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Title: Consumer acceptance of Lentils-Coconut Ice Cream Effects of varying Xantham Gum

Student Name: Kai Beckles

Project Supervisor: Neela Badrie

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Department of Agricultural Economics & Extension
Faulty of Food and Agricultural

CONSUMER ACCEPTANCE OF LENTILS-COCONUT ICE CREAM: EFFECTS OF VARYING XANTHAM GUM

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Table of Contents

List of Tables and Figures

Abstract

Background

Vegetarian eating and healthy eating are growing trends around the world. The benefits of healthy eating are endless but the options for healthy foods, especially desserts, are not. So as more and more of the population is trying to adopt a healthier lifestyle and more and more healthy snacks are being produced, it was inevitable that the ice cream being introduced follow along the same principle.

The purpose of this study was to produce a completely vegetarian alternative to ice cream with all the physical properties (flavour, smoothness, appeal) and acceptability of the already available (non-vegetarian) version.

Method

An initial formula of the Lentils-Coconut ice cream was produced and distributed among a ten (10) panelist focus group to get feedback from potential consumers on improvements that can be made to the produce. Their ages ranged from 21-54 years. The modified lentil-peas ice cream was subjected to Hedonic testing by 50 panellists. The colour of the ice cream was determined instrumentally. The forms were then gathered; the data recorded and analysed using SPSS.

Results

Each 100g serving (as fed) of ice cream contains: 24.57 % dry matter, 2.45 % protein and 1.56 % fat.

Eighty two percent (82%) of the sensory evaluation panelists liked the ice cream, the average rating, using a nine (9) point hedonic scale was 6.80 (like moderately) and a standard error of ± 0.256. Forty percent (40) of the panelists thought it was a good product when comparing it to other brands of ice cream and gave it an average rating of 2.51 (good) with a standard error of ±0.177.

Conclusion

From the feedback given, it is clear to see that alternative ingredients can be used to achieve a healthy ice cream with desired qualities.

Introduction

Animal-based foods are high in protein, and because of this, it is a common misconception that vegans don't get enough of it. Vegetarians can get all the protein they need from lentils, tempeh, tofu, beans, nuts, seeds, and even vegetables. (Harvard school of public health 2012)

A vegetarian lifestyle has become more popular in the United States, with sales of vegetarian foods and publications on the rise. A study based on data collected by Harris Interactive (2008) for and published by Vegetarian Times indicated that 3.2% of US adults (7.3 million people) follow a vegetarian-based diet. Approximately 0.5% of US adults were vegans, and 10% said they largely follow a vegetarian-inclined diet. (vegetariantimes.com)

More and more Trinidadians and Tobagonians are adopting the vegetarian lifestyle. In response to this increased popularity of meatless food, there are now more choices for vegetarians in local supermarkets. (Bishop 2008)

With that being said, the aim of this assignment is to create a vegetarian ice cream with all the desired properties of the non-vegetarian product. These desired qualities include smoothness, overrun and mouth feel

Conventionally, ice cream is a smooth, frozen mixture of milk, cream, sugar, flavourings, and, sometimes eggs. It is churn-frozen, meaning it is mixed constantly while being frozen. The churning keeps the ice crystals small and incorporates air into the mixture. (Gisslen 2009)

Each ingredient has a specific role and contributes to the overall quality of the finished product (as outlined previously). However, for this assignment, I attempted to use completely different ingredients to achieve the same results or as close to the same as possible.

The alternative ingredients used were:

- **Coconut Milk -** to be used in place of milk and milk products. Powdered coconut milk to be used as it has fewer additives (maltodextrin being the only one) than canned, liquid coconut milk.
- **Honey-** the sweetener to be used in place of sugar(s). It is a healthier alternative to sugar and high fructose corn syrup,
- **Flavourings-** predominantly from the coconut milk. Cinnamon to be added as well.
- **Xanthan Gum-** the stabilizer/emulsifier of choice. It is also used as a thickener in this application.

Lentils are small lens shaped legumes. The botanical name for lentils is *Lens ensculenta*. Compared to other types of dried beans, lentils are relatively quick and easy to prepare. They readily absorb a variety of wonderful flavours from other foods and seasonings, are high in nutritional value and are available throughout the year. (whfoods.org)

Lentils, a small but nutritionally loaded member of the legume family, are a very good source of cholesterol-lowering fiber. Not only do lentils help lower cholesterol, they are of special benefit in managing blood-sugar disorders since their high fiber content prevents blood sugar levels from rising rapidly after a meal. (whfoods.org)

There are several varieties of lentils, which include; brown lentils, green lentils, French green lentils (Puy lentils), yellow lentils (yellow split peas), red lentils and black/beluga lentils to name a few. (Gisslen 2009) Of these varieties, brown, yellow and green lentils are more readily available in the Caribbean.

Rationale

The main rationale behind making lentils-coconut ice cream was to provide a dessert, not loaded with empty calories and is suitable for vegetarians as well as the health conscious. Lentil peas was used because it is loaded with vitamins and minerals and is can be easily manipulated as it does not have a very distinct flavour.

Objectives

- To produce a healthy and acceptable ice cream suitable for vegetarians and the health conscious.
- To use varying percentages of xanthan gum to achieve the desired texture of ice cream.
- To use healthy alternatives to produce an ice cream product with the same 'desirable' characteristics as an ice cream made with the traditional ingredients.

Literature Review

Vegetarian eating is a growing trend and is higher now than before. This trend is likely to continue so it is best for businesses within the food industry to get in on the ground floor by broadening the scope of products they offer. They can start by offering delicious, convenient, and affordable plant-based foods. (Ginsberg) The dessert area is a great place to start.

Ice cream is a complex food colloid that consists of air bubbles, fat globules, ice crystals and an unfrozen serum phase. (Goff 1997) the amount of air bubbles, size of fat globules and ice crystals are what give an ice cream product its desirable qualities. These qualities include;

1. **Smoothness**: This is related to the size of the ice crystals in the product. Ice cream should be frozen rapidly and churned well during freezing so large crystals don't have a chance to form. (Gisslen 2009)
2. **Overrun**: This is the increase in volume due to incorporation of air when freezing ice cream. Some overrun is necessary to give a smooth, light texture. If ice cream has too much overrun, it is airy and foamy and lacks flavour. (Gisslen 2009)
3. **Mouth feel**: depends in part, on smoothness and overrun as well as other qualities. Good ice cream melts in the mouth to a smooth, not too heavy liquid.

