PRODUCTION OF MORINGA CANDY

BY

HELLEN AMA ANNAN AND APOLLONIUS NYARKO

FOOD RESEARCH INSTITUTE, (CSIR)

B.O.BOX M.20, ACCRA, GHANA

2011

Contents

1.0 INTRODUCTION

Moringa oleifera is the most widely cultivated species of the *Moringaceae,* which are native to the sub-Himalayan tracts of India, Pakistan, Bangladesh and Afghanistan (Fahey, 2005). This rapidly-growing tree (also known as the horseradish tree or drumstick tree), was utilized by the ancient Romans, Greeks and Egyptians. It is now widely cultivated and has become naturalized in many locations in the tropics (Fahey, 2005). Analyses of the leaf composition have revealed them to have significant quantities of vitamins A, B and C, calcium, iron and protein (Ramachandran *et al*., 1980). In Ghana, Moringa has been grown for centuries and probably widely used by traditional herbalist for a much longer period, but it has only recently been embraced by Ghanaians for its nutritional and anecdotal medicinal properties. Many families are reportedly incorporating this herb into their food to supplement their diets (www.info-ghana.com). *Moringa oleifera* is the best known of the thirteen species of the genus *Moringacae.* It is found wildly cultivated throughout the plains especially in hedges and in house yards. The Moringa tree (*Moringa Oleifera*) is a slender, semi-deciduous, perennial tree that grows to about 10 meters tall, with drooping branches. It thrives in subtropical and tropical climates, giving fruit and flowers continually. However, the drought resistant Moringa grows best in dry, sandy soil. This makes it an ideal tree to grow in semi-desert conditions, as it provides both food and shade. The Moringa is a fast growing tree that can reach up to 3 meters in its first year.

It thrives best under the tropical climate and is abundant near the sandy beds of rivers and streams (Qaiser, 1973). It is little affected by drought (Morton, 1991). According to Palada and Changl,(2003*), Moringa Oleifera* tolerates a wide range of rainfall with minimum annual requirements estimated at 250mm and maximum at over 300mm.

In the past moringa was mainly planted for the purpose of fencing houses and feeding ruminanats but it has now assumed great importance as food supplement which is being produced by many micro small and medium enterprises

Moringa is considered as a vegetable tree or herb that has been used in Africa as a nutrient food supplement to treat and prevent malnourishment. Virtually every part of the tree, including the leaves, pods, flowers, seeds, stem, bark, as well as roots is said to have beneficial properties that can serve humanity.

There are many reports in scientific journals describing and outlining the nutritional and medicinal properties of the Moringa plant (Elkhalifa et. al, 2007, Morton, 1991 and Fahey, 2005). The leaves of the moringa tree could treat at least 300 diseases (Anon 2006). Moringa has no proven bad effects and is absolutely safe and organic. Because of its tolerant properties, it has been given to malnourished little babies in Africa. Over the past two decades, many reports have appeared in mainstream scientific journals describing its nutritional and medicinal properties.. People in societies around the world have made use of these properties.

Figure 1.0 Moringa leaves

Dried moinga leaves are currently being produced by many Small and Medium Enterprises in Ghana as food supplement for health benefits. It has now assumed great importance in Ghana and West Africa in general.

2.0 MATERIALS AND METHODS

2.1 Source of Raw Materials

Fresh *Moringa oleifera* leaves were obtained from a farm in Food Research Institute of CSIR, Okponglo, and condenced milk was purchased from the Shop Right in Accra. The Proximate and Microbiological analysis were carried out in the Food Chemistry and Food Microbiological laboratories of the above Institute.

2.2 PREPARATION OF MORINGA CANDY

2.2.1 Moringa powder production

Fresh moringa was harvested from the farms of the Food Research Institute.

The leaves were separated from the stock and washed thoroughly in plenty of clean water.

The water was allowed to drain from the leaves putting them in a basket sieve.

The drained leaves were put into the hot air mechanical dryer at a lower temperature of about 55^0C to dry. The dried product was milled into a fine powder.

The dried sieved product was packaged in polythene pouches and kept in a cool and dry environment.

2.2.2 CANDY PRODUCTION

Ingredients; Dried moringa powder and condensed milk. Production of the candy was based on the different formulation given by the statistical tool called Mixture Design (MINITAB14).The design yielded ten possible formulations based on the lower and upper limit of the moringa powder. The different formulations are listed below;

	Lower limit	Upper limit
Milk	0.890	0.897
Moringa	0.100	1.000
Lime juice	0.003	0.010

Table 2.1 The 10 formulations obtained from the design

	Milk	Moringa	Vitamin C
1)	0.891	0.101	0.008
2)	0.890	0.104	0.007
3)	0.894	0.104	0.003
4)	0.890	0.100	0.010
5)	0.890	0.107	0.003
6)	0.894	0.100	0.007
7)	0.895	0.101	0.004
8)	0.892	0.102	0.005
9)	0.891	0.105	0.004
10)	0.897	0.100	0.003

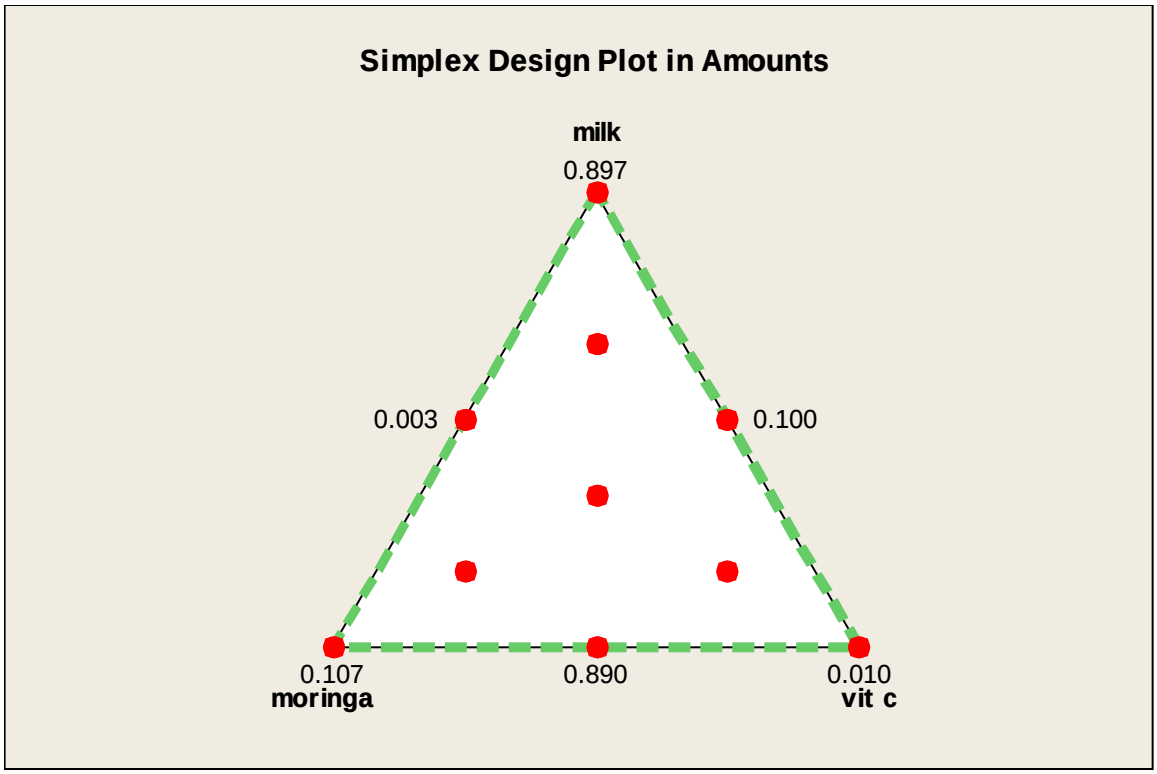

Figure 2.0 Simplex designs for ten formulations

28/01/2011 06:35:16

Simplex Centroid Design

Components: 3 Design points: 10

Process variables: 0 Design degree: 3

Mixture total: 1.0000

Bounds of Mixture Components

Amount Proportion Pseudocomponent

Comp	Lower	Upper	Lower	Upper	Lower	Upper
A	0.890000	0.897000	0.890000	0.897000	0.000000	1.000000
B	0.100000	0.107000	0.100000	0.107000	0.000000	1.000000
C	0.003000	0.010000	0.003000	0.010000	0.000000	1.000000

