as a dry smooth, free flowing powder for consumers to mix as a nutritional supplement. An alternative method for unleashing the great benefits of this nutritionally important plant is to incorporate it in a refreshing beverage.

From a preliminary study, aqueous extract of fresh Moringa leaves was dark green, and did not appeal to consumers as a refreshing and attractive beverage. The fresh raw Moringa extract flavor was also not a particularly good selling point to consumers. Subsequently, it was determined that a beverage made using moringa leaf extract would need to have an acceptable flavor, taste and color. Appreciable amounts of pineapples are lost due to improper post-harvest handling and management. Mixing pineapple juice with the water extract of Moringa leaves would provide a natural sweetening source to the Moringa beverage and increase the utilization of a highly perishable crop. It would also lighten the dark green color of the moringa leaves extract. Additionally, incorporation of the aqueous extract of carrot and a natural ginger distillate to the Moringa- pineapple juice mixture would further improve the color and flavor of the product, and better appeal to consumers.

This study describes the formulation and optimization of the proportions of the three components (Fresh Moringa leaf extracts, pineapple juice and carrot extract) in a beverage using response surface design and sensory analysis.

2. Materials and Methods

2.1 Juice extraction

One hundred gram (100g) of cleaned and blanched (Hot water of 90^{o}C for 10mins) (Potter, 1973) *Moringa* *oleifera* tender leaves, one hundred gram (100g) of cleaned sliced carrot (*Daucus carota*) and one hundred gram (100g) of cleaned sliced ginger (*Zingiber officinale*) were slurred in two hundred milliliter (200ml), Six hundred milliliter (600ml) and two hundred milliliter (200ml) of treated water (Boiled at 100^{o}C and cooled) respectively, using a commercial laboratory blender (Christison laboratory blender, California, USA) at low speed of 19,000 rpm for 5mins.

The slurries were filtered using sterilized cheese cloth. Filtrate from Moringa slurry was centrifuged (Haraeus cryofuge 8500i low speed floor standing model centrifuge – 6x100ml bottles) to obtain a clear extract. The ginger filtrate was distilled using steam distillation to obtain a clear distillate.

Cleaned peeled, sliced and blanched (Hot water of 90^{o}C for 10min) pineapple was pulped using commercial laboratory blender (Christison laboratory blender, California, USA) at low speed of 18,000 rpm for 5mins and filtered using a sterilized cheese cloth to obtain a clear pineapple juice.

Moringa extract, carrot extract and pineapple juice were then pasteurized at 62^{o}C for 30minutes (Aurand *et al.*, 1987).

2.2 Experimental Design

A three-component constrained simplex centroid mixture design (Cornell, 1983) was used. The mixture components consisted of moringa (x_1), pineapple (x_2) and carrot (x_3), which made up 98% of the total formulation. All formulations contained 2% ginger distillate. Component proportions were expressed as fractions of the mixture and the sum (x_1+x_2+x_3) of the proportions equaled 1.0. The practical range of proportions of component variable (x_1+x_2+x_3) was established following preliminary work. Based on the Minitab statistical software (Minitab version 14, Minitab Inc, PA USA) for three components, ten component formulations were generated for the experiments (Fig. 1 and Table 1).

Table 1 – Composition of *Moringa oleifera* leaf beverage formulation in three-component constrained simplex centroid mixture design evaluated for acceptability of sensory qualities [a]

Formulation Number b	Proportion of Ingredient (%) Moringa(X_1)	Pineapple(X_2)	Carrot(X_3)	Total
1	50.0	30.0	20.0	100
	49.0	29.4	19.6	98
2	53.4	23.0	23.0	100
	52.4	22.8	22.8	98
3	60.0	20.0	20.0	100
	58.8	19.6	19.6	98
4	70.0	20.0	10.0	100
	68.6	19.6	9.8	98
5	56.7	26.7	16.6	100
	55.5	26.2	16.3	98
6	53.3	33.3	13.3	100
	52.3	32.6	13.1	98
7	50.0	20.0	30.0	100
	49.0	19.6	29.4	98
8	60.0	30.0	10.0	100
	58.8	29.4	9.8	98
9	50.0	40.0	10.0	100
	49.0	39.2	9.8	98
10	63.4	23.3	13.3	100
	62.1	22.8	13.1	98

[a] Moringa leaf beverage components (100% in mixture design) were 98% of actual formulations. All formulations contained 2% ginger distillate for a total of 100%.