   Butter fat from cream contributes to a rich mouth feel. However, too high a fat content can detract from the texture. (Gisslen 2009)

The general proportion of ingredients in an ideal ice cream product is as follows:

- greater than 10% milkfat and usually between 10% and as high as 16% fat in some premium ice creams
- 9 to 12% milk solids-not-fat: this component, also known as the serum solids, contains the proteins (caseins and whey proteins) and carbohydrates (lactose) found in milk

- 12 to 16% sweeteners: usually a combination of sucrose and glucose-based corn syrup sweeteners
- 0.2 to 0.5% stabilisers and emulsifiers
- 55% to 64% water, which comes from the milk or other ingredients. (UoG Food Science)

Each ingredient has a specific role in the ice cream making process;

- **Milk and Milk Products**- Milk fat is the most important ingredient in ice cream. It contributes a characteristic richness to produce a full, rich, creamy flavour which ice cream should have. The milk solids-not-fat increase the viscosity and resistance to melting and also lowers freezing point.
- **Sweetening Agents**- sweeteners are the sugars used in the manufacture of frozen desserts. Their main function is to increase acceptance of the product, not only by making it sweeter but also by enhancing the pleasing creamy texture and the desirable flavours. Sugars increase the viscosity and the total solids concentration of the milk, which improves the body and texture of the finished product. Sugars lower the freezing point of the mix that results in slower freezing and requires a lower temperature for proper hardening.
- **Flavouring-** the primary purpose of flavouring is to provide variety, assortment and increased acceptance.
- **Eggs-** eggs act as an emulsifier, they keep the mixture cohesive. They also increase the whipping quality of the ice cream and improve the body and texture. (armymedical.tpub)

Legumes are important sources of vegetarian food protein. In many regions of the world, legume seeds are the unique protein supply in the diet. They are rich in high quality protein and are a highly nutritious food source. (Duranti 2005) Lentils are a member if the legume family and contain the third highest amount of protein of any legume, listed only below soybeans and hemp. They are also high in iron, fiber, and folate. (whfoods.org)

Table 1: In-Depth Nutrient Analysis of Lentils Peas

Lentils, cooked (in three cups of liquid)		
1 cup (198 g)		GI: low
BASIC MACRONUTRIENTS AND CALORIES		
nutrient	**amount**	**DRI/DV (%)**
Protein	17.86 g	35.72
Carbohydrates	39.86 g	13.29
Fat - total	0.75 g	1.15
Dietary Fiber	15.64 g	62.56
Calories	229.68	12.76
MACRONUTRIENT AND CALORIE DETAIL		
nutrient	**amount**	**DRI/DV (%)**
Carbohydrate:		
Total Sugars	3.56 g	
Soluble Fiber	2.57 g	
Insoluble Fiber	13.07 g	
Other Carbohydrates	20.65 g	
Fat:		
Monounsaturated Fat	0.13 g	
Polyunsaturated Fat	0.35 g	
Saturated Fat	0.10 g	
Calories from Fat	6.77	
Calories from Saturated Fat	0.94	
MICRONUTRIENTS		
nutrient	**amount**	**DRI/DV (%)**
Vitamins		
Water-Soluble Vitamins		
B-Complex Vitamins		
Vitamin B1	0.33 mg	22.00
Vitamin B2	0.14 mg	8.24

Vitamin B3	2.10 mg	
Vitamin B3 (Niacin Equivalents)	4.77 mg	
Vitamin B6	0.35 mg	17.50
Choline	64.75 mg	15.24
Folate	358.38 mcg	89.59
Folate (DFE)	358.38 mcg	
Folate (food)	358.38 mcg	
Pantothenic Acid	1.26 mg	12.60
Vitamin C	2.97 mg	4.95
Fat-Soluble Vitamins		
Vitamin A (Retinoids and Carotenoids)		
Vitamin A International Units (IU)	15.84 IU	0.32
Vitamin A mcg Retinol Activity Equivalents (RAE)	0.79 mcg (RAE)	
Vitamin A mcg Retinol Equivalents (RE)	1.58 mcg (RE)	
Carotenoid mcg Retinol Equivalents (RE)	1.58 mcg (RE)	0.02
Beta-Carotene	9.90 mcg	
Beta-Carotene Equivalents	9.90 mcg	
Vitamin E		
Vitamin E mg Alpha-Tocopherol Equivalents (ATE)	0.22 mg (ATE)	1.10
Vitamin E International Units (IU)	0.32 IU	
Vitamin E mg	0.22 mg	
Vitamin K	3.37 mcg	4.21
Minerals		
nutrient	**amount**	**DRI/DV (%)**
Calcium	37.62 mg	3.76
Copper	0.50 mg	25.00
Iron	6.59 mg	36.61

Magnesium	71.28 mg	17.82
Manganese	0.98 mg	49.00
Molybdenum	148.50 mcg	198.00
Phosphorus	356.40 mg	35.64
Potassium	730.62 mg	20.87
Selenium	5.54 mcg	7.91
Sodium	3.96 mg	0.17
Zinc	2.51 mg	16.73
INDIVIDUAL FATTY ACIDS		
nutrient	**amount**	**DRI/DV (%)**
Omega-3 Fatty Acids	0.07 g	2.92
Omega-6 Fatty Acids	0.27 g	
18:2 Linoleic	0.27 g	
18:3 Linolenic	0.07 g	
Saturated Fatty Acids		
16:0 Palmitic	0.09 g	
18:0 Stearic	0.01 g	
INDIVIDUAL AMINO ACIDS		
nutrient	**amount**	**DRI/DV (%)**
Alanine	0.75 g	
Arginine	1.38 g	
Aspartic Acid	1.98 g	
Cystine	0.23 g	56.10
Glutamic Acid	2.77 g	
Glycine	0.73 g	
Histidine	0.50 g	38.76
Isoleucine	0.77 g	66.96
Leucine	1.29 g	50.99
Lysine	1.25 g	53.19
Methionine	0.15 g	20.27
Phenylalanine	0.88 g	73.95
Proline	0.75 g	

Serine	0.82 g	
Threonine	0.64 g	51.61
Tryptophan	0.16 g	50.00
Tyrosine	0.48 g	49.48
Valine	0.89 g	60.54

*The nutrient profiles provided are derived from The Food Processor, Version 10.12.0, ESHA Research, Salem, Oregon, USA. (2002)

Table 1 gives a complete nutritional (vitamins and minerals) breakdown of one (1) cup of lentil peas cooked in three (3) cups of water.