A-Milk content

B-Moringa content

C-Vitamin c content

3.0 RESULTS

3.1 SENSORY EVALUATION

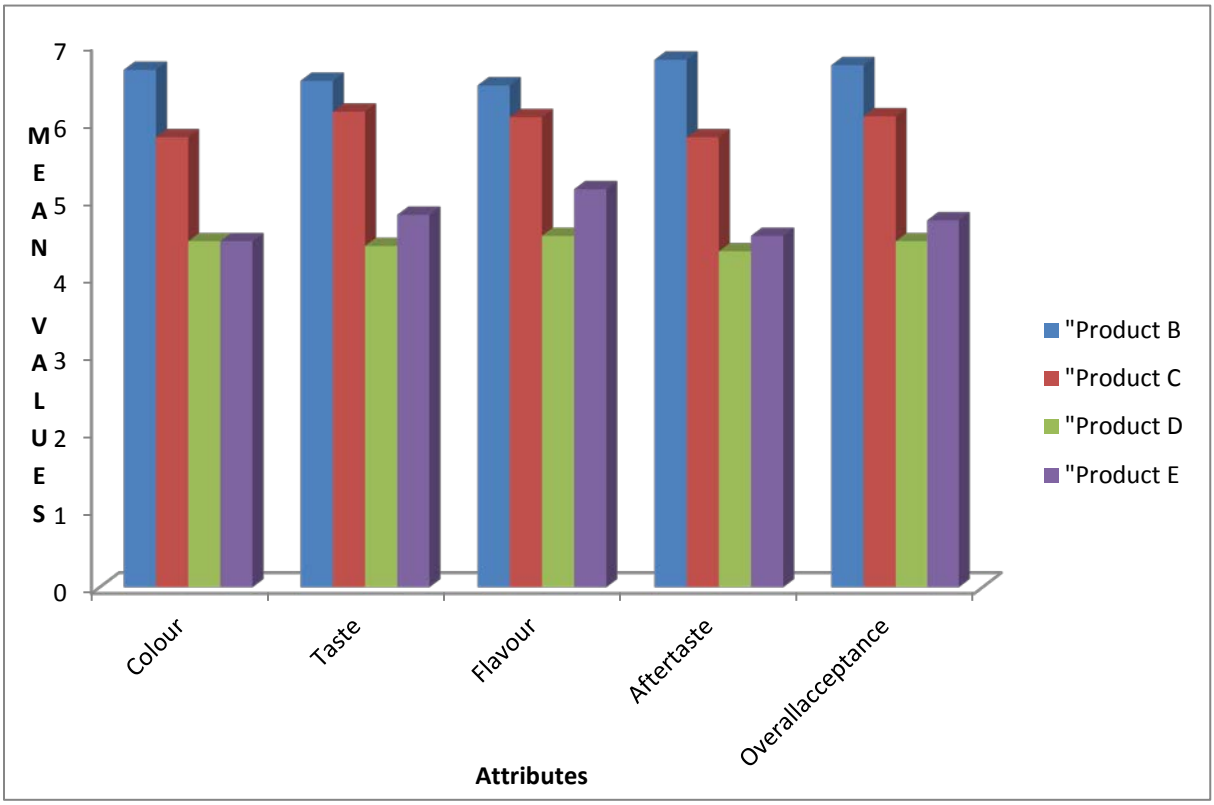

FIGURE 3.1 Means for four different formulated products

NB: Mean score of panelist are represented as 7-like very much; 6- like moderately; 5-like slightly; 4-neither like nor dislike; 3-dislike slightly; 2-dislike moderately; 1-dislike very much.

The mean value for colour ranges between 6.67 to 4.46 with product B scoring the highest and product D and E having equal least score. That for taste is from 6.13 to 4.80. The flavor showed a range of 6.47 to 5.13 and after taste ranges from 6.80 to 4.33.The overall acceptance of the formulated candy ranges from 6.73 to 4.73 with product B scoring the highest and product E scoring the least.

3.2 COLOUR DETERMINATION

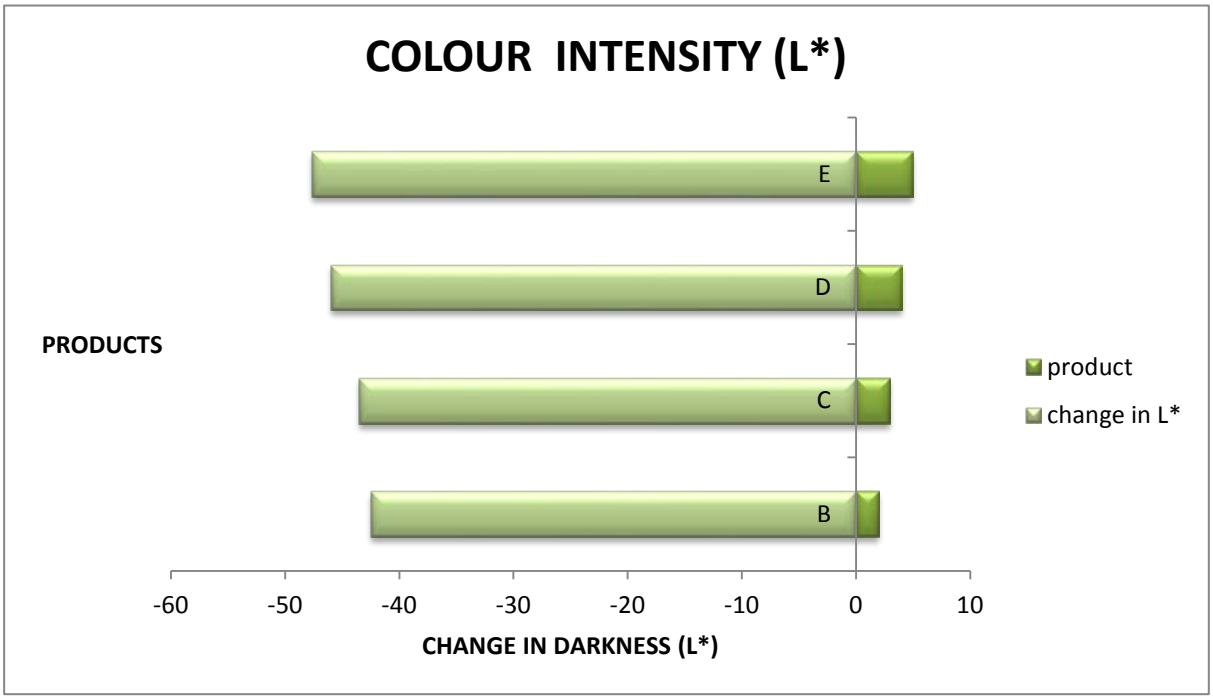

FIGURE 3.2 Change in darkness of the formulated products

The change in darkness of the product ranged from -42.43 to – 47.64. Product B a lighter green colour compared to product E which showed a darker green colour. Product E contained the greatest amount of moringa whilst product B had the least amount of moringa.

