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Synthesis Process and Nutritional Evaluation of Plantain as a Supplementary Food for Toddlers in Sierra Leone: A Study Utilizing Biuret's, Benedict's, and Iodine Solution Test

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ABSTRACT

Research on developing plantain fruit into juice, jam, ice cream, and fritters as a food supplement for toddlers was conducted in Sierra Leone. The work was done at the Mosoudo section of Daru village, Jawie Chiefdom, in Kailahun District. Four bunches of plantains were harvested from Jawei Chiefdom and stored in Mosoudo. Two bundles of the raw plantain were peeled, dried, and ground into powder, while the other two left to ripen at room temperature for nine days. Test were conducted using Iodine solution, Benedict solution, and Biuret test to check the presence of starch, glucose, and protein, respectively, in both the powdered and ripe plantain. The ripe plantains were then made into juice, jam, ice cream, and fritters. Fifty mothers/caregivers, along with their children, were randomly selected to evaluate the color, taste, smell, and texture of the four plantain products. The sensory evaluation results showed high acceptance levels: color (53.5%), taste (59.0%), smell (61%) and texture (59.9%). The results suggest that the project could successfully provide nutritious and appealing food supplements for toddlers in Sierra Leone. It was recommended that the government and NGOs promote the cultivation of plantains instead of importing food supplements for children in Sierra Leone.

Keywords: juice, jam, sensory analysis, food tests

INTRODUCTION

This research work is geared towards producing ripe plantain drinks, jam, ice cream, and fritters to be used as food supplements for toddlers in Sierra Leone. Plantains are essential food crops in Sierra Leone and mid-altitude agro-ecological zones of Sub-Saharan Africa and one of the significant sources of carbohydrates in Asia, Oceania, Africa, and Central Americas [1][2][3][4]. In some parts of East Africa, the plantains are reported to be an essential beer-making crop, notable in Centre and Eastern Uganda and Tanzania. Universally, plantains account for about 85% of all banana cultivation worldwide [5]. Plantains are a common sight in Sierra Leone, particularly in the study area of Mosoudo Section, Daru, Jawie Chiefdom, and Kailahun District. They are used in a variety of dishes, from boiled to fried, and are a staple for both adults and children. However, despite their widespread use, there has been a notable absence of research on the development of plantain-based food supplements for toddlers in Sierra Leone. Plantains have been found to be a rich source of several organic mineral nutrients [6][7][8][9][10]. They have been shown to make a significant contribution to food security and the eradication of malnutrition, making them a staple food in several tropical and subtropical climates [11]. Furthermore, plantains contain flavonoids and polyphenols, natural beneficial compounds found in plants, which act as antioxidants, help in fighting free radicals that cause oxidative stress in the body, and also regulate hormones associated with obesity [12].

Mineral contents, antioxidant capacities, and phytochemical constituents of Plantain whole fruit (pulp and peel) and pulp extracts determined and reported [13]. The phytochemical screening showed that the plantain whole fruit and pulp extracts contained phenols, terpenoids, flavonoids, cardiac glycosides, reducing sugars, alkaloids, and steroids [14]. The findings revealed that unripe plantain whole fruit and pulp extracts are a source of critical nutrients and bioactive substances. These elements are obtained from the soil and atmosphere with the help of moisture (water) that dissolves them into a solution and is then taken up through the roots). Plantain is a perennial crop with strong pseudostems and a large, broad spiral pattern of stacked leaves [15][16]. Numerous recipes utilize plantains. When ground into flour, it is usually used to make porridge. Mature fruits are cooked, roasted, mashed, baked, or fried [17].

Banana meals are often served with stews or vegetable sauces and either fish or meat, depending on the household's income [18].

FIGURE 1. ***Musa paradisiaca*** **(**Plantain) plant and fruits.

Botanical Name: ***Musa paradisiaca*** Linn [19]

Vernacular Botanical Names Sierra Leone [20]

Mende	MAA/MANA/MANI
Creole	PLANTIN
Temne	Ɛ-PLANTI
Kissi	gBƆLƆ - BANA
Fula	KƆNTƆMBƆLƆ
Susu	KƆNTƆMBOLONYI
Kono	MAA
Loko	MAA-WAWA

The plantain plant is a gigantic herb that springs from an underground stem or rhizome. Most varieties are 3–10 meters (10–33 feet) tall and have a conical false "trunk" formed by the leaf sheaths of long, spirally arranged leaves. The fruit, which is green to brown-yellow, is typically more significant than the typical banana and is borne in bunches. Different parts of Plantain have been used for different domestic and medicinal purposes. The fruit is eaten as food, the juice extract from the leaf is used in the treatment of fresh wounds and cuts, while its sap is used as a remedy for epilepsy, diarrhea, and dysentery [21].

