



Food Processing: Reducing Postharvest Losses of Plantain Through Alternative Recipe Development

Commey Vida^{1*}, Catherine Impraim Evelyn¹, Harrietta Akrofi-Ansah¹, Asamoah Edwina² and Quao Beatrice²

¹Faculty of Applied Sciences and Technology, Department of Hotel Catering and Institutional Management, Kumasi Technical University, Ghana

²Faculty of Applied Sciences and Technology, Department of Hospitality Management, Sunyani Technical University, Ghana

*Corresponding Author: Commey Vida, Faculty of Applied Sciences and Technology, Department of Hotel Catering and Institutional Management, Kumasi Technical University, Ghana.

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Abstract

This paper reviewed previous work on recipe development for plantain with the aim of reducing its postharvest losses. The researchers adapted the Traditional Development Value Chain model normally used by pharmaceutical firms in recipe development. Sensory analysis was conducted on the product for its general acceptability. Majority of respondents, that is 83% accepted the developed recipe based on the sensory analysis. It is recommended that more of such recipes should be developed to popularize the use of unripe plantain and other farm produce in our hotels and restaurants. Commercialization is also recommended due to the product sensory scores and price.

Keywords: Recipe Development; Ghanaian Farm Produce; Plantain

Introduction

Plantain is a staple food crop grown throughout the tropics and significantly constitutes a major food source for millions of Africans [1], Latin America, Asia and the Pacific [2]. Ghana is one of the leading producers of plantains globally and the largest producer in West Africa besides Côte d'Ivoire, Guinea and Nigeria producing more on the continent [1]. According to the FAOSTAT [3], Ghana produced an estimated 3.95 million metric tons of plantain in 2016 which contributed about 13.1% to the agricultural Gross Domestic Product (GDP). Plantain is categorized into non-traditional segment of the rural economy, with 90% of cultivation done by small-holder farmers [4,5]. Cultivation of plantain is seen as one of the viable economic activities for rural settlers in Ghana since it is one of the primary sources of income for many cultivators [6]. Despite the significant economic output, the processing and use of plantain portions other than the fruit remain undeveloped, offering an unrealized opportunity to support a sustainable food security [4].

A major problem encountered in the production of plantain in Africa is post-harvest losses [1,7,8]. According to Olayemi, et al. [8], post-harvest losses in plantain production occur along the production and supply chains, that is from harvesting to consumption. Moreover, due to the perishable nature of plantains, postharvest losses are common and the situation is worsened by factors

including poor transportation and distribution channels, poor storage facilities as well as [7,9-12]. While this situation is evident, Strano, et al. [13] intimate that recipe development is seen as one of the sustainable strategies to minimise postharvest losses including unripe plantain. This is essentially because, developing recipes from unripe plantain can address over-ripening and further spoilage through value addition and prolonged life-span. This research sought to add to the few existing recipes from fresh plantain, with the primary aim of promoting its consumption and alleviate postharvest losses.

Problem Statement

The launch of planting for food and jobs by the government of Ghana in early parts of 2017 saw a significant rise in the production and supply of plantain. Tortoe, et al. [14] affirmed that about 30% of plantain produced in Ghana are either left to go waste on the farms or while they are being transported to the market. Baral and Hoffmann [15] and Adu-Amankwa and Boateng [16] also add that, postharvest losses of plantains in Ghana is evident due to the crop's perishable nature and absence of effective storage facilities coupled with poor transport and distribution network from the farms to final consumers. Among other interventions to address this challenge, the study argues that the nutritional values and medicinal properties of fresh plantains calls for the need to consider

recipe development of unripe plantains to enhance its utilization while reducing the overall postharvest loss. Thus, value can be added to fresh plantains through strategic recipe development in order to minimize its postharvest losses while maximizing its economic values for farmers. Following this, we used plantain to create one pot dish with the aim of popularizing its use in Ghanaian commercial kitchens to minimize post-harvest losses and add to the few existing recipes. The researchers have the following objectives in achieving the study aim

- To create a new recipe using fresh plantain.
- To conduct sensory analysis for the new product to ascertain its acceptability.
- To conduct recipe evaluation of the developed recipe.