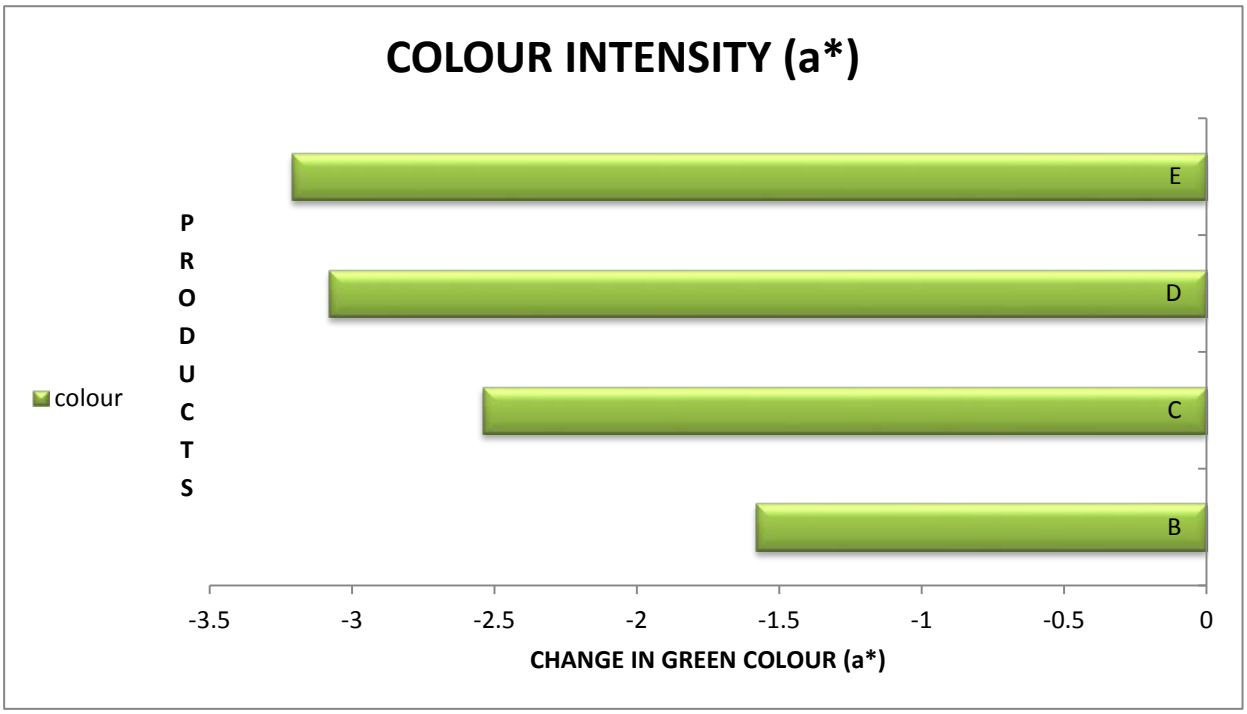

FIGURE 3.3 Change in green colour of the formulated products.

The change in green colour of the product ranged between -1.58 and -3.21 with product E showing it greener in colour than product B which contains the least amount of moringa.

3.3.0 PROXIMATE AND NUTRITIONAL ANALYSIS

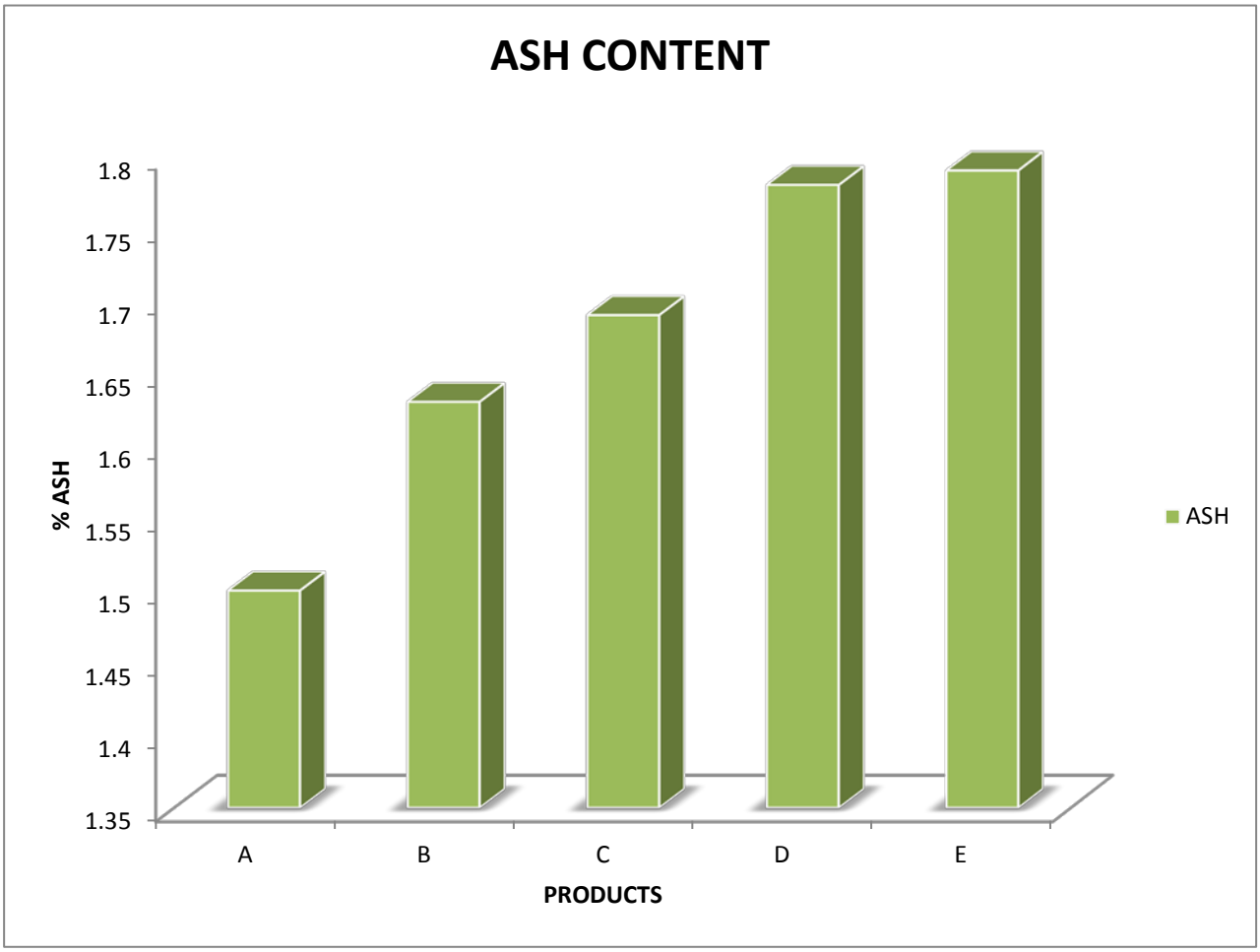

FIGURE 3.4 Ash contents of the products

The mean values of ash ranges from 1.50 to 1.79. That of the control, product A shows a mean value of 1.50 indicating that the control had less amount of inorganic content and product E had the highest ash content indicating a higher inorganic content.

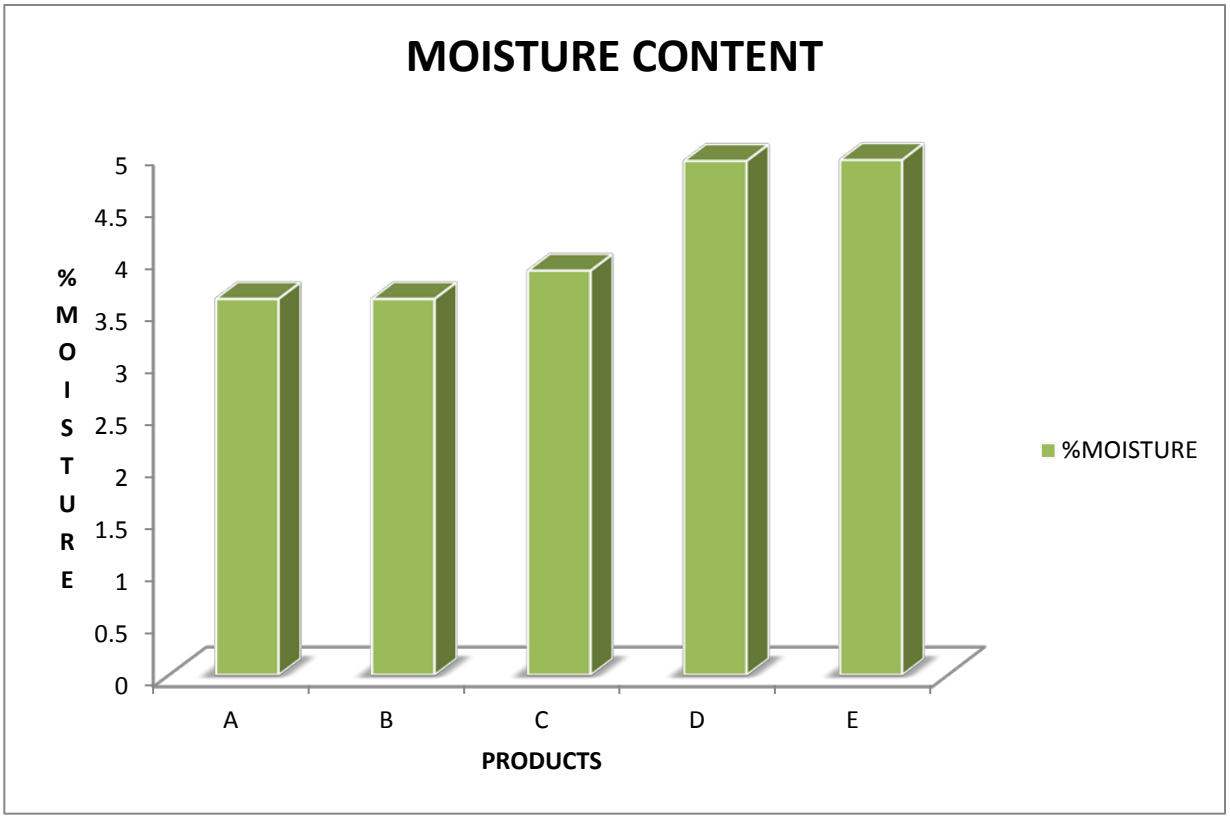

FIGURE 3.5 Moisture contents of the samples

The moisture content of the products ranges between 3.61 to 4.94, with the control which is product A having the least and product E having the lowest.