Research work on nutritional and mineral compositions of Plantain revealed that mature unripe Plantain contained 60.22% moisture, 0.86% ash, 5.54% fat, 20.84% crude fiber, 5.05% protein and 7.49% carbohydrate [22]. Mineral analysis using Atomic Absorption Spectroscopic method revealed that Plantain fruit contained 2754 mg/100g iron, 1360 mg/100g potassium, 320.1 mg/100g zinc, 282 mg/100g calcium, 180.6 mg/100g copper, 130 mg/100g magnesium, 65.9 mg/100g manganese and 26.1 mg/100g sodium, heavy metal minerals like chromium, lead and cadmium were absent [23]. The elements or mineral nutrients play important roles in the biochemical processes in the process of healthy growth and development of this crop [24].

Plantain products have been reported to contain aggregates of other permitted food-use ingredients, including cereals, sugars, fruit flavorings, chocolate, vanilla, sweeteners, fruits or dehydrated vegetables [25] elaborated powdered mixtures for instant milk drinks from unconventional flours such as pre gelatinized banana flour and rice bran (*Oryza sativa L.*), resulting in good sensory acceptance as a balanced diet.

Martinez reported that it has high starch content, is widely used in infant feeding as a source of energy, and has excellent medicinal properties, especially for cases of gastrointestinal infection [26]. It has been reported that magnesium present in Plantain helps with migraine headaches, insomnia, and depression [27].

METHOD

The Area of Study

This research was conducted in the unique Mosoudo section of Daru, Jawie Chiefdom in Kailahun District. The Mosoudo people, a part of the Mende ethnic group, are known for their

distinct cultural practices and agricultural traditions. The Mosoudo section, governed by a paramount chief, is one of several sections within the Jawie Chiefdom in Daru.

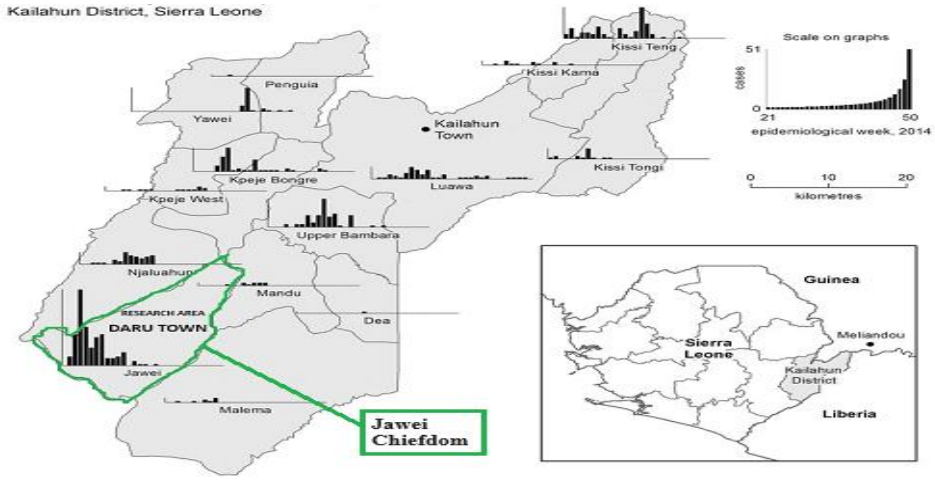

FIGURE 2. Jawei Chiefdom where project site is located.

The Mosoudo section of Jawei Chiefdom has a population of 1000 residents, who are primarily traders and farmers. Daru is a town in Kailahun district in the Eastern Province of Sierra Leone with a population of 5,951 (According to the 2015 Population and Housing Census by Statistics Sierra Leone). Daru lies approximately 25 miles (40 kilometers) to Kenema. According to statistics in Sierra Leone in the census, Daru is home to one of the most extensive military barracks in Sierra Leone. The vast majority of the people in the town are from the Mende group.