The justification for this research lies in the fact that, while postharvest losses of plantain in Ghana is apparent, it becomes imperative to develop an alternative recipe and test its sensory attributes and general acceptability to promote and sensitize the general public about the crop's nutritional properties in order to minimise the crop's post-harvest losses and also promote its cultivation.

Literature Review

Overview of plantain

Plantain (*Musa paradisiaca*) is a reliable all-season staple food grown mostly in the tropical regions of the world. Due to the popularity and consumption globally, plantains are ranked as the tenth most important staple food in the world [17,18]. Despite its popularity, only 15% of global plantain production is used in international trade with the rest consumed domestically in producing countries [19]. In terms of nutritional value, plantains are rich sources of complex carbohydrates, minerals, vitamins as well as being easy to digest [1,20]. Also, plantains are highly nutritious, good source of potassium, low in fat and sodium with no cholesterol as well as containing about 80 calories [17].

In Ghana, plantains are important food crop for both cash and subsistence basis. Plantains are generally cultivated by small-scale farmers and the crop remains popular amongst them because production cost of plantain per hectare is low as compared to crops like maize, rice, yam and cassava [15,16]. According to Ofosu, *et al.* [21], farmers in Ghana like many tropical countries frequently depend on the availability of the market while harvesting their crop, which may occur after the plantains have attained physiological maturity. Farmers harvest plantains, but they are not adequately kept before being sold to dealers or aggregators. Moreover, fruit ripening and softening likely to occur more quickly when plantain traders inappropriately transport them using unsuitable vehicles [21]. Plantains are a bit different from bananas, harder to peel (es-

pecially when green), and cannot be eaten raw. Plantains must be cooked for consumption whereas bananas are eaten raw. Unlike bananas, plantains are always ready for cooking no matter what stage of ripeness - green, yellow or black, and are used in different dishes from appetizers to desserts [1,22].

Plantains go through various stages of ripeness and this is evidenced by the changing color of its skin. Green plantains are firm and starchy and resemble potatoes in flavour. Yellow plantains are softer and starchy yet sweet. Extremely ripe plantains have softer, deep yellow pulp that is much sweeter. Thus, in the stages of ripeness, unripe plantains are green and this changes color to yellow or yellow dappled with black indicating medium ripe plantains. Furthermore, the skin changes colour to almost black which shows that the plantains are fully ripe, aromatic and sweet. Significantly, if plantains remain unused at this stage and enzymes action continues, plantains go bad and become unwholesome for consumption [22-24]. Such post-harvest losses are widespread in plantain production within the Ghanaian context and this ranges between 10 to 30% because pre-climacteric period of plantains is short as well as shelf life which could be less than 2 weeks under ambient conditions [21,23,25]. Under ambient conditions, the shelf life of plantains can be less than 2 weeks [21,23].

Recipes

A recipe is a standardized and tested procedure used in preparing food, whereby the ingredients, their quantities, mixing process, cooking time and temperature have carefully been planned to produce a coherent and delicious food [26]. Recipes and new food products normally consist of several components including: name of dish, required ingredients and quantities, equipment, preparation time, ordered list of preparation steps and number of servings for the recipe [27,28].

According to Sozuer-Zorlu, *et al.* [26] and De Minicis, *et al.* [29], the types of recipes are general recipes, site recipes, master recipes and control recipes. Specifically, general recipes are those created without specific knowledge of information regarding the process used to manufacture the product. The general recipe uses raw materials, quantities and processing requirement without regard to specific sites. Site recipe involves recipes that are specific to a particular site but is not specific to particular equipment. It is a combination of site specific and general recipe. Moreover, master recipes are specific to the equipment, raw material and capabilities of a process cell. These are derived from the general or site recipe information or alternatively created as a separate master recipe. Lastly, control recipes are copies of specific version of a master recipe modified as necessary with scheduling and operational information [29].

Recipe development

According to Min., *et al.* [30] and Aramouni and Deschenes [31] recipe development is an important part of nutrition education strategy. Recipe development uses horticultural produce to develop recipes including snacks, main meals, soups, complementary food, salads and fruit-based beverages. Moreover, in the development of recipes, local food crops are adapted to indigenous cultural tastes and preferences to ensure the promotion and consumption of micronutrient-rich delicacies. Importantly, the nutritional value of recipe is usually improved by restoration, fortification and enrichment [32,33].