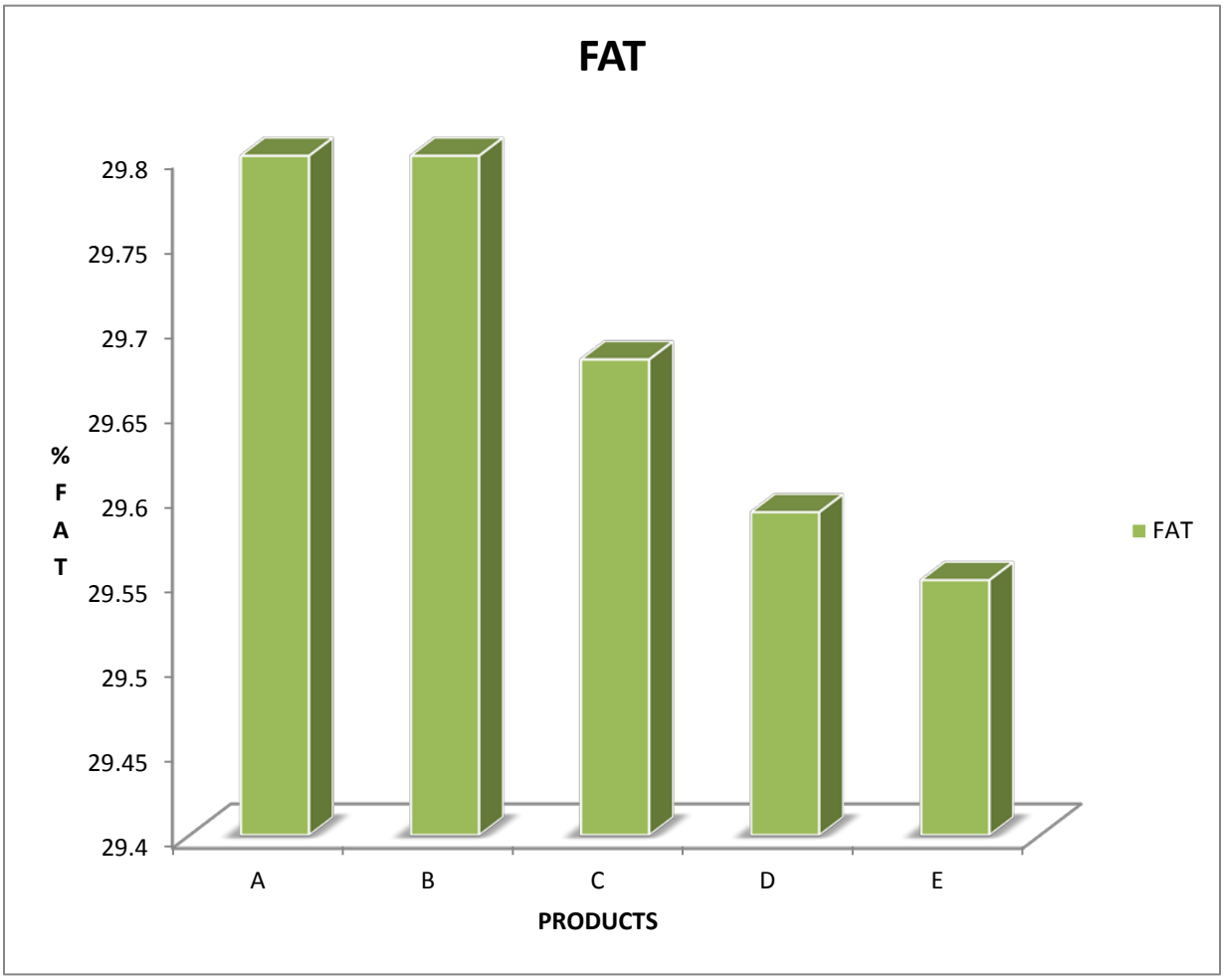

FIGURE 3.6 Fat contents of the products

The fat content of the products ranges from 29.80 percent to 29.55 percent. Product A and B showed the highest equal amounts, and product E which contained the lowest amount of moringa showed the least fat content.

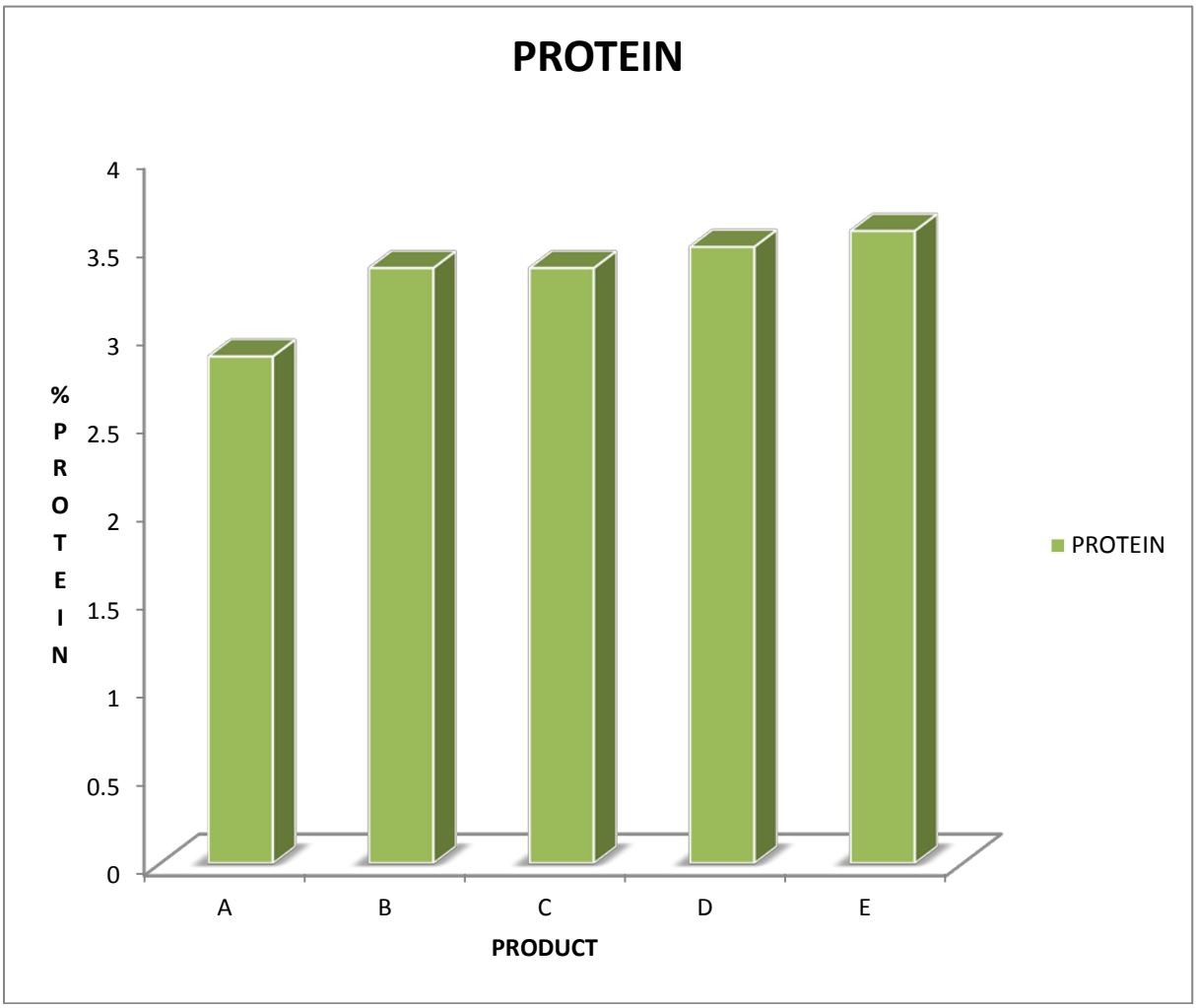

FIGURE 3.7 Protein contents of the products

The protein content of the products ranges between 2.87 to 3.58 percent. Product A which is the control showed the least amount of protein and product E showed the highest percentage protein. Product B and C recorded an equal amount of protein.