Preparation of Plantain Materials

Four bunches of plantains were carefully harvested from the Jawei Chiefdom and stored at Mosoudo Section of the Daru town. Two bundles of the raw plantain were peeled, dried and grounded into powder with utmost precision. The other two bundles were allowed to ripe at room temperature for nine days, ensuring the accuracy of our research.

Source of Data

Data were sourced from both questionnaire and desk review. The field data collection process, which involved structured questionnaires, personal observation, and interaction with the respondents, was a significant part of the research, providing valuable insights and perspectives.

Data Collection

The instrument for data collection was a well-structured questionnaire that was drafted in English and sectioned based on the research objectives so that the instruments could address the research questions adequately and bring out the desired results. The questionnaire was designed as follows:

- Section A captures information on the demographic characteristics of respondents - age, sex, education, marital status, and occupation
- Section B describes the view of respondents on ripe plantain juice (RPJ 001).
- Section C describes the view of respondents on ripe plantain jam (RPJ002).
- Section D describes the view of respondents on ripe plantain ice cream (RPI 003).
- Section E describes the view of respondents on ripe plantain fritters (RPF 004).
- Section F open ended questions on their general view on ripe plantain products.

Data Collection Procedure

The data collection process was divided into two, namely field data collection and the coded questionnaire administered one-on-one to the respondents by the researcher..

Data Analysis

The administered questionnaires were coded, processed, and analyzed using tables and percentages.

Food Test

The Ripe Plantain and Green Plantain flour materials were tested for glucose, starch, proteins and fats and oils, which were coded as follows;

- Sample A: Raw Plantain Powder (Labelled A)
- Sample B: Ripe Plantain (Labelled B)

Test Reagents used.

- A001 – Biuret's Test (To test for Protein)
- A002 – Benedicts Solution (To test for Glucose)
- A003 – Iodine Solution (To test for Starch)

Biuret Test (AOO1): Test for Protein

Two gram of the powdered plantain flour was placed in a petri dish, and a few drops of 2M Sodium Hydroxide were added and stirred. 2-3 drops of 1% Copper Sulphate solution added to the mixture and stirred again. The same test was repeated for the ripe plantain. The formation of a violet color after a few minutes indicates the presence of proteins.

Benedicts Solution (A002) – Test for glucose

Benedict's test (002) – 10 gram of the powdered plantain flour was put into a test tube, and 20 ml of water was added. The mixture was boiled for two minutes, and 1 ml of Benedict's reagent was added to the test tube. The whole mixture was boiled for 5-10 minutes in a water bath. The same test was repeated for the ripe plantain.

A change in color of the solution from blue to green, to yellow precipitate indicates the presence of glucose.

Iodine Solution (A003) – Test for starch

Iodine Test: 5 gram of the powdered plantain flour was put into a test tube, and 20 ml of water was added. The mixture was boiled for two minutes. The mixture was allowed to cool, and 2-3 drops of iodine solution were added. The formation of a blue-black color indicates the presence of Starch. The same test was repeated for the ripe plantain. The results of each of the above tests are reported in Table 2 of chapter four.

Sensory Analysis

The ripe plantain products are prepared and labeled:

- RPJ001 - Juice
- RPJ002 - Jam
- RPI003 - Ice cream
- RPF004 - Fritters

The ripe plantain products were served to 50 semi-untrained mothers/caregivers and their toddlers who were selected through balloting from the Mosoudo section of the Daru town to carry out the sensory evaluation in terms of the flavor, taste/mouth feel, color and texture, using a set of prepared evaluation sheet based on a five point hedonic ranking scale. The five point hedonic scale is listed below:

- 1 = like very much
- 2 = like moderately
- 3 = neither like nor dislike
- 4 = dislike moderately
- 5 = dislike very much.

Using a score sheet, the panelists identified their acceptance of characteristics (color, taste, aroma/smell, and texture). The acceptability test results were used to obtain the best formulations using the Effectiveness Index Method. The sensory evaluation results are presented using statistical tools (Respondents and percentages) and interpreted in simple tables.