Azanedo., *et al.* [34] and De Greef., *et al.* [35] noted that recipes and new products are developed for the purpose of increasing product visibility, product usage and minimizing safety problems of products. Furthermore, a typical example of a challenge in new product development is mistakes in variations in preparation procedures and equipment which can create alterations in the final product, usually making the recipe undesirable. Following De Minicis., *et al.* [29], recipe development for this research was performed by adapting the Traditional Development Value Chain model, which has widely been used in the pharmaceutical industry.

Review of existing plantain recipes

Several studies including Kwofie., *et al.* [36], Akinyemi., *et al.* [37] and Abiodun-Solanke and Falade [38] have been conducted to evaluate recipes prepared from plantain. Thus, since plantain remains an important staple food, it is used in food production as well as raw material for many products. The Plantain Council [19] identified that in Kerala, India, ripe plantains are steamed to make breakfast dishes while ripe plantains in Guatemala are eaten boiled, fried or eaten with sweetened black beans.

In Nigeria, plantains at every stage in the ripening process (from unripe to overripe) are used as a source of food. The unripe plantains are used in preparing '*plantain fufu*' or chips while the ripe plantains are fried and added to beans for a full course meal. Moreover, overripe plantains are processed into beer or spiced with chili pepper, fried with palm oil and served as snacks [37]. Abiodun-Solanke and Falade [38] also found that fried plantain has become popular and commercial production and marketing has increased worldwide in the last two decades with such chips commonly sold at grocery stores. Likewise, in Cameroun, Newilah., *et al.* [39] revealed that plantains are used in recipes like plantain porridges, chips, fried plantain, traditional recipes called '*kondre*' and '*malaxé*' as well as traditional puree, which use overripe plantain pulps.

In an effort to increase nutritional diversity and reduce food waste, [36] investigated the use of overripe plantains and peppercorns to make a beverage in Ghana. They tested the newly created product using overripe plantains through a sensory assessment, and the results showed that customers found it to be highly acceptable. This result implies that people and households are likely to

accept novel food items derived from plantains, and that plantains (*Musa spp.*) can be used in numerous useful ways in contemporary food processing. Due to the natural pro-vitamin A carotenoids and other nutrients that plantains contain, as well as other inherent nutritional benefits, there may be a greater use of the fruit as a result of increased knowledge and education about plantain-based recipes. This could lower the prevalence of nutritional deficiencies, especially in developing nations. Moreover, Abiodun-Solanke and Falade [38] indicated that plantains are consumed at several stages of ripeness and used to prepare recipes such as '*tatale*', '*kaklo*', '*kelewele*' (ripe stage) whereas it is used in preparing '*fufu*' at the early stage of ripeness. Also, [6] affirmed that plantains in Ghana are processed into '*ampesi*', '*fufu*', '*ofam*', '*tatale*', '*kaklo*', chips and fried plantain.

The recipes discussed above, especially in the Ghanaian context showed that most recipes are prepared with ripe and overripe plantains while a few like '*fufu*' and '*ampesi*' are prepared with green plantain. Following this, the study popularized the use of unripe (green) plantains to prepare Ghanaian dishes. Moreover, from the reviewed literature, a key aspect that seems to be missing in the use of plantain in recipe development is follow-up with the target audience to determine if the recipes are used and reactions to the recipes in terms of taste, cost, and ease of preparation.

Research Methodology

The research methodology describes the overall model, methods, raw materials, proportions and processes used in preparing the plantain delicacy. Moreover, it provides data analysis and sensory evaluation of the recipe prepared.

Recipe development process

The researchers based their recipe development from unripe plantain on the traditional value chain development model which has widely been used in drug production in the pharmaceutical industry [29,40-42]. This model was adapted as framework to guide this study. The traditional value chain analysis is a tool that aids the understanding of activities that create the business value [43]. The model helps to identify and analyze value chain activities and focuses on aspects such as production, processing, distribution, marketing and consumption of products via eliminating activities that inhibit value creation [44]. Figure 1 presents the phases in the recipe development process.