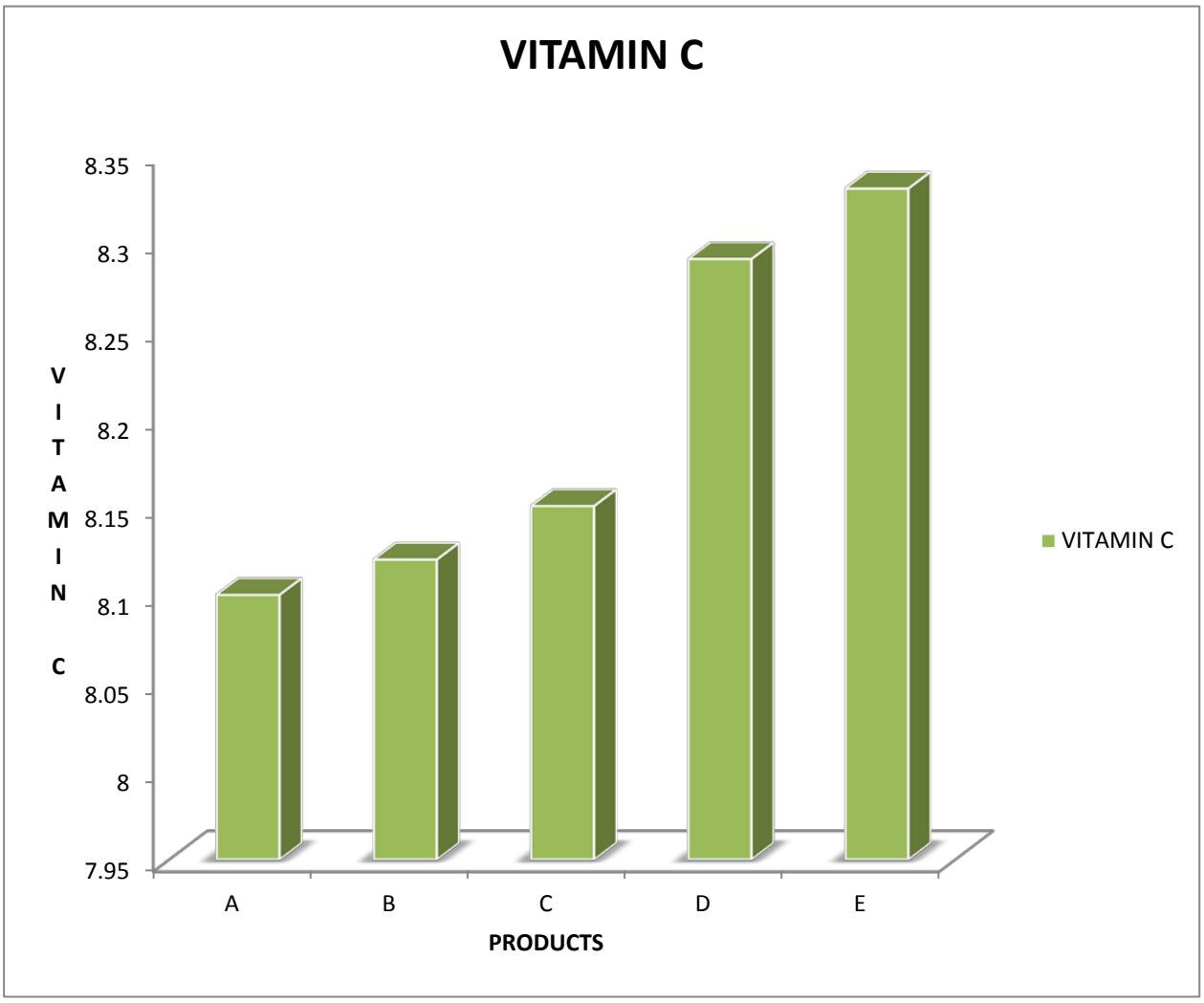

FIGURE 3.8 Vitamin C of the products.

The vitamin C contents of the product ranges between 8.10mg/ml to 8.33mg/ml with product E which contains the highest amount of moringa recording the highest vitamin C content and the control recording the least vitamin C content.

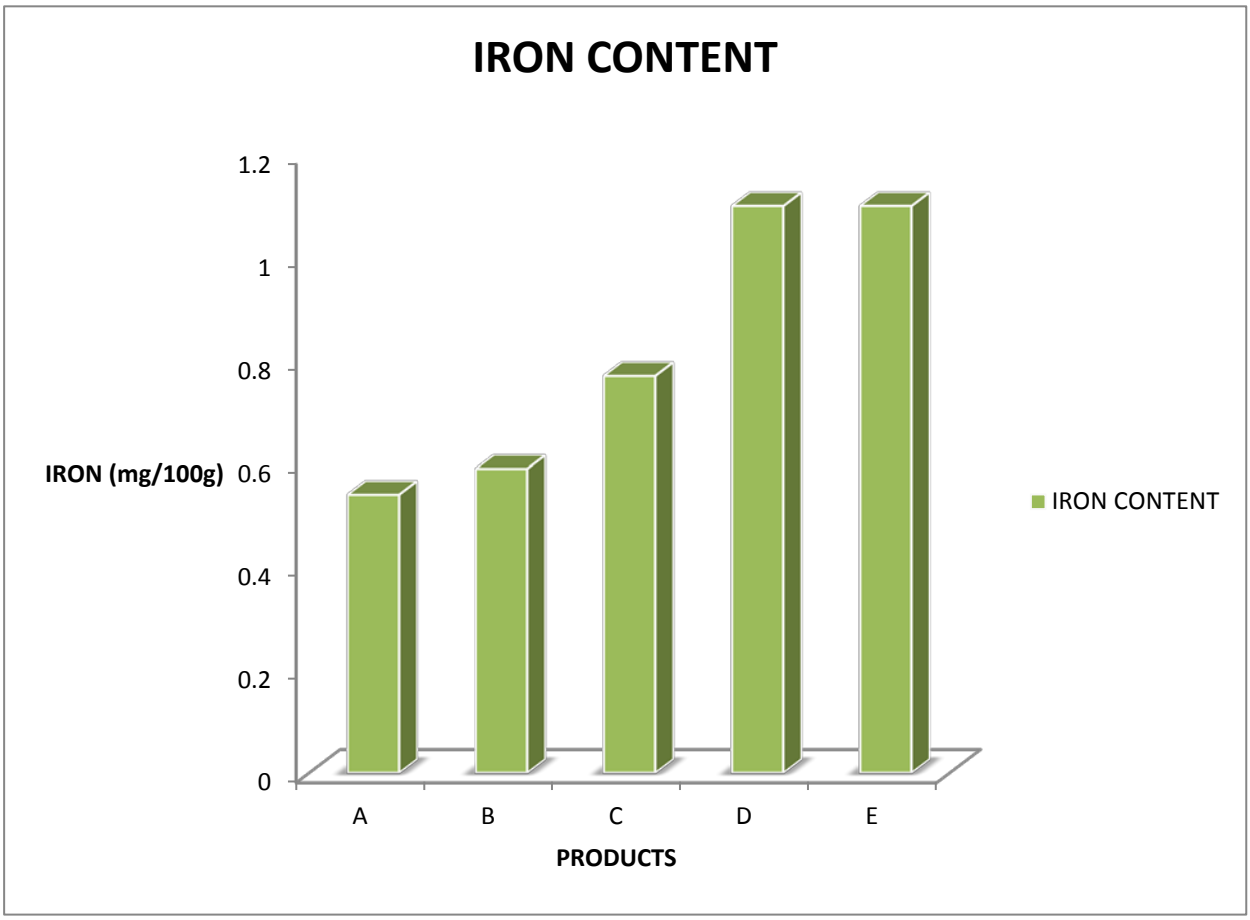

FIGURE 3.9 Iron contents of the products.

The iron content of the products ranges between 0.54mg/ 100g to 1.1mg/100g with product E showing the highest and product A showing the least. Products D and E showed an equal amount of iron content.