[b] Formulation numbers correspond to the numbers shown in Fig. 1.

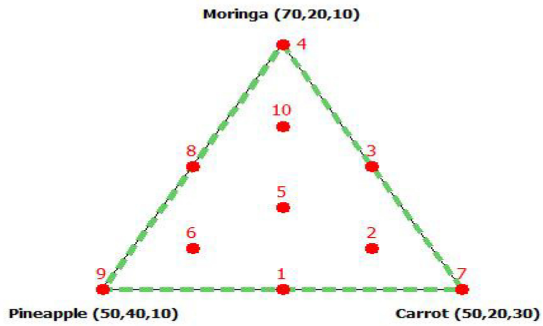


Fig. 1 – Constrained region defined by the following restrictions: $50 \leq x_1 \leq 70$, $20 \leq x_2 \leq 40$ and $10 \leq x_3 \leq 30$. Numbers (1-10) represent ten formulations and correspond to the numbers in Table 1.

2.3 Consumer acceptance test

Untrained consumers (n = 60) were randomly recruited from among the staff of the Ghana Standards Board and the staff and students of the Department of Nutrition and Food Science, University of Ghana. The criteria of selection of panelists were that (a) they will be available and willing to participate in panel tests, (b) they are regular consumers of juices, and (c) they are of sound health. A balanced incomplete block design (t=10, k=4, r=6, b=15, λ=2) described by Cochran and Cox, (1957) was used to assign the ten (10) products to fifteen (15) panelists such that each panelist evaluated only four (4) products without the danger of fatigue. The tests were replicated with four different sets of 15 panelists: two sets by students in the Department of Nutrition and Food Science, Legon and the other two sets by staffs of the Ghana Standard Board, Okponglo in Accra.

The sensory attributes considered for the evaluation were color, taste, flavor, aftertaste and overall acceptability. Panelists assessed and assigned scores to the attributes using the 9 – point Hedonic scale where 1 represented dislike extremely, 5 represented neither like nor dislike and 9 represented like extremely. Responses from the products' sensory attributes were analyzed using ANOVA and regression techniques.

2.4 Data analysis

The Minitab software version 14 was used to fit a quadratic canonical polynomial model described by Scheffé (1958) as follows:

$$Y= \beta_1X_1 + \beta_2X_2 + \beta_3X_3 +\beta_{12}X_1X_2 +\beta_{13}X_1X_3 + \beta_{23}X_2X_3$$

Where Y = a predicted dependent variable (color, taste, flavor, aftertaste or overall acceptance). β_1, β_2, β_3, β_{12}, β_{13}, β_{23} = Corresponding parameter estimates for each linear and cross product term, X_1= Moringa, X_2= Pineapple and X_3= Carrot.

2.5 Determining the optimum formulation

The predictive regression models developed for each of the attributes (color, taste, flavor, aftertaste, and overall acceptability) were used to generate ternary contour plots to display the effects of the components on the attributes. Contour plots of the attributes were overlaid based on the (consumer acceptable) limits of the attributes. The optimum region was determined by superimposing the contour plots (Palomar *et al.,* 1994) of all sensory attributes that would meet the criteria for an acceptable prototype product (Prinyawiwatkul *et al.,* 1997).

3. Results and Discussion

3.1 Consumer acceptability

There were significant differences ($p \leq 0.05$) in the sensory attributes of, color and overall acceptability among the ten formulations. This suggests that, good variations existed between the formulations and therefore panelists were able to assess the differences in the sensory attributes of the various formulations.