- **Stage 1:** Research on plantain led to the discovery of its nutritional value and existing recipes and the need to create more recipes for fresh plantain.
- **Stage 2:** At the pre-development stage, ideas were generated on ingredients, method, and equipment choice of the recipe. Numerous ideas were screened with cost, availability of materials at all time, its acceptability by majority of consumers were also considered to guide the screening process. For example, the plantain being the main ingredient was peeled and

cut into different shapes and cooked. Then the sauce was prepared with protein and vegetables and mixed with the plantain.

- **Stages 3-5:** a prototype of product was developed tested and tried. At every stage, samples were given to lecturers and students who gave their comments for modification and improvement of the product. Finally, evaluation analysis was done on nutrition, cost and resourcefulness to evaluate the overall suite of the product to the target audience.

The stages of the recipe refer to the business model implementation sequence: from the informal first idea to a process of trial and error shaping its final design, or a continuous process of modification, where customers and technologists are asked to try the new product. The process corresponds to the iconic business model which can inspire other strategists and recipe developers [40,41].

Source of raw materials and study settings

The raw plantains were obtained from Kumasi Asafo market. Ideal milk was bought from supermarket in Kumasi and all other ingredients were obtained from Kumasi Township. Preparation was done in the Department of Hotel Catering and Institutional Management kitchen of Kumasi Technical University.

Ingredients and Quantities for Recipe Preparation (Idealicious Plantain Delicacy)

Sample preparation

Ingredients	Quantity
Beef fillet/chicken fillet/fish fillet	0.5kilo
Beef fillet/chicken fillet/fish fillet	0.5kilo
Ideal milk	90ml (3tins)
Plantain (unripe)	4 fingers
Carrot	2 fingers
Shallots	10 bulbs
Kpakpo shito	8 bulbs
Corn flour	2 tablespoons
White pepper	1 tablespoon
Cayenne pepper	1 tablespoon
Onions	2 bulbs
Maggi cube/salt to taste	1

Table a

Fresh green plantain was washed and peeled. The rest of the ingredients were also prepared. The beef was washed and shredded, seasoned with nestle magi cube and cooked with ideal milk diluted with a little water for 10 minutes. The corrugated cut plantain was added and cooked for five minutes. The corn flour was dissolved, added and left to simmer for 5minutes. The cut vegetables were added and the seasoning was corrected. 5minutes.

Method of recipe preparation

- Wash and shred beef fillet, chicken fillet/fish fillet.
- Season with nestle magi cube and salt
- Cook seasoned beef fillet with ideal milk and little water for few minutes
- Add corrugated cut plantain and cook few minutes
- Dissolve corn flour and add to the mixture, leave to simmer for few minutes
- Add vegetables and correct the seasoning
- Serve as one pot dish

Sensory analysis

In the sensory evaluation of the prepared recipe, handout recipe sheets were given to participants together with evaluation sheets and the sample products. Respondents tasted the three protein products and fill the form for their observation and comment.

Results and Discussion

The main objective of this study was to create a new recipe using fresh plantain, to conduct sensory analysis for the new product, to ascertain its acceptability and to conduct recipe evaluation of the developed recipe and cost evaluation.

Sensory analysis for the new product to ascertain its acceptability

The sensory evaluation test forms were given to respondents to comment on the appearance, taste, texture, aroma and aftertaste of the product. The results are displayed on table 1.

Sensory Attributes	Scale; 1-Don't Like; 2-Neutral; 3-Like; 4-Very Much Like							
	Don't Like		Neutral		Like		Very Much Like	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Appearance	0	0	0	0	12	40	18	60
Taste	0	0	0	0	7	23.33	23	76.67
Texture	0	0	0	0	10	33.33	20	66.67
Aroma	0	0	0	0	11	36.67	19	63.33
Aftertaste	0	0	0	0	5	16.67	25	83.33

Table 1: Summary of sensory Analysis by Respondents.

Source (Field Work, 2023).