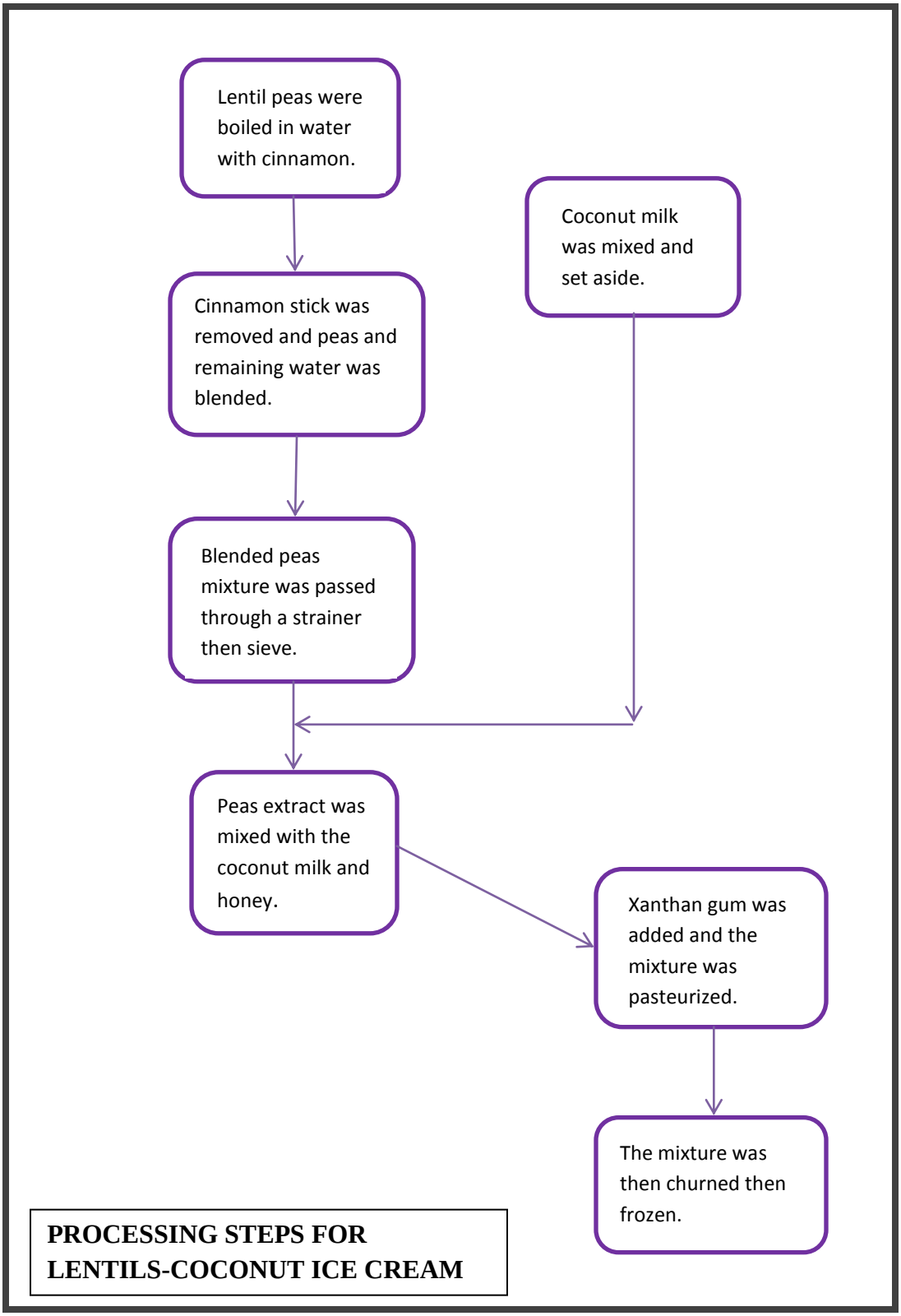
Xanthan gum is a complex microbial polysaccharide produced by the plant-pathogenic bacterium *Xanthomonas campestris*. It is widely used as a thickener or viscosifier in both food and non-food industries. Xanthan gum is also used as a stabilizer for a wide variety of suspensions, emulsions, and foams. (Becker, et al. 1998). The use of xanthan gum in mixtures has no marked effect on pH values or contents of total solids. It is widely used in the food industry because;

- It is soluble in hot or cold water.
- It has high viscosity at low concentrations.
- It has stable viscosity with changing temperature.
- It has excellent solubility and stability in acid systems.
- It has unique rheological properties that provide high viscosity under low sheer and low viscosity under high sheer.
- It has excellent compatibility with a wide range of salts.
- It has excellent thermal stability.
- It has the ability to provide good freeze-thaw stability.
- It has excellent suspending properties owing to a high yield value. (El-Sayed, et al, 2002)

For its wide range of uses, especially its ability to provide good freeze-thaw stability, xanthan gum was used in this project. In this application, it will act as a stabilizer.

Methodology

Diagram 1: The procedure used to produce lentils-coconut ice cream



Four hundred and twenty seven (427) grams of brown lentils peas was boiled in 3L of water with 5 grams of cinnamon stick, until cooked soft. Then 100 grams of coconut milk powder (Kendel- produced in Jamaica, purchased at local supermarket "China") was mixed in 250mls of water and set aside (this yielded 350mls of coconut milk).