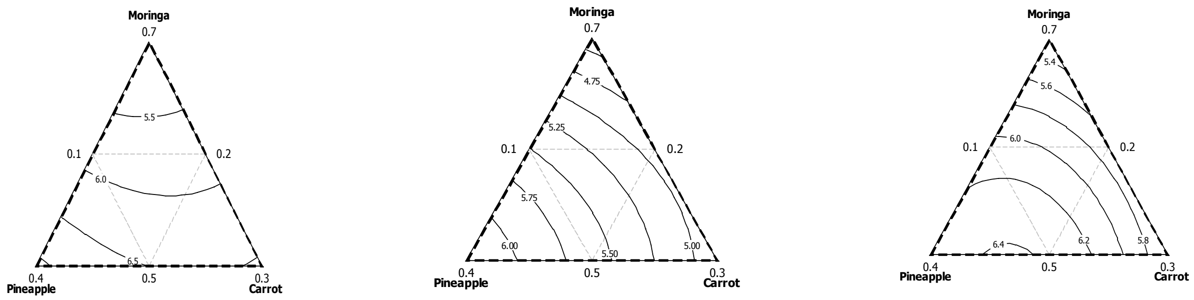
3.2 Color

The mean score data for color, taste, flavor, aftertaste and overall acceptance (Fig. 2, Table 2) shows that, product number (7), was more highly rated for color. This formulation as shown in Table 1, had minimum content of Moringa at 50%, minimum carrot 10% and maximum pineapple content at 40%. The sensory data for color was fitted to a regression model (Table 3) and it was reasonably accurate, showing R-squared (adjusted) of 70%. Minimum proportion of Moringa juice in the formulation improved the color appreciation by the panelists. This could be attributed to consumers not being familiar with green beverages, and hence the less green the color of the juice the higher it was scored.

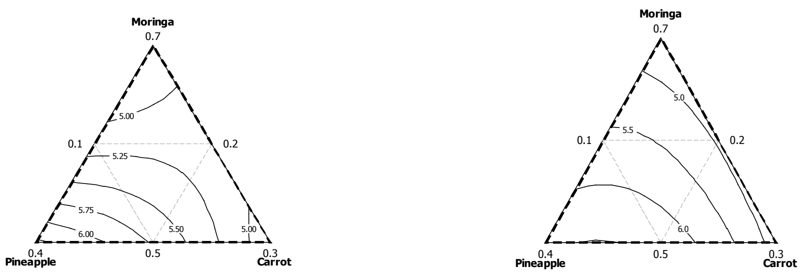
Table 2 – Mean consumer scores for color, taste, flavor, aftertaste and overall acceptance with Moringa leaf beverage.

FORMULA NUMBER[a]	COLOR	FLAVOR	TASTE	AFTERTASTE	OVERALL ACCEPTABILITY
1	5.96	6.21	5.29	5.17	5.33
2	6.50	5.63	4.83	4.75	4.83
3	6.75	6.08	5.96	5.54	6.38
4	5.00	6.08	4.75	5.04	5.13
5	6.33	6.42	5.67	5.83	6.58
6	6.42	6.00	5.13	5.33	5.08
7	7.00	6.33	6.17	6.33	6.25
8	5.92	6.00	5.63	5.29	5.79
9	5.21	5.13	4.42	4.75	4.63
10	5.92	5.54	5.08	5.17	5.29

[a] Formulation numbers correspond to the numbers shown in Fig. 1 and Table 1.



Color Taste Flavor



Aftertaste Overall acceptability

Fig. 2 – Contour plots for predicted acceptability values of color, taste, flavor, aftertaste and overall

3.3 Taste

The highest mean score, >6 (Table 2) for taste was obtained when pineapple was at its highest level. The taste of the beverage was not much liked when moringa at the maximum level. This taste of the beverage was not influenced by the level of carrot in the formulation. It was neither liked nor disliked when carrot was at the maximum level. This confirms that pineapple was the main ingredient that influenced the product taste. The model for taste showed an adjusted R-squared of above 88 percent (Table 3).

Table 3 – Reduced quadratic canonical polynomials for each of dependent sensory attributes of moringa beverage containing proportions of Moringa (x_1), pineapple (x_2) and carrot (x_3)[a]

Dependent Variable	**Predictive Model**	**R^2 adjusted (%)**
Color	$3.81X_1 +24.39X_2 +13.71X_3 -22.77X_1X_2 -0.04X_1X_3 -34.13X_2X_3$	70.03
Taste	$-1.147X_1 +4.393X_2 -8.066X_3 -20.423X_1X_2 -30.082X_1X_3 -6.787X_2X_3$	88.58
Flavor	$0.26X_1 -6.27X_2 -10.70X_3 -32.90X_1X_2 -26.65X_1X_3 -44.27X_2X_3$	66.81
Aftertaste	$5.88X_1 +26.80X_2 -18.07X_3 -39.18X_1X_2 +32.41X_1X_3 +16.50X_2X_3$	87.28
Overall acceptance	$2.47X_1 +3.18X_2 -17.99X_3 +8.72X_1X_2 +20.65X_1X_3 +72.36X_2X_3$	68.53