Processing of Ripe Plaintain into Juice (RPJ001)

Recipe

Ten large ripe plantains 1½, liters of pure water, Sweetener (optional), Added flour (optional)

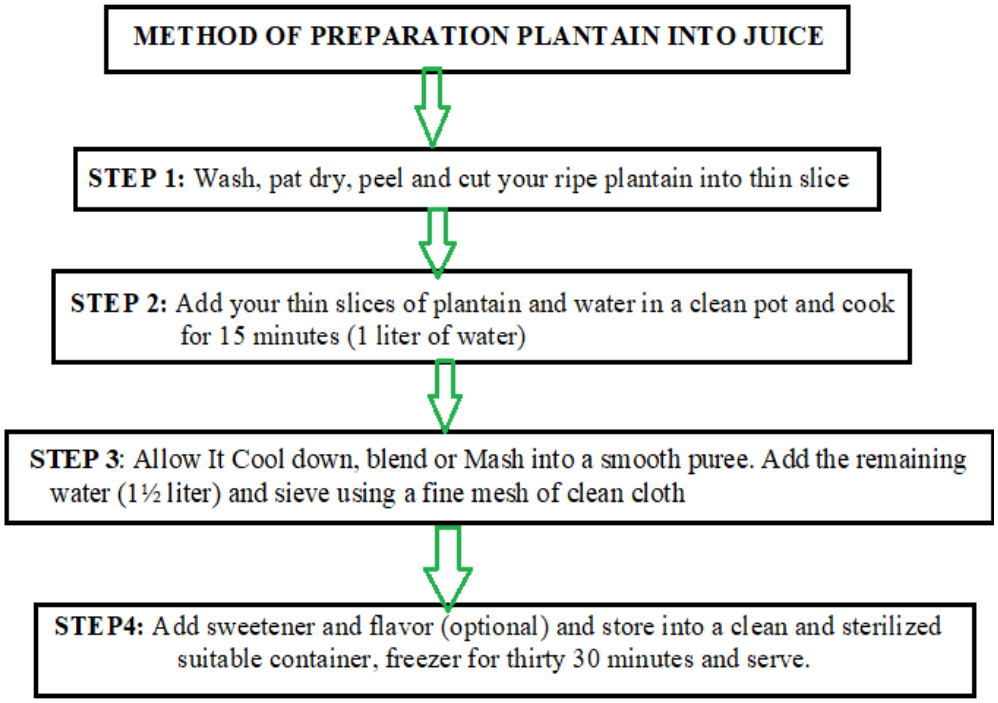

FIGURE 3. Flowchart of method of preparation plantain into juice.

And ripe plantain and the juice produced in this research is shown below.

FIGURE 4. Ripe plantain and plantain juice produced.

Processing of Ripe Plantain into Jam (RPJ002)

Receipe

Five large ripe plantains, One cup granulated sugar, Lime juice one tbs and 250 ml of water

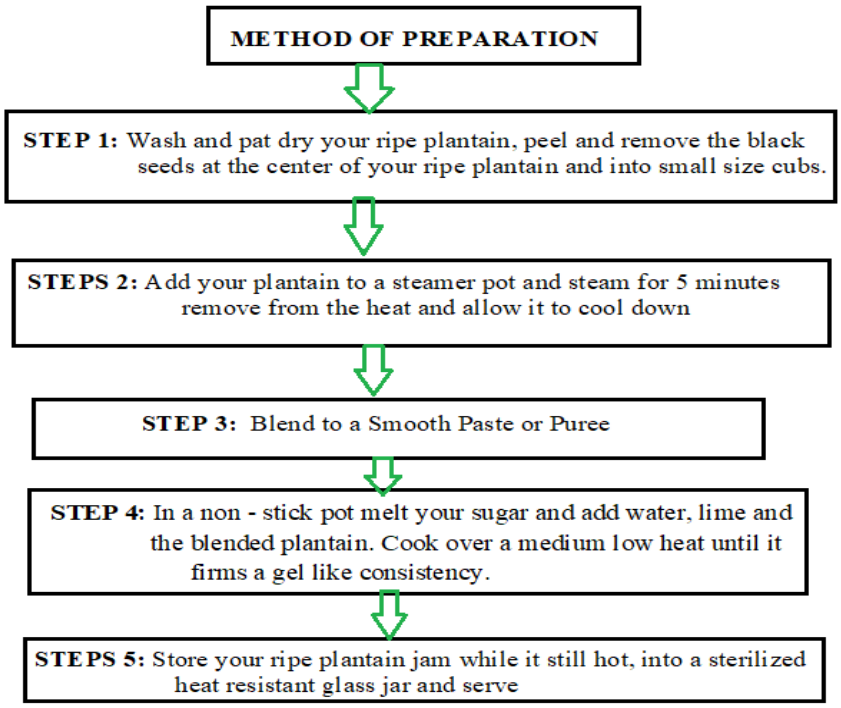

FIGURE 5. Flowchart of method of preparation plantain into jam.