The cinnamon stick was removed (after the peas was cooked soft) and the cooked (boiled in water until soft) lentil peas was blended (into as smooth a mixture as possible) with the water left from the cooking process. The mixture was passed through a strainer (0.500mm) then passed through a smaller sieve (0.425mm). This process yielded 450mls liquid mixture.

The coconut milk was mixed with the lentil peas liquid/extract and 250mls of honey (purchased from a vendor in Valencia) was added. Four (4) grams of xanthan gum (0.4% stabilizer) (sourced from the lab) was also added to the mixture and pasteurized at 80°C for approximately 20 minutes.

The mixture (1000 grams total) was cooled then poured into a *Rival Ice Cream Maker: 8405M* (manufactured in Kansas City, USA) pail and chilled (5°C) for approximately 30 minutes. Once chilled, the mixture was put to churn until the appropriate texture was achieved. Overrun was calculated at 100%. The mixture was then put into 2 oz. sample containers and frozen (-18°C) overnight for microbiological analysis could be done the next day.

Overrun was calculated using the following formula: $\frac{Volume\ \ of\ ice\ cream - Volume\ \ of\ mix}{Volume\ \ of\ mix} \times 100$

Table 2: Percentage of each ingredient in the original ice cream sample

INGREDIENTS	PERCENTAGE
Lentil peas extract	45%
Coconut milk	35%
Honey	20%
TOTAL	**100%**
Xanthan Gum	0.4% of total

Microbial Analyses on Ice Cream

Microbial analysis, which includes tests for total aerobic bacteria (Plate Count Agar), *Escherichia coli* (Eosin methylene Blue Agar) and *Staphylococcus aureus* (Mannitol Salt Agar), were conducted on a sample of the ice cream.

1. 10.21 grams of the sample was liquefied in 90mls of sterile water.
2. 1ml of sample was added to 9mls of sterile water in a test tube (10^{-2}). Then 1ml of that mixture was added to 9mls of sterile water in another test tube (10^{-3}).

For the total aerobic bacteria- Plate Count Agar (PCA), the pour plate method was used. Two samples each of 10^{-1} and 10^{-2} dilutions and two controls (water and agar) were used. The samples were placed into sterile, labelled petri dishes.

1. 1ml of sterile water was placed into a sterile petri dish. 1ml sample from the 10^{-1} dilution was placed into 2 petri dishes and the same was done with the 10^{-2} dilution.

2. Molten agar was poured into the 6 petri dishes and mixed gently by swirling. The agar was allowed to solidify and placed, inverted, into the incubator at 35°C for approximately 48 hours.

The spread plate method was used for the *Escherichia coli* and *Staphylococcus aureus.* Two samples each of 10^{-2}, 10^{-3} and the control were used for these tests. The samples were placed into sterile, labelled petri dishes.

1. 0.1ml of sample from 10^{-2} and 10^{-3} dilution was placed into petri dishes (done in duplicate) which contained the prepared media.
2. A bent glass rod (dipped in alcohol, flamed and cooled) was used to spread the sample on the media in the dishes. It was allowed to dry then placed, inverted, into the incubator at 35°C for approximately 48 hours.

The samples were checked approximately 48 hours after.

Focus Group

A focus group was conducted to get feedback from potential consumers of the Lentils-coconut ice cream. The group consisted of ten (10) persons; seven females, one of who was vegetarian and three (3) males. Their ages ranged from 21-54 years. The group was asked question ranging from "Do you like the flavour?" to "What in your opinion can be done to improve the product?" in order to present an acceptable product to consumers.

The general consensus of the group was that the ice cream;

- Was too sweet- to change this, less honey was used.

- Was too grainy- to combat this, the lentils peas mixture was run through cheese cloth to achieve a smoother texture.
- Lacked a distinct flavour- more cinnamon was used to change this.
- Was not creamy enough- almond milk was used in place of water, to mix the coconut milk powder.

Altered Procedure (From the focus group evaluation, modifications were made.)

Eight hundred and twenty nine point three (829.3) grams of brown lentils peas was boiled in 5L of water with 19.7 grams of cinnamon stick and 2 grams of cinnamon powder, until cooked soft. Then 200 grams of coconut milk powder was mixed in 500mls of unsweetened almond milk (Blue Diamond Almond Milk produced in California, USA.,purchased at a local super market "HiLo") and set aside (this yielded 700mls of coconut-almond milk mixture).

The cinnamon stick was removed and the cooked (boiled in water until soft) lentil peas was blended (into as smooth a mixture as possible) with the water left from the cooking process. The mixture was passed through cheese cloth. This process yielded 1.2 L liquid mixture but only 750mls was used.

The coconut-almond milk mixture was mixed with the lentil peas liquid/extract and 150mls of honey was added. Two (2) grams of cinnamon powder was added and the mixture was passed through cheese cloth again to ensure a smooth mixture. Eight (8) grams of xanthan gum (0.5% stabilizer) (sourced from the lab) was added and the mixture was blended to properly incorporate the xanthan gum. The mixture was chilled overnight. It was pasteurized at 80℃ for approximately 20 minutes the following morning.

The mixture (1.6 L total) was cooled then poured into a *Rival Ice Cream Maker: 8405M* pail and set to churn until the appropriate texture was achieved. The finished product measured 2.8 L. The mixture

was then put into sample containers and frozen for nutrient analysis and sensory evaluation to be conducted.

Overrun was calculated using the following formula: $\frac{Volume\ \ of\ ice\ cream - Volume\ \ of\ mix}{Volume\ \ of\ mix} \times 100$

Table 3: Percentage of each ingredient in the improved sample of ice cream

INGREDIENTS	**PERCENTAGE**
Lentil peas extract	46.73%
Coconut-almond milk	43.75%
Honey	9.38%
Cinnamon	0.14%
TOTAL	**100%**
Xanthan Gum	0.5% of total

Hedonic Testing

The sample size for the Hedonic testing was 50 panellists. Forty (40) of the panellists were chosen randomly from the Faculty of Food and Agriculture and the Faculty of Science and Technology at the University of the West Indies St Augustine Campus. The other ten (10) panellists were the members of the focus group, which was conducted on the first batch of lentil-coconut ice cream.