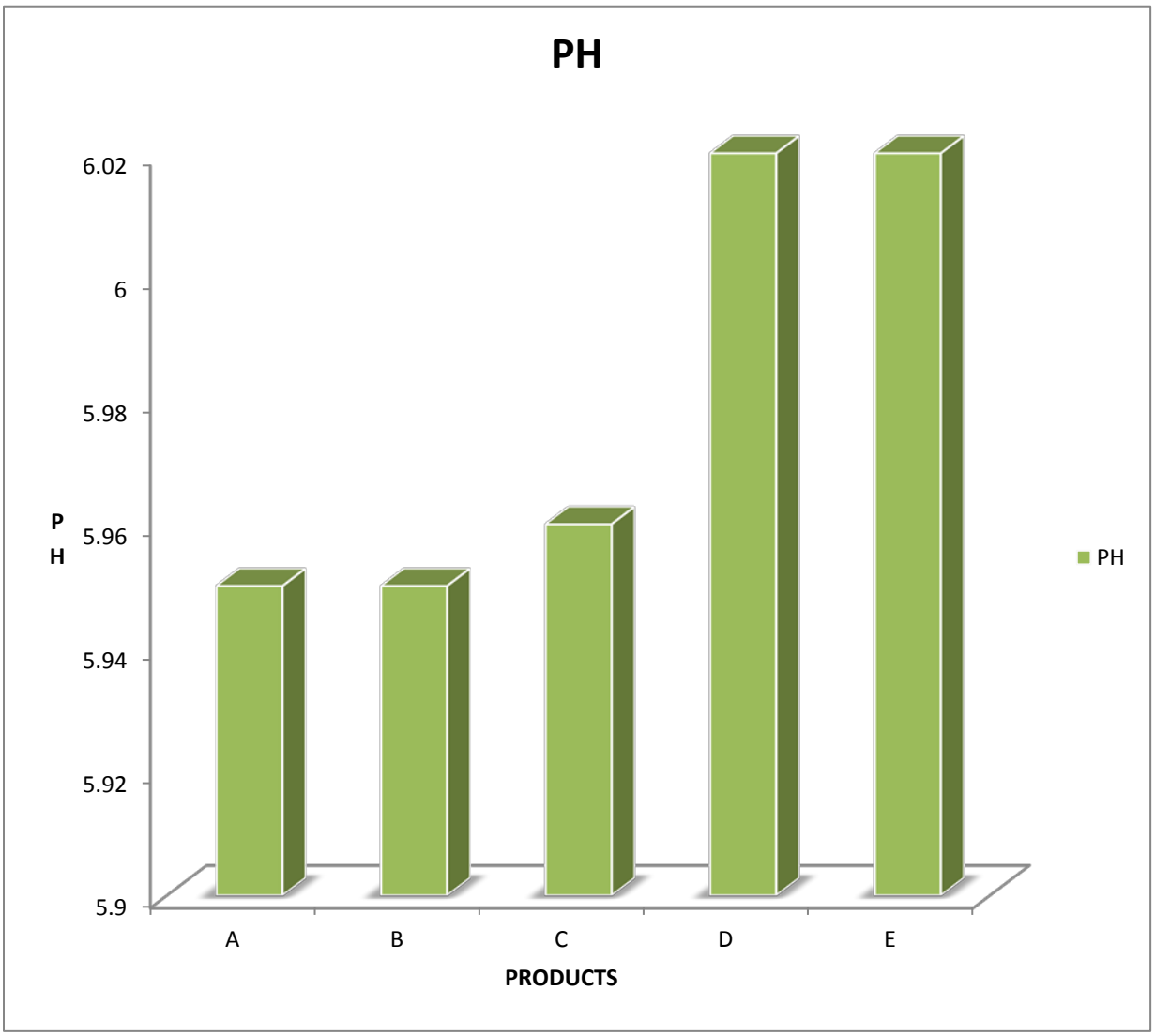

FIGURE 3.10 PH values of the products.

The PH values of the product ranges between 5.95 to 6.02 with product E showing a higher PH and product A showing a lower P^H. Products D and E showed an equal P^H value

3.4.0 MICROBIAL ANALYSIS:

Table 4.1 Microbiological Analysis on moringa candy

PRODUCT	Aerobic mesophillic count	Yeast and moulds	Coliforms
A (control)	11	0	0
B	10	0	0
C	15	0	0
D	7	0	0
E	9	0	0

All the products showed no growth of yeast and moulds as well as coliforms bacteria, but aerobic mesophilic count recorded growth ranging from 7 to 15cfu/g with product C showing the highest count and product D showing the least.

CHAPTER 4

4.0 DISCUSSIONS AND CONCLUSIONS

4.1 DISCUSSIONS

4.1.1 Sensory analysis: Analysis of the sensory data from the study showed significant differences ($p \leq 0.05$) in all the attributes among the products (Appendix 5, Table 10). 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.

4.1.2 Colour: Colour is a sensation that forms part of the sense of vision and judges the appearance of a food product (Jellinek, 1985).Figure 4.1 showed that, product B, was more highly rated for color having a mean score of 6.67. (Appendix 4, Table 5) showed that 73% of the panelist liked the colour of sample B very much while sample E was least rated for colour. Statistically, colours of the formulated products were significantly different at $p \leq 0.05$ (Appendix 5, Table 10). This variation may be due to differences in the concentration of moringa added to the candy.

4.1.3 Aftertaste: Aftertaste is the lingering of the sense of taste of a product on taste buds or the sensations perceived after food has been swallowed(The least score of (4.33) for aftertaste according to Figure 4.1 was obtained for products E with high amounts of Moringa while the highest mean score (6.80) was obtained for product B. Thus high amounts of moringa in the product may have increased the score for aftertaste. Appendix 4, Table 6 showed that 46% of the panellist disliked the after taste of product E and product B had 0% score for after taste. Analysis of variance showed significant

differences of $p \leq 0.05$ (Appendix 5, Table 10). This implies that increased concentration of moringa into the candy impacted negatively to the atertase of the products.

4.1.4 Flavour: Flavour is the perception one gets after tasting food, which includes both the taste and aroma of the food (Stone and Sidel, 2004). Flavour includes tastes and the aroma perceived through tasting (Jellinek, 1985). Figure 4.1 shows that product 04 had the least mean score of 4.53 and also had only 13% of the panelists' score (Appendix 4, Table 7). This shows that increasing the amount of Moringa in the candy gave a flavor that was least liked by consumers. On the other hand, 53% of the panelist liked the flavor of sample 02 which also had the highest percentage score of 53%. Statistically, the flavours of the individual formulated products were significantly different at $p \leq 0.05$ (Appendix 5 Table 10). This means that differences in the concentration of moringa added attributed to the variations in the flavour

4.1.5 Taste: The sensation of taste is a result of the effect of water molecules interacting with receptors on the tongue and in the oral cavity (Rolland P. Carpenter *et.al* 1998). Figure 4.1 revealed that the taste of the candy was scored the highest of 6.53 for product C but product D had the least mean score of 4.40. Appendix 4, Table 8 showed that 66% of the panelist liked the taste of product C very much. There was significance difference between the tastes of the products at $p \leq 0.05$ (Appendix 5 Table 10). As the concentrations of the moringa increased, the taste of the candies changed, diminishing the original taste of milk candy.

4.1.6. Overall acceptance: According to Figure 4.1, the least accepted product was product E which had a score of 4.73 whilst product B was highly accepted.80% of the panelists scored product 02 as highly acceptable (Appendix 4, Table 9). The least accepted product had the highest amount of moringa, meaning that the increase in moringa impacted negatively on the sensory properties. The most accepted product was product B which contained the least amount of moringa.

4.2 PROXIMATE AND NUTRITIONAL ANALYSIS

4.2.1 MOISTURE CONTENT

Figure 4.5 shows that the moisture content increased as the quantity of moringa in the candy increased with product E having the highest moisture content of 4.94 % and product A having the lowest of 3.61 %. It was also observed that the moisture content of the control was lower. In comparison with the Ghana standards for milk toffee of 6 % maximum moisture (Appendix 3), all the products had their moisture content below the maximum. This implies that low moisture content will lower the activities of micro-organisms since shelf life of any food product is highly dependent on the moisture content (Isengard, 2001). Statistically, there was no difference in the moisture contents of the product at $p \geq 0.05$(Appendix 5, Table 11)

4.2.2 ASH CONTENT

Figure 4.4 showed the ash content increased as the amount of moringa increased. This could be attributed to the increase in moisture contents that resulted in corresponding increases in dry matter contents due to the increasing amount of moringa in the candy. The total ash of a food product indicates the inorganic content of the food which indicates the mineral content present in the food (Fennema, 1996). Even though the ash content

increased with the increasing amount of moringa in the candy, it is within the acceptable range of the Ghana standards for milk candies which is expected to have a maximum of 2.5 % (Appendix 3). There was no significant difference between the ash content of the products at $p \geq 0.05$ (Appendix 5, Table 11).