And the ingredients of ripe plantain that processed into jam and the result is shown below.

FIGURE 6. Ripe plantain, ingredients and plantain jam product.

Developing Ripe Plantain into Ice Cream (RPI003)

Ten large ripe plantains, one cup total fat powdered milk, ⅓ cup of condensed milk, ½ tsps. Salt. Water ½ liter, Flavor (optional)

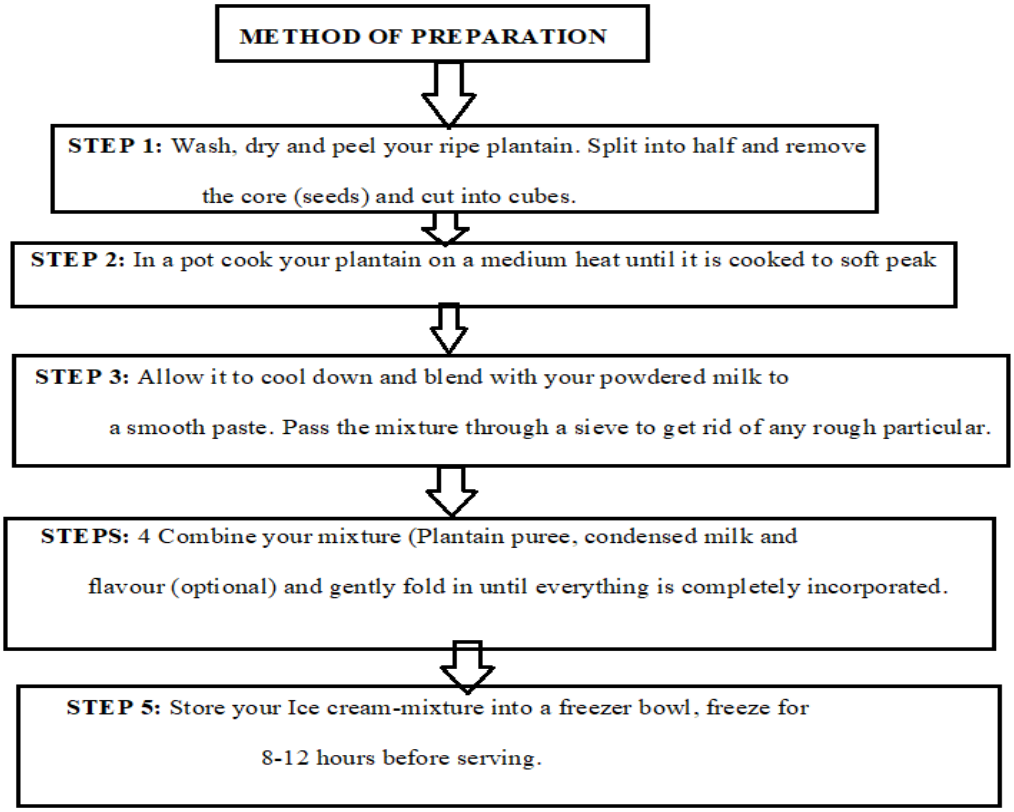

FIGURE 7. Flowchart of method of preparation plantain into ice cream.

And the ingredients of ripe plantain that processed into ice cream and the result is shown below.

FIGURE 8. The ingredients of ripe plantain needed to process into ice cream and the result.

Processing Ripe Plantain into Fritters (RPF 004)

Recipe

Four large ripe plantains, two cups of flour, one tsp of salt, one small cube of chicken seasoning 1clove of garlic, three large chicken eggs (raw), 250 ml of water, ½ tsp. of baking powder One cup of oil for frying.