The ice cream was served in two (2) once (sample size), plastic, containers with corresponding plastic lids.

Table 4: Participants response to physical appearance of the ice cream

Variables	Appearance/ colour	Flavour/ taste	Flavour/ aroma	Texture/ mouth-feel	Texture/ smoothness
Dislike Extremely	0	0	0	0	0
Dislike Very Much	0	2	0	0	0
Dislike Moderately	0	3	2	0	1
Dislike Slightly	2	6	1	1	3
Neither Like nor Dislike	2	3	9	5	3
Like Slightly	9	4	10	8	7
Like Moderately	12	12	10	10	9
Like Very Much	17	12	10	14	14
Like Extremely	8	8	8	12	13
Mean	7.28	6.56	6.74	7.34	7.2
Standard Error	±0.181	±0.287	±0.226	±0.195	±0.225

Colour Measurement/Analysis

Colour was tested on both samples of the ice cream using a *Konica Minolta: Chroma Meter CR-400* (manufactured in the Netherlands). Three readings of each sample were taken and the chroma and hue angle were calculated for each. Then the standard deviation was found using SPSS.

Chroma was calculated using the formula: Chroma (C) = $(a^2 + b^2)^{½}$

Hue angle was calculated using the formula: Hue angle (H°) = $\frac{a}{(a^2+b^2)½}$

Nutritional Analysis

The sample used for the sensory evaluation was tested to measure dry matter, protein and fat content. Each test was done in duplicate. To prepare the sample, the Gravimetric Method was used.

The ice cream was placed into two (2) petri dishes labelled 1A and 1B. 41.9221g and 23.8255g (respectively) of ice cream was placed into the petri dishes and put on a *Gallenhamp Sand Bath FA 2000* (manufactured in England) at setting 3.25 (approximately 50°C) for two and a half (2.5) hours. The samples were then placed in the oven at 100°C for three and a half (3.5) hours. They were then cooled in an active desiccator overnight. The following day, the samples were ground to a powder then replaced in the desiccator overnight. (AOAC 941.08)

The percentage of dry matter was calculated using the following formula:

$$\frac{\text{wt of dry sample}}{\text{wt of wet sample}} \times 100$$

- **Protein Analysis**

To analyse the protein content of the sample, the Kjeldahl method was used to determine the nitrogen level in the sample. The protein is then calculated using the nitrogen and a conversion factor of 6.25 (equivalent to 0.16 g nitrogen per gram of protein). The procedure is as follows;

1. Two samples of 2.0038g and 2.0218g were measured out and placed into two (2) Kjeldahl flasks and labelled IC 1 and IC 2 respectively.
2. Two (2) catalyst tablets and 25ml of concentrated sulfuric acid (H_2SO_4) were then added to the flask and placed on the active digestion rack until the charred material was dissolved and digested clean. Once digested, the flask and contents was left to cool and 100ml of distilled water was added, mixed well and left to sit overnight.

3. The next day, distilled water was added to the dilute digest to make 250ml and mixed well (both samples).
4. Five (5) ml of sodium hydroxide (NaOH) was poured into the boiling tube of *BUCHI KjelFlex K-360 1153/48834/044* (manufactured in Switzerland) flexible distillation unit and 5ml of the diluted digest was pipetted into the tube. The tube was then placed in the unit and the unit was turned on (the distillation process started). A small beaker was used to collect the resulting liquid from the distillation process.
5. The liquid collected in the beaker was titrated with 0.01 N acid.
6. Steps 4 and 5 were repeated for each sample.

The percentage of nitrogen was calculated using the following formula:

$$\frac{0.014 \times 50\ acid\ \ volume\ \times acid\ \ N}{wt\ \ of\ \ sample} \times 100$$

The percentage of crude protein was calculated using the following formula:

% Nitrogen x 6.25 (AOAC 930.33)

Determination of Ether Extract (Fat)

Ether extract was used to determine the lipid concentration of each sample.

1. The weights of the two (2) extraction beakers (flasks), containing bumping stones, to be used were taken.
2. Two (2) samples of 1.5052 and 1.0517 were measured out and placed on filter paper. The paper was folded around the sample and placed into two (2) extraction thimbles.
3. One hundred (100) ml of ether was placed into each flask.

4. Petroleum ether was added to the *Gerhardt Soxtherm 406* automatic extraction system (manufactured in Germany) until it siphons once. More ether was added until the barrel of the unit was almost full.
5. The thimbles were placed into the holders and the holders then placed into the flasks. Rubber seals were placed on the mouth of the flasks then connected to the extractor unit.
6. The water to the condenser was turned on and the heater was turned on and adjusted so the ether boils gently.
7. The samples were refluxed for 16 hours.
8. After reflux, the flask was dried in the oven at 105°C overnight. It was then cooled to room temperature in the desiccator overnight and weighed.

The formula used to determine the ether extract (fat) is as follows:

$$\frac{wt\ of\ flask\ and\ extract\ -wt\ of\ flask}{wt\ od\ sample} \times 100 \qquad \text{(AOAC 952.06)}$$

Results

- Overrun was calculated using the following equation;

$$\text{Overrun} = \frac{Volume\ \ of\ ice\ cream - Volume\ \ of\ mix}{Volume\ \ of\ mix} \times 100$$

$$= \frac{2\,800 - 1\,600}{1\,600} \times 100$$

$$= 75\%$$

Overrun was calculated at 75%.

- Microbial Analysis

No visible activity/colonies were detected on any of the samples.