4.2.3 FAT CONTENT

Figure 4.6 indicates that the increasing amount of the moringa in the candy resulted in a decrease in the fat content of the products. Both the control A and product B had the same maximum value of 29.80% whilst product E which had the highest amount of moringa had the lowest fat content of 29.55%. The Ghana standards for fat in milk toffee indicates a minimum amount of 4.0% which means the fat content of the products analysed is far above the minimum value. This could be due to the concentrated nature of the milk which was the raw material used. Anova showed no significance difference between the fat contents at $p \geq 0.05$.

4.2.4 PROTEIN CONTENT

Protein is essential for growth and development because it needed for the manufacture of hormones, enzymes, antibodies e.t.c. Figure 4.7 shows the increasing amount of protein in relation to the increase in moringa in the product. A minimum amount of 3.0% protein is required by the Ghana standards in milk toffee (Appendix 3) and the results obtained from the protein analysis reveal that product E had the maximum of 3.58% whilst the

control A had 2.87%. This makes the control product that does not contain moringa has a protein level lower than the required standard.

4.2.5 VITAMIN C CONTENT

Statistically, there was no significant difference between the levels of vitamin C in the products. Vitamin C is a water soluble vitamin that is minor components of foods that play an essential role in human nutrition. Lack of vitamins has long been recognized to result in serious deficiency. Figure 4.8 show that again the product with the highest amount of moringa recorded the highest amount of vitamin C (8.33mg/100g). At $p \geq 0.05$ (Appendix 5, Table 13), there was no significance difference in the vitamin C contents of the candy.

4.2.6 IRON CONTENT

Figure 4.9 shows the amount of iron in the individual product with product D and E having the same amount of 1.1mg/100g of iron. The iron contents increased progressively as the moringa content increased.). At $p \geq 0.05$ (Appendix 5, Table 14) there was no significance difference in the iron contents of the candy

4.2.7 pH:

Figure 4.9 shows pH values ranges between 5.95 for control and 6.02 for products 04 and 05. This implies that the addition of the moringa leaves decreases the acidity of the candy. Moringa leaves are known to contain oxalic acids, which is an organic acid and phenolics such as chlorogenic acids (Amaglog, 2004). Anova showed no significance difference in the ph values at $p \geq 0.05$.

4.2.8 COLOUR DETERMINATION

Colour is one of the most important quality attributes of food. The first impression of the quality and acceptability of a particular food is judged upon its appearance (Neilsen, 1998). Some consumers make choices of food products based on colour.

- If $\Delta\mathbf{L}$ is positive, then the sample is lighter than the standard. If negative, it would be darker than the standard
- If $\Delta\mathbf{a}$ is positive, then the sample is more red (or less green) than the standard.
- If negative, it would be more green (or less red)

4.2.9 Colour L*: According to fig 4.2, the L* indicates the lightness or darkness of the product. The more negative the value, the more darker the product.Product E has the highest amount of moringa, and the value of L* indicated in Figure 4.2 for product E is -47.64 which implies that sample E is darker than sample B which contains the lowest amount of moringa.

4.2.10 Colour a*: Figure 4.3 shows the change in the green colour of the product. The more negative the value of a*, the more greener the product. A negative a* value suggests green coloration, and this was significantly higher in product E (-47.64) than product B (-42.43). This implies that product E is greener than product B.

4.3 MICROBIOLOGICAL ANALYSIS

The marginal growth of aerobic mesophiles could be due to contaminants either from the environment or during the moulding of the candies. However, all the counts recorded were within Ghana Standards Boards Specifications (GSB 1998), Appendix 3.

4.4 CONCLUSIONS

Candy is very popular among children, and it is the leading form of conversionary consumed. The choice of candy is usually determined by its colour and taste. High amounts of Moringa powder in the composite candy impacted negatively on its sensory acceptability but increased on its nutritional quality which confirms the hypothesis that there are differences in the nutritional composition of milk candy and moringa incorporated candy. Comparing the nutrient composition, the candy with the highest moringa content that is product E was more nutritious considering the protein, Iron, vitamin A and C contents .How ever product E was less preferred by the panelists due to the bitter after taste. All attributes were better preferred with product B.

4.5 ACKNOWLEDGEMENTS

The technical help of Godwin Armah of the Processing and Engineering Division of the Food Research Institute is acknowledged.

REFERENCES:

Anwar, F., Latif, S., Ashraf, M., Gilani, A.H., (2007). Moringa oleifera: a food plant with multiple medicinal uses. Department of Chemistry, University of Agriculture, Pakistan 21(1), pp 17 - 25.

AOAC. (1990) Official Methods of Analysis of the Association of Official Analytical Chemists (15th edition), Washington D.C.

Bauman, D. E. and Davis C. L. (1974). Biosynthesis of milk fat in Lactation - A Comprehensive Treatise. Vol II (B.L. Larson and V.R. Smith, eds.). Academic Press, New York. pp 31-75.

Barasi, M.E. 1997. Human Nutrition. Arnold International Students' Edition Published. London. 328pp.

Beard, J. 2001. Iron- Definciecy Anemia: Reexamine the Nature and Magnitude of the Public. Journal of Nutrition v131:568S-680S.

Bennett, R. N., Mellon, F. A., Foidl, N., Pratt J. H., Dupont, M. S., Perkins, L. And Kroon, P. A. (2003). Profiling glucosinolates and phenolics in vegetative and reproductive tissues of the multi-purpose trees Moringa oleifera L. (horseradish tree) and Moringa stenopetala L. *J Agric Food Chem*. 2003 Jun 4; 51 (12):3546-53 12769522 [Cited: 1]

Berry, D. 2003. A Natural Fit for Nutritional Beverages. Dairy Foods. v104 (5): 24-26.

Berry, O.P. (1993). Stability of Vitamins in food. In: The Technology of Vitamins in Food. ed: Berry Ottaway P., Chapman and Hall publishers, London. pp. 90 - 113.

Berry, D. 2003."New bottle Can" Can Work with Milk. Dairy Foods. v104 (5):20.

Bordi, P.L., Lambert, C.U., and Borja, M.E. 2001. Acceptability of Lower-Fat Dessers by Pre-Adolescent Children. The Journal of Child Nutrition and Management, v25 (1):19 23.

Cross, H. R. and Overby, A. J. (Eds.) (1988). In: World Animal Science- Meat Science, Milk Science and Technology. Elsevier Science Publishers, B. V. Amsterdam. pp. l75,411

DeLong, D. (1979). How to Dry Foods. HP Books, Tucson, Arizona

DeMan, J. (1990). Principles of Food Chemistry, second edition. Chapman and Hall, International Thomson Publishing. London, New Yolk, Tokyo pp. 222-232, 241247; 334-353

Elkhalifa, Osman, E. Ahmed. Souad, A. Adam and Sara. 2007. Nutritional evaluation of Moringa Oleifera leaves and extract. Ahfad Journal

Fahey, J.W. (2005). Moringa oleifera: A review of the medicinal evidence for its nutritional, therapeutic, and prophylactic properties. *Trees of life Journal* (1), pp 2.

Fuglie, L.J. (1999) The Miracle Tree: *Moringa oleifera*: Natural Nutrition for the tropics. Church World Service, Dakar, pp 68

Fennema, Owen. R., 1996.Food chemistry, 3rd Ed, Marcel Dekker, Inc. New York.

FDA (1998). Milk In: "Code of Federal Regulations. Title 21. Section 131.110. U.S. Govt. Printing Office. Washington.

Grant, D. R. and Patel, P. R. (1980). Changes in protein composition of milk by ratio of roughage to concentrate. Journal of Dairy Science. 63:756-761.

Isengard HD. Water content, one of the most important properties of food. *Food Control*. 2001;12(7):395-400

Jellinek, G. (1985). Sensory Evaluation of Food. Theory and Practice. Ellis Horwood international publishers in science and technology, Chichester England, pp 145,159.

Kaufmann, W. and Hagemeister, H. (1987). Composition of Milk. In: "World Animal Science Production - System Approach to Dairy Cattle Production"- Gravert, H. O. (Ed). Elsevier Science Publishers. Amsterdam. pp. 107-164, 173-176.