[a] Consumer scores were based on a 9-point hedonic scale (1= dislike extremely, 5= neither like nor dislike and 9= like extremely)

3.4 Flavor

Flavor includes taste and aroma perceived through tasting (Jellinek, 1985). The least acceptable flavor (mean score of 5.4, Table 2) was found in product number 9 (Table 1) that had the highest amount (70%) of moringa, the lowest proportion of pineapple 20% and carrot 10%. Increasing the amount of moringa in the juice gave a flavor that was least liked by consumers. A reduction in the amount moringa to the minimum level gave an acceptable mean score of 6.2 (Fig. 2). The decrease in flavor score with increasing Moringa levels was probably due to the strong herbal flavor.

3.5 Aftertaste

The least score for aftertaste was obtained for products 2 and 9, Table 1) with high amounts of moringa while the highest mean score (6.33) was obtained for product 7, which had maximum amounts of pineapple and the lowest proportions of moringa. Thus high amounts of pineapple in the product may have increased the score for aftertaste. This may be due to the sweetening nature of pineapple. Regression model for aftertaste showed R-square of 87%. Contour plots obtained from the regression model for aftertaste (Fig. 2) showed that carrot and moringa at their maximum levels gave juices that were neither liked nor disliked by consumers. As the compositions of moringa and carrot were reduced, high mean scores for aftertaste in the juice were recorded.

3.6 Overall acceptability

Analysis of variance (ANOVA) (Table 2) indicated that differences existed in color and overall acceptability of the ten formulations. The pattern of consumer acceptability scores for taste and aftertaste of moringa beverage was similar to that for overall acceptability (Table 2). Consumers are influenced differently by specific sensory attributes when they judge overall acceptability (Moskowitz, 1994). Scrutinizing results from ANOVA, it was concluded that taste and aftertaste, rather than color and flavor, most influenced overall acceptability of some formulations for moringa beverage. For example; color and flavor of moringa beverage containing 53% moringa, 23% pineapple and 23% carrot (Formula 6) was accepted (6.00 – 6.42) but taste and aftertaste was neither liked nor disliked (5.08 – 5.33). This caused overall acceptability of the product to be neither liked nor disliked (Score = 5.08, Table 2). Again, color and flavor of moringa beverage containing 70% moringa, 20% pineapple and 10% carrot (Formulation 9) was neither liked nor disliked (5.13 – 5.21) but taste and aftertaste was disliked (4.42 – 4.75). This caused overall acceptability of the product to be disliked (Score = 4.63, Table 2).

3.7 Deriving the optimum formulation

To obtain the optimum the ingredient formulation that would obtain optimum sensory acceptability for Moringa leaf juice, the contour plots for these attributes were overlaid in a single graph as shown in Fig. 3. The optimum region in this overlaid plot is where the criteria for acceptability for all the five response variables (color, taste, flavor, aftertaste, overall acceptability) were satisfied.

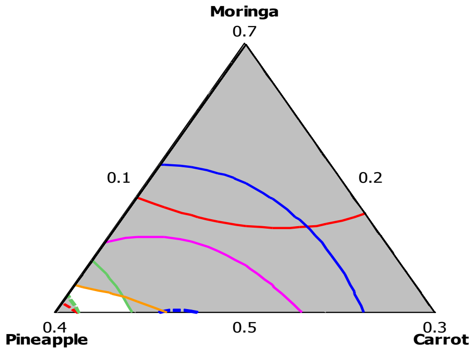


Fig. 3 – Optimum region (not shaded)

4. Conclusion

High amounts of moringa extracts in the composite juice impacted negatively on its sensory acceptability. On the other hand high amounts of pineapple juice strongly improved sensory scores of the beverage. Using constrained mixture optimization techniques, it was possible to obtain an acceptable composite juice that had a ratio of 50:38:12 for Moringa: Pineapple: Carrot respectively.

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