- Colour Analysis

Table 5: Chroma Meter readings for both ice cream samples

	SAMPLE USED FOR FOCUS GROUP (ORIGINAL)			**SAMPLE USED FOR SENSORY EVALUATION (IMPROVED)**		
Readings	**1**	**2**	**3**	**1**	**2**	**3**
L	57.15	57.02	56.05	60.95	58.41	59.64
a	0.95	0.86	0.84	0.28	0.39	0.11
b	11.84	11.54	11.19	11.80	12.26	10.16

Table 6: Readings for L, C and H° of the Original Sample

Original Sample			
Readings	**1**	**2**	**3**
L	57.15	57.02	56.05
C	11.88	11.57	11.22
H°	85.29	85.24	85.69

Table 7: Readings for L, C and H° of the Improved Sample

Improved Sample			
Readings	**1**	**2**	**3**
L	60.95	58.41	59.64
C	11.80	12.27	10.16
H°	88.64	88.18	89.38

Table 8: Colour Statistics (SPSS) for the Original Sample

Original Sample			
	N	**Mean**	
	Statistic	**Statistic**	**Std. Error**
L	3	56.7400	±0.34704
C	3	11.5567	±0.19064
H°	3	85.4067	±0.14240

Table 9: Colour Statistics (SPSS) for the Improved Sample

Improved Sample			
	N	**Mean**	
	Statistic	**Statistic**	**Std. Error**
L	3	59.6667	±0.73336
C	3	11.4100	±0.63956
H°	3	88.7333	±0.34954

From the analysis done we can see that the colour of both the original and improved samples was dull and lies between orange (45°) and yellow (90°)**.** However, the improved sample had a slightly lighter colour than the original sample.

The standard errors for L, C and H° for both samples all fall under 1. This means, the means for L, C and H° are more accurate reflections of the readings taken with a confidence of 95%.

Nutritional Analysis Calculations

- **% Dry Matter** = Avg 24.57 %

- **% Crude Protein** = Avg 9.97 % (based on dry matter)

Converted to as fed = 2.45 % crude protein

- **% Fat =** Avg 6.33 %(based on dry matter)

Converted to as fed = 1.56 %

Each serving (100g) of ice cream contains (from dry sample): 24.57 % dry matter

9.97 % protein

6.33 % fat

Each serving (100g) of ice cream (as fed) contains: 24.57 % dry matter

2.45 % protein

1.56 % fat

Evaluation Forms Analysis

Table 10: Frequency and percentage of demographic questions on evaluation form

VARIABLE	FREQUENCY	PERCENTAGE
Sex		
Female	39	78
Male	11	22
Age		
18-24 years	28	56
25-34 years	17	34
35-44 years	0	0
45+ years	5	10
Race/Ethnicity		
African	23	46
East Indian	13	26
Chinese	1	2
Caucasian	1	2
Other	2	24
Area of Residence		
North	7	14
South	17	34
East	16	24
West	7	14
Central	3	6
Education Level		
Primary	0	0
Secondary	9	18
Technical	1	2
Tertiary	40	80
Occupation Status		
Employed	17	34
Unemployed	1	2
Student	32	64

Table 9 shows the social demographic characteristics of the participants by gender. Participants were predominantly females, from the 18-24 age group, of African descent, residing in the southern area of the country and in the process of achieving a tertiary level education.

Table 11: Frequency and percentage of participants who like lentil peas and their knowledge of its protein content

VARIABLE	FREQUENCY	PERCENTAGE
Lentil peas Preference		
Yes	48	96
No	2	4
Lentil peas Knowledge		
Yes	45	90
No	5	10

Table 10 shows the majority of participants like lentil peas and think it is an adequate source of protein.

Table 12: The regularity at which participants purchase ice cream

VARIABLE	FREQUENCY	PERCENTAGE
Never or < once per month	17	34
1-3 tines per month	21	42
Once a week	10	20
> once a week	2	4

Table 11 shows the regularity at which participants purchase ice cream in a given month. The majority of them purchase ice cream 1-3 times per month.

Table 13: Statistical analysis (mean, standard error, standard deviation) of Hedonic questions based on the physical properties of the ice cream

Statistics	Appearance/ colour	Flavour/ taste	Flavour/ aroma	Texture/ mouth-feel	Texture/ smoothness
Mean	7.28	6.56	6.74	7.34	7.28
Standard error	0.181	0.287	0.226	0.195	0.225
Standard deviation	1.278	2.032	1.601	1.079	1.591

Nine Point Hedonic scale

1 Dislike Slightly
2 Dislike Moderately
3 Dislike Very Much
4 Dislike Extremely
5 Neither Like nor Dislike
6 Like Slightly
7 Like Moderately
8 Like Very Much
9 Like Extremely

Table 12 shows the average Hedonic rating participants gave for each physical property of the ice cream. With the use of a nine point hedonic scale, participants moderately liked the colour, taste, aroma, mouth-feel and smoothness of the ice cream.

Table 14: Statistical analysis (mean, standard error, standard deviation) on participants overall like/dislike of the ice cream and comparison rating to other products

	N	Mean	Standard Error	Standard Deviation
Overall opinion	50	6.80	0.256	1.807
Quality rating	49	2.51	0.117	0.820

Table 13 shows the average Hedonic rating participants gave for their overall opinion of the ice cream. Participants moderately like the ice cream overall and gave it a "good" rating when comparing it to other ice creams on the market.

Table 15: Participants comments on the sweetness and texture on the ice cream

VARIABLE	FREQUENCY	PERCENTAGE	Mean
Sweetness			
Not sweet	29	58	1.43
Sweet enough	19	38	
Too sweet	1	2	
Total	**49**		
Texture			
Grainy	9	18	1.86
Smooth	32	64	
Icy	3	6	
Total	**44**		

Ratings

Sweetness	Texture
1 Not Sweet	1 Grainy
2 Sweet enough	2 Smooth
3 Too sweet	3 Icy

Table 14 shows the general categories participants used to comment on the sweetness and texture of the ice cream. It also shows the mean rating for these comments. The majority of participants thought the ice cream was not sweet but found it to be smooth.