Morton, J.F. (1991). The Horseradish Tree, Moringa Pterigosperma (Moringaceae). A Boon To Arid Lands. Econ Bot 45: pg 318-333

Paine, F.A. and Paine, H.Y. (1983) A handbook of food packaging, Blackie, Glasgow, ISBN 0–249– 44164–0.

Palada, M.C.and Chang, L.C., (2003). Suggested Cultural Practices for Moringa

APPENDIX 1

SENSORY EVALUATION FORM

DATE: ..…… Product code.....PRODUCT: candy

INSTRUCTION: You have been given samples of CANDY. Examine and evaluate them in terms of the listed attributes and the scale below. Wash down the previous sample before attempting the next.

A SEVEN POINT HEDONIC SCALE

		Colour	Taste	Flavour	After taste	Overall Acceptance
7	Like very much					
6	Like moderately					
5	Like slightly					
4	Neither like nor dislike					
3	Dislike slightly					
2	Dislike moderately					
1	Dislike very much					

Any other comment(s).....

.....

.....

APPENDIX 2

MEDIA PREPARATION

1. Plate Count Agar (Oxoid CM0325)

Component	g/l
Tryptone	5.0
Yeast Extract	2.0
Glucose	1.0
Agar	9.0(top up to 17.5g)

Suspend 17.5g in distilled water and bring to boil to dissolve the medium completely. Dispense into flasks and sterilize by autoclaving at 121^{o}C for 15 mins. Adjust Ph to 7.0±0.2 before and after sterilization.

2. Violet Red Bile Agar (Oxiod CM01107)

Components	g/l
Peptone	7.0
Sodium Chloride	5.0
Bile Salt	1.5
Lactose	1.0
Neutral Red	0.03
Crystal Violet	0.002
Agar	12(top up to 17.5g)

Suspend 38.5g in 1 litre distilled water and bring to boil to dissolve the medium completely. No further sterilization is necessary. Cool to 50^{o}C and mix well before pouring. Adjust Ph to 7.4±0.2 before and after boiling.

3. Tryptone Soya Agar (Oxiod CM131)

Component	g/l
Tryptone	15.0
Soya peptone	5.0
Sodium Chloride	5.0
Agar	15.0(top up to 17.5)

Suspend 40.0g in 1 litre distilled water and bring to boil to dissolve the medium completely. Dispense into flasks and sterilize by autoclaving at 121^{o}C for 15 minutes. Adjust pH to 7.3±0.2 before and after sterilization.

4. Oxytetracycline Yeast Extract Agar(Oxiod CM 0545)

Component	g/l
Yeast extract	5.0
Glucose	20.0
Agar	12.0(top it up to 17.5)

Suspend 18.5 in 500ml of distilled water and bring to the boil to dissolve completely. Sterilize by autoclaving at 115^{o}C for 10minutes. Cool to 50^{o}C and the contents of 1 vial of oxytetracycline supplement (SR0073A).Adjust p^{H} to7.0±0.2 before and after sterilization.

APPENDIX 3

Ghana Standard Board Microbiology Standards for Food Samples (GSB, 1998)

Organisms	Standard Requirement
Yeast and moulds	$<1.0x10^4$cfu/g
Total viable count	$<1.0x10^6$ cfu/g
E.coli	zero cfu/g
Staphylococcus aureus	zero cfu/g
Salmonella spp	zero cfu/g
B. cereus	$<1.0x10^4$

Ghana Standard Board, Standards for Milk Toffee (GSB; 2007)

Characteristics	Milk Toffee
Moisture, % by mass (max)	6.0
Ash, % by mass (max)	2.5
Acid Insoluble ash, % by mass (max)	0.2
Reducing sugar, % by mass (min)	10.0
Sucrose,% by mass (max)	65.0
Fat, % by mass (min)	4.0
Protein (Nx6.25) % by mass (min)	3.0
Lactose % by mass, (min)	3.5
Aflatoxin (ug/kg)	4.0

APPENDIX 4

TABLE 1.Mean values for colour determination of the products

PRODUCT	L*	a*	b*
B	55.06	+3.85	-1.14
C	53.70.	+2.35	-2.31
D	51.42	+2.22	-5.01
E	49.85	+2.82	-5.37

TABLE 2:Table showing the change in lightness and greenish colour of products

PRODUCT	ΔL*	Δa*
B	-42.43	-1.58
C	-43.73	-2.54
D	-45.97	-3.08
E	-47.64	-3.21

TABLE 3: MEANS VALUES FOR PROXIMATE AND NUTRITIONAL ANALYSIS

Product	% Moisture	% Ash	% Fat	% Protein	Vitamin C	Iron	Ph
A(control)	3.61	1.50	29.80	2.87	8.10	0.54	5.95
B	3.61	1.63	29.80	3.37	8.12	0.59	5.95
C	3.88	1.69	29.68	3.37	8.15	0.77	5.96
D	4.93	1.78	29.59	3.49	8.29	1.1	6.02
E	4.94	1.79	29.55	3.58	8.33	1.1	6.02

TABLE 4: Mean score values for the four different formulated products (15 Panelists)

Product	Colour	Taste	Flavour	After taste	Overall
B	6.67±0.61	6.13±0.63	6.47±0.62	6.80±0.41	6.73±0.59
C	5.80±0.67	6.53±1.30	6.06±1.30	5.80±1.20	6.07±0.70
D	4.46±1.80	4.40±1.95	4.53±1.60	4.53±1.90	4.46±1.60
E	4.46±1.84	4.80±1.92	5.13±1.64	4.33±1.50	4.73±1.61

TABLE 5: SENSORY ANALYSIS ON COLOUR (%)

PRODUCT CODE	Like very much	Like moderately	Like slightly	Dislike
B	73%	20%	7%	0%
C	33%	53%	14%	0%
D	13%	7%	40%	40%
E	7%	20%	46%	28%

TABLE 6: SENSORY ANALYSIS ON AFTER TASTE

PRODUCT CODE	Like very much	Like moderately	Like slightly	Dislike
B	80%	20%	0%	0%
C	33%	26%	27%	14%
D	13%	27%	7%	53%
E	6%	13%	35%	46%

TABLE 7: SENSORY ANALYSIS ON FLAVOUR

PRODUCT CODE	Like very much	Like moderately	Like slightly	Dislike
B	53%	40%	7%	0%
C	40%	46%	7%	7%
D	13%	20%	47%	20%
E	23%	31%	26%	20%

TABLE 8: SENSORY ANALYSIS ON TASTE

PRODUCT CODE	Like very much	Like moderately	Like slightly	Dislike
B	60%	33%	7%	0%
C	66%	20%	7%	7%
D	13%	20%	40%	27%
E	5%	7%	44%	44%

TABLE 9: OVERALL ACCEPTANCE OF PRODUCTS (%)

PRODUCT CODE	Like very much	Like moderately	Like slightly	Dislike
B	80%	13%	7%	0%
C	26%	60%	7%	7%
D	13%	13%	47%	27%
E	6%	12%	25%	57%

APPENDIX 5

TABLE 10

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Colour	Between Groups	52.450	3	17.483	9.307	.000
	Within Groups	105.200	56	1.879		
	Total	157.650	59			
Taste	Between Groups	47.467	3	15.822	6.353	.001
	Within Groups	139.467	56	2.490		
	Total	186.933	59			
Flavour	Between Groups	34.717	3	11.572	5.580	.002
	Within Groups	116.133	56	2.074		
	Total	150.850	59			

Aftertaste	Between Groups	60.067	3	20.022	8.017	.000
	Within Groups	139.867	56	2.498		
	Total	199.933	59			
Overallacceptance	Between Groups	52.467	3	17.489	9.552	.000
	Within Groups	102.533	56	1.831		
	Total	155.000	59			

ANOVA FOR MOISTURE CONTENT

PRODUCT					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9.500	3	3.167	6.333	.282
Within Groups	.500	1	.500		
Total	10.000	4			

ANOVA FOR FAT CONTENT

PRODUCT					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.095	3	.032	6.333	.282
Within Groups	.005	1	.005		
Total	.100	4			

ANOVA FOR FAT CONTENT

PRODUCT					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.095	3	.032	6.333	.282
Within Groups	.005	1	.005		

ANOVA FOR FAT CONTENT

PRODUCT					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.095	3	.032	6.333	.282
Within Groups	.005	1	.005		
Total	.100	4			

ANOVA FOR PROTEIN CONTENT

PRODUCT					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.095	3	.032	6.333	.282
Within Groups	.005	1	.005		
Total	.100	4			