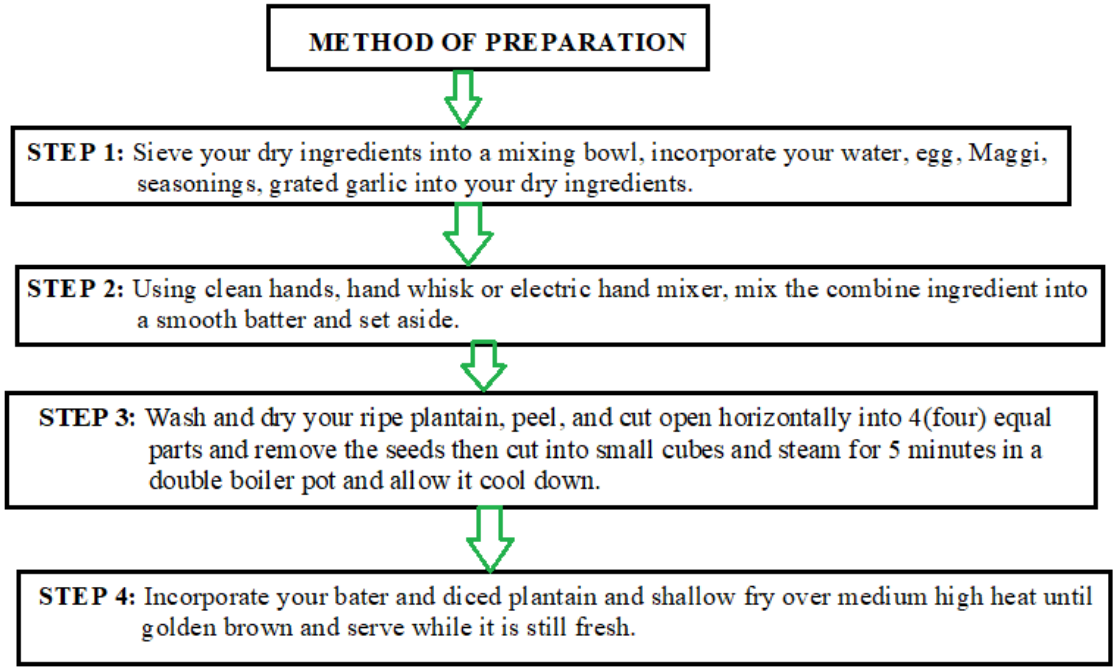

FIGURE 9. Flowchart of method of preparation plantain into fritters.

And the ingredients of ripe plantain that processed into fritters and the result is shown below.

FIGURE 10. Flowchart of method of preparation plantain into fritters.

RESULT AND DISCUSSION

This research was geared towards developing ripe plantain into juice, jam, ice cream, and fritters as food supplement for toddlers in Sierra Leone. The following work was carried out:

- Demographic Characteristics of Respondents.
- Food tests in order to determine the nutritional values of the raw.
- Plantain powder and ripe plantain provide valuable insights into their nutritional values.

Sensory analysis of the products using 50 toddlers and their mothers/caregivers in terms of the suitability of ripe plantain juice, jam, ice cream, and fritters as food supplements for toddlers.

Demographic Characteristics of Respondents (Parents/Caregivers)

The demographic characteristics of respondents in this research work are reported in TABLE 1, below.

TABLE 1. Showing the age range of respondents

Item	Age Ranges (years)	Number of Respondents	Percentage
1	18 - 24	18	36
2	25 - 34	25	50
3	35 - 44	5	10
4	45 - 54	2	4
5	55 +	0	0
TOTAL		50	100

TABLE 1 indicates that 50% of the respondents were within the ages of 25 – 34 while 36 % of the respondents between 18 – 24 years of age, 10% between 35 - 45 and 4% between 45 – 54 years. None of the respondents were above 55 years.

TABLE 2. Showing the educational status of respondents

Item	Age Ranges (years)	Number of Respondents	Percentage
1	Primary	13	26
2	Secondary	8	16
3	Tertiary	3	6
4	Non - Formal	26	52
	TOTAL	50	100

TABLE 2 indicate that 52 % of Respondents were not educated, % attained primary school level, 16% secondary level and 6% attained tertiary level.

TABLE 3. Showing the marital status of respondents

Item	Marital Status	Number of Respondents	Percentage
1	Single	28	56
2	Married	10	20
3	Separated	7	14
4	others	5	10
	TOTAL	50	100

TABLE 3 indicates that 56% of the Respondents were single parents, 20% were married, 14% were separated, and 10% for others.

TABLE 4. Showing the occupational status of respondents

Item	Age Ranges (years)	Number of Respondents	Percentage
1	Farmers	2	4
2	Traders	20	40
3	None	18	36
4	others	10	20
	TOTAL	50	100

TABLE 4 indicates that 40% of the respondents were traders, 36% had nothing to do with only 4% were farmers, and 20% for others.