Discussion

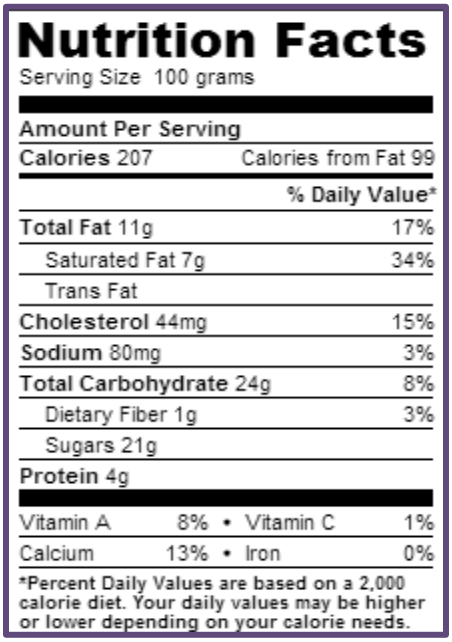
The sample population was made up of seventy eight percent (78%) female participants. Even though the sample was random, it was a close representative of the general market, in terms of customer and gender segmentation. Studies have shown that gender is one of the most common demographic variables that marketers use to segment markets and, the female population (in general) is more likely to spend more on food than their male counterparts. (Kotler 1997 and Harvard Business Review)

The majority of panelists liked the ice cream and the concept behind the product but thought it could be sweeter. They also liked the smoothness of the product, linking it to that of home-made ice cream. This, for them is a desirable texture.

However, few of the panelists reported getting a slimy mouth feel. This can be attributed to the xanthan gum. For further applications, instead of using 0.5% xanthan gum, 0.45% should be used.

A 100g serving of lentil-coconut ice cream contains 24.57% dry matter, 2.45% protein and 1.56% fat.

Diagram 2: Nutrition facts panel for 100g vanilla ice cream



Nutrition Facts

Serving Size 100 grams

Amount Per Serving

Calories 207	Calories from Fat 99
	% Daily Value*
Total Fat 11g	17%
Saturated Fat 7g	34%
Trans Fat	
Cholesterol 44mg	15%
Sodium 80mg	3%
Total Carbohydrate 24g	8%
Dietary Fiber 1g	3%
Sugars 21g	
Protein 4g	

Vitamin A	8%	• Vitamin C	1%
Calcium	13%	• Iron	0%

*Percent Daily Values are based on a 2,000 calorie diet. Your daily values may be higher or lower depending on your calorie needs.

When compared to vanilla ice cream, the values for the vegetarian ice cream are lower for fat and solids (dry matter) and protein. Amounts of protein claimed on Nutrition Facts labels for a single serving (100g) of vanilla ice cream generally range from 2.0 to 3.5 g. (Goff H. Douglas 1997) However, the nutrition facts panel provided (diagram 2), records a protein level of 4g. Most, if not all the protein in non-vegetarian ice cream comes from the milk and milk based ingredients (and gelatin if it is used). Considering the lentil-coconut ice cream was made using only vegetarian ingredients, and the protein content falls within the general range (2.0-3.5g) of protein for conventional ice creams, goes to show just how adequate lentil peas are as a protein source.

On average, a 100g serving of vanilla ice cream contains 11% total fat and 7% saturated fat (see diagram 2). The fat content of the lentil-coconut ice cream is considerably lower than the vanilla ice cream. This reduced fat content is a major advantage and can be used to market this product.

Conclusion

Even though each ingredient has a specific purpose and adds to the texture, mouth feel and overall quality of ice cream, it is quite possible to use unconventional ingredients to achieve the same desirable outcome as I have achieved this in doing this project.

My objectives, to produce a healthy and acceptable ice cream suitable for vegetarians and the health conscious, to use varying percentages of xanthan gum to achieve the desired texture of ice cream and to use healthy alternatives to produce an ice cream product with the same 'desirable' characteristics as an ice cream made with the traditional ingredients have been met.

Recommendation

It is strongly recommended that larger ice cream producers get into the production of vegetarian ice creams. It can be a relatively inexpensive venture and the market for such a product is growing daily.

With better resources, the possibilities of having a finished product which consumers cannot distinguish from the non-vegetarian alternative are endless. The biggest difference would be by way of the nutritional content.

Healthy, vegetarian ice cream can and should become a staple on supermarket shelves.

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Appendices

Colour formulas and workings:

$$\textbf{Chroma (C)} = (a^2 + b^2)^{½}$$

Chroma for Original Sample

1. a = 0.95b = 11.84

   $= (a^2 + b^2)^{½}$

   $= (0.95^2 + 11.84^2)^{½}$

   $= \sqrt{(0.95^2 + 11.84^2)}$

   $= \sqrt{0.9025 + 140.1856}$

   $= \sqrt{141.0881}$

   C = 11.88

2. a = 0.86b = 11.54

   $= (a^2 + b^2)^{½}$

   $= (0.86^2 + 11.54^2)^{½}$

   $= \sqrt{(0.86^2 + 11.54^2)}$

   $= \sqrt{0.7396 + 133.1716}$

   $= \sqrt{133.9112}$

   C = 11.57

3. a = 0.84b = 11.19

   $= (a^2 + b^2)^{½}$

   $= (0.84^2 + 11.19^2)^{½}$

   $= \sqrt{(0.84^2 + 11.19^2)}$

   $= \sqrt{0.7056 + 125.2161}$

   $= \sqrt{125.9217}$

   C = 11.22

Chroma for Improved Sample

1. a = 0.28b = 11.80

   $= (a^2 + b^2)^{½}$

   $= (0.28^2 + 11.80^2)^{½}$

   $= \sqrt{(0.28^2 + 11.80^2)}$

   $= \sqrt{0.0784 + 139.24}$

   $= \sqrt{139.3184}$

   C = 11.80

2. a = 0.39b = 12.26

   $= (a^2 + b^2)^{½}$

   $= (0.39^2 + 12.26^2)^{½}$

   $= \sqrt{(0.39^2 + 12.26^2)}$

   $= \sqrt{0.1521 + 150.3076}$

   $= \sqrt{150.4597}$

   C = 12.27

3. a = 0.11b = 10.16

   $= (a^2 + b^2)^{½}$

   $= (0.11^2 + 10.16^2)^{½}$

   $= \sqrt{(0.11^2 + 10.16^2)}$

   $= \sqrt{0.0121 + 103.2256}$

   $= \sqrt{103.237725.9217}$

   C = 10.16

Hue angle (H°) = $\frac{a}{(a^2+b^2)½}$

Hue angle for original sample

1. a = 0.95 $(a^2 + b^2)½ = 11.57$

   $= \theta \frac{0.95}{11.57}$

   $= \theta 0.0821$

   H° = 85.29°

2. a = 0.96 $(a^2 + b^2)½ = 11.57$

   $= \theta \frac{0.96}{11.57}$

   $= \theta 0.0830$

   H° = 85.24°

3. a = 0.84 $(a^2 + b^2)½ = 11.19$

   $= \theta \frac{0.84}{11.19}$

   $= \theta 0.0751$

   H° = 85.69°

Hue angle for improved sample

1. a = 0.28 $(a^2 + b^2)½ = 11.80$

   $= \theta \frac{0.28}{11.80}$

   $= \theta\ 0.0237$

   H° = 88.64°

2. a = 0.39 $(a^2 + b^2)½ = 12.26$

   $= \theta \frac{0.39}{12.26}$

   $= \theta 0.0318$

   H° = 88.18°

3. a = 0.11 $(a^2 + b^2)½ = 10.16$

   $= \theta \frac{0.11}{10.16}$

   $= \theta 0.0108$

   H° = 89.38°

Nutritional analysis and workings:

- **% Dry Matter** $= \frac{\text{wt of dry sample}}{\text{wt of wet sample}} \times 100$

$\equiv \frac{C-A}{B-A} \times 100$

Where: A=weight of dish B=weight of dish + sample (wet) C=weight of dish + sample (dry)

Sample 1

A= 38.7486 g

B= 80.6707g

C= 49.0987g

$\frac{C-A}{B-A} \times 100$

$= \frac{49.0987-38.7486}{80.6707-38.7486} \times 100$

$= \frac{10.3501}{41.9221} \times 100$

= 24.689%

Sample 2

A= 43.2356

B= 67.0611

C= 49.0611

$\frac{C-A}{B-A} \times 100$

$= \frac{49.0611-43.2356}{67.0611-43.2356} \times 100$

$= \frac{5.8255}{23.8255} \times 100$

= 24.451%

- **% Crude Protein** = % Nitrogen x 6.25 % Nitrogen = $\frac{0.014 \times 50 \times acid\ volume \times acid\ N}{wt\ of\ sample} \times 100$

Sample 1

Weight of sample – 2.0038g

Titration volume – 4.5ml

% Nitrogen = $\frac{0.014 \times 50 \times 4.5 \times 0.01}{2.0038} \times 100$

$= \frac{0.0315}{2.0038} \times 100$

= 1.572013175×6.25

= 9.83%

Sample 2

Weight of sample – 2.0218g

Titration volume – 4.5ml

% Nitrogen = $\frac{0.014 \times 50 \times 4.5 \times 0.01}{2.021} \times 100$

$= \frac{0.0315}{2.0218} \times 100$

= 1.558017608×6.25

= 9.74%

To convert to as fed = % crude protein x dry matter %

= 9.97 x 24.57

= 2.45 %

- **% Fat =** $\frac{wt\ of\ flask\ and\ extract\ -wt\ of\ flask}{wt\ od\ sample} \times 100$

Sample 1

Weight of flask and extract – 147.6472g

Weight of flask - 147.5456g

Weight of sample - 1.5052g

% Fat = $\frac{wt\ of\ flask\ and\ extract\ -wt\ of\ flask}{wt\ od\ sample} \times 100$

= $\frac{147.6472-147.5456}{1.5052} \times 100$

= 0.067499335×100

= 6.75%

Sample 2

Weight of flask and extract – 150.6436g

Weight of flask - 150.5547g

Weight of sample - 1.5017g

% Fat = $\frac{wt\ of\ flask\ and\ extract\ -wt\ of\ flask}{wt\ od\ sample} \times 100$

= $\frac{150.6436-150.5547}{1.5017} \times 100$

= 0.059199573×100

= 5.92%

To convert to as fed = % fat protein x dry matter %

= 6.33 x 24.57

= 1.56 %

Sample of evaluation form used to collect data

Sensory Evaluation of Lentils-Coconut Ice Cream

1. **SEX:** Female ☐$_0$ Male ☐$_1$

2. **AGE**: 18-24yrs ☐$_1$ 25-34 yrs ☐$_2$ 35-44yrs ☐$_3$ 45+ yrs ☐$_4$

3. **RACE / ETNICITY:** African ☐$_1$ East Indian ☐$_2$ Chinese ☐$_3$ Caucasian ☐$_4$ Other ☐$_5$

4. **In which area do you live?** North ☐$_1$ South ☐$_2$ East ☐$_3$ West ☐$_4$

5. **Level of education attained?** Primary ☐$_1$ Secondary ☐$_2$ Technical ☐$_3$ Tertiary ☐$_4$

6. **Current occupation?:** Employed ☐$_1$ Unemployed ☐$_2$ Student ☐$_3$

7. **Do you like lentils peas?** No ☐$_0$ Yes ☐$_1$

8. **Do you think lentils peas is an adequate source of protein?** No ☐$_0$ Yes ☐$_1$

9. **How often do you purchase ice cream?**

Never or < once per month ☐$_1$ 1-3 times per month ☐$_2$ Once a week ☐$_3$ > Once a week ☐$_4$

Please tick one response to each section and leave a comment if desired.

Category	Like Extremely $(1)_1$	Like Very Much $(2)_2$	Like Moderately $(3)_3$	Like Slightly $(4)_4$	Neither Like nor Dislike $(5)_5$	Dislike Slightly $(6)_6$	Dislike Moderately $(7)_7$	Dislike Very Much $(8)_8$	Dislike Extremely $(9)_9$
1. Appearance									
Colour									
2. Flavour									
Taste									
Aroma									
Comment on the sweetness of the ice cream									
3. Texture									
Mouth-feel									
Smoothness									
Comment on the texture/mouth-feel of the ice cream									
4. Overall Opinion									
How much did you like the ice cream?									

5. How do you rate the quality of this product in comparison to other brands of the product?

Excellent $\square_1$ Good $\square_2$ Fair $\square_3$ Not Satisfied $\square_4$