Results of The Food Tests Carried Out on The Dried Powdered Plantain Powder

The results of the food tests carried out on the powdered plantain and the ripe plantain are reported in TABLE 5 below.

TABLE 5. Sample A: raw plantain powder (labelled A)

Reagent	Test	Observation	Inference
A001	A001 + Sample A	Light Violet colour seen	Slight Protein Present
A002	A002 + Sample A+ Heat	Yellow precipitate seen	Slight Glucose Present
A003	A003 + Sample A	Deep blue-black precipitate seen	Starch Present

Sample A (raw plantain powder) tested slightly positive for Protein, slightly positive for Glucose, and strongly positive for Starch, supporting the use of the plant material as food for toddlers.

TABLE 6. Sample B: ripe plantain (labelled B)

Reagent	Test	Observation	Inference
A001	A001 + Sample B	Light Violet colour seen	Protein Present
A002	A002 + Sample B + Heat	Brick-red precipitate seen	Glucose Present
A003	A003 + Sample B	Deep blue-black precipitate seen	Strong Starch Present

Sample B (ripe plantain) tested slightly positive for Protein, strongly positive for Glucose, and strongly positive for Starch, supporting the use of the plant material as a food supplement for toddlers.

FIGURE 11. Showing food test results on the plantain materials investigated.

Development of Ripe Plantain Products as Food Supplements For Toddlers

Below are the images of the ripe plantain products developed at the Food Science and Consumer Studies Department during the research work, a significant achievement in our quest to provide nutritious food supplements for toddlers.

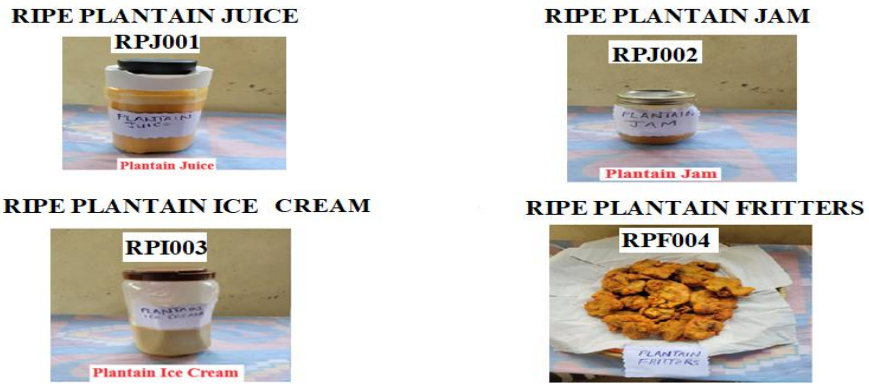

FIGURE 9. Showing the various plantain products.

These products were then served to 50 untrained panelists, mainly mothers and caregivers with their children in the project area, for sensory evaluation.

The Results of Sensory Analysis of Plantain Products

The results of the sensory analysis on the various plantain products are reported and discussed in the following tables.

TABLE 7. Showing the results of sensory evaluation of the colour of the various plantain products

Item	Description	RPJ001		RPJ 002		RPI 003		RPF 004	
		Total	%	Total	%	Total	%	Total	%
I	Like very much	18	36	19	38	15	30	14	28
II	Like Moderately	24	48	25	50	30	60	28	56
III	Neither like or dislike	5	10	4	8	4	8	7	14
IV	Dislike moderately	3	06	2	4	1	2	1	2
V	Dislike very much	-	0.0	-	-	1	2	1	2
	TOTAL	50	100	50	100	50	100	50	100

These results (TABLE 7) provide a strong indication of the products' potential acceptance, with a significant percentage (average 53.5%) expressing a moderate liking for the products' color.

TABLE 8. Showing the results of sensory evaluation of the odour/smell of the various plantain products

Item	Description	RPJ001		RPJ 002		RPI 003		RPF 004	
		Total	%	Total	%	Total	%	Total	%
I	Like very much	30	60	31	62	33	66	28	56
II	Like Moderately	10	20	10	20	10	20	11	22
III	Neither like or dislike	8	16	5	10	3	6	4	8
IV	Dislike moderately	1	2	2	4	4	8	4	8
V	Dislike very much	1	2	2	4	-	-	3	6
	TOTAL	50	100	50	100	50	100	50	100

TABLE 8 indicates responses to the sensory evaluation made on the odor/smell of the various products. The results indicated higher percentages, 60%, 62%, 66%, and 56% (an average of 61.0%), respectively, in favor of the odor/smell of each plantain product.

TABLE 9. Showing the results of sensory evaluation of the taste of the various plantain products

Items	Description	RPJ001		RPJ 002		RPI 003		RPF 004	
		Total	%	Total	%	Total	%	Total	%
I	Like very much	29	58	31	62	30	60	28	56
II	Like Moderately	9	18	9	18	10	20	10	20
III	Neither like or dislike	7	14	6	12	4	8	8	16
IV	Dislike moderately	3	6	3	6	4	8	4	8
V	Dislike very much	2	4	1	2	2	4	-	-
TOTAL		50	100	50	100	50	100	50	100

TABLE 9 indicates responses to the sensory evaluation of the taste of the various products. The results indicated higher percentages, 58%, 62%, 60%, and 56% (with an average of 59.0%), respectively, in favor of the taste of each of the plantain products.

FIGURE 10. Showing some of the images of the sensory evaluation of the taste of plantain juice.

TABLE 10. Showing the results of sensory evaluation of the texture of the various plantain products

Item	Description	RPJ001		RPJ 002		RPI 003		RPF 004	
		Total	%	Total	%	Total	%	Total	%
I	Like very much	10	20	12	24	14	28	12	24
II	Like Moderately	29	58	31	62	30	60	29	58
III	Neither like or dislike	5	10	4	8	4	8	7	14
IV	Dislike moderately	4	8	2	4	1	2	1	2
V	Dislike very much	2	4	1	2	1	2	1	2
TOTAL		50	100	50	100	50	100	50	100

TABLE 10 indicates responses to the sensory evaluation of the texture of the various Plantain products. The results indicated higher percentages of 58%, 62%, 60%, and 58% (an average of 59,9%), respectively, in favor of the texture of each plantain product.

Figure 11. Showing sensory evaluation of the various plantain by both the parents and their children.

SUMMARY

Summary

This research has developed plantain powder and ripe Plantain and carried out food tests for starch, glucose, and protein on each of them. Ripe Plantain was also developed into Juice, Jam, Ice Cream, and fritters. The total sample comprised Fifty (50) Respondents who were used for Demographic Characteristics and Sensory Analysis of the plantain products. The Sample size comprised mainly mothers/Caregivers and their children.

The results of the food tests indicated that both the plantain powder and ripe Plantain tested positive for starch, glucose, and proteins, supporting the use of the Plantain Products as food for toddlers in Sierra Leone. The results of the sensory evaluation of the Plantain Products (Juice, Jam, ice cream, and fritters) served to (50) semi-untrained panelists (mainly mothers/Caregivers and their children) indicated that the average percentage acceptances in favor of color (53.5%), taste (59.0%), odor/smell (61%) and texture (59.9%) as acceptable and good.

Conclusions

The main aim of this research work was to develop ripe plantain into juice, jam, ice-cream and fritters as food supplement for toddlers in Sierra Leone. The plantain powder and ripe plantain tested positive for starch, glucose, and proteins, supporting the use of plantain as food for toddlers in Sierra Leone. In the research work, the ripe plantain was developed into juice, jam, ice cream, and fritters. The plantain products were served to fifty mothers/caregivers with their children during sensory analysis. The products were all accepted by mothers/caregivers and their children.

Recommendations

The results of this research work have shown that both raw and ripe Plantain products can be used to prepare food supplements for toddlers in Sierra Leone, potentially reducing the need for imported food supplements and boosting the local economy. Therefore, it is recommended that further analysis be carried out to determine the mineral composition of Plantain and the percentage composition of the food nutrients in Plantain, which could lead to exciting new discoveries in the field of nutrition.

The Government of Sierra Leone and Non-Governmental Organizations should commit themselves to the cultivation of Plantain Fruits, a sustainable solution that could reduce the need to use foreign reserves to purchase food supplements for children.

It is also recommended that the Chemistry and Food Security and Consumer Education Departments of the Eastern Technical University of Sierra Leone, Kenema Campus, explore the commercial potential of developing Plantain Products for the market.

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Conflict of Interest

The authors have declared that no competing interests exist.

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