Table 1 clearly shows that the Very Much Liked (VML) frequencies and their corresponding percentages are high which indicate the overall acceptability of the product. It is also clear that none of the respondents disliked the product.

Evaluation of the developed recipe

Table 2 and table 3 presents the evaluations of the resourcefulness and cost of developed recipe product respectively.

Maximum Score	Criteria	Description	Points	f	%
27	Resourcefulness		30	2	6.6
		Overall evaluation of how well-suited recipe is to target audience; includes creativity, imagination, ease of preparation, availability of ingredients, and inventiveness	27	15	
Total			25 23 18	10 2 1	

Table 2: Evaluation of resourcefulness of product. Source Field Work (2023).

Table 2 reveals that the highest frequency is 27 selected by 15 respondents. This indicates that the recipe developed resourcefulness is of good quality in terms of creativity, imagination, ease of preparation, availability of ingredients and inventiveness. 10 respondents said it is good work, and only one person said it is unacceptable. It is therefore concluded that 25 out of 30 respondents representing 83% are of the view that the recipe is of good quality and it is good work done.

In Table 3 above, the total cost of all ingredients used for the preparation of the product amounted to Ghc 26.00 which is the total cost for four portions. To calculate for the cost per portion, the total cost for the four portions Ghc26.00 was divided by 4. The cost per portion amounted to Ghc6.50 which indicates that the cost meets the criteria recommended by Lappi., *et al.* [46-48]. This means that one plate of the new product for lunch can be priced Ghc6.50 which is far cheaper than a plate of good fried rice which is a similar product.

Maximum Score	Cost Analysis	Ingredients	Cost GHc	Cost/portion
25	Ingredients	Plantain Beef fillet Corn flour	2.00 10.00 1.00	Total cost divided by number of portions i.e. 26 = 6.50
		Idea milk	7.50	4
		Maggi carrots, cayenne pepper green pepper oil kpakpo shito	1.00 1.50 0.50 1.00 0.50 0.50	
		TOTAL	26.00	

Table 3: Cost evaluation of product. Source (Field Work, 2023).

Nutrition Analysis

The ingredients used to accompany the plantain were carefully chosen to compliment other nutrients and make the food as balanced as possible. This was done using the Recommended Dietary Allowances Intake and Dietary Reference Intake charts [45].

The summary of the evaluation score is 27 which rate this developed recipe product as good work. The study showed that a most of the respondents (83%) agreed that the newly developed recipe is both innovative, cost effective, resourceful and enjoyable. According to literature, a good recipe should use low-cost, readily available ingredients; use basic equipment and appliances; be easy to read and follow [46-48], be successfully tested by a minimum of three people; and teach at least one Dietary Guideline principle [49]. Furthermore, Miller., *et al.* [50] developed a cookbook for emergency feeding programs and audiences with limited-resources and used many of the same criteria as Schuster [49]. Additional criteria they used specified that the recipes should be nutritious and tasty; have a limited number of ingredients; and be flexible so that the same basic recipe can be used with fresh, frozen, or canned food varieties. The authors believe that this work fulfil all these criteria and

Overall Average Score	Presentation	Average score for evaluations by all participants
27	Sensory Resourcefulness Cost Analysis	30 27 25

Table 4: Summary of Evaluations by All Participants. Source (Field Work, 2023).

Overall Evaluation

- 30 = exceptionally good quality, 27 = good quality
- 25 = good work, 23 = acceptable, average quality
- 21 = minimally acceptable, 18 = unacceptable work

suggest that researchers with interest in recipe development follow the same process to help them achieve their goal.

Conclusion and Recommendation

The study has demonstrated that plantains are widely utilized worldwide, but there exist a limited number of recipes for unripe plantains, leading to significant post-harvest losses as most of the produce ripens. Most opportunities in the adoption of a standard for recipe management process still reside in the possibility of creating executable recipes, which is recipe processes that can be run by a computer which can be applicable to the same equipment using different plants, through a one-to one correspondence of process actions. This undoubtedly will provide job opportunities for people because once a product is commercialized it means demand for raw material is high and must be cultivated. Also, most of the Ghanaian farm produce can be prevented from going waste by recipe development, which can also reduce the rate of unemployment drastically. To reach this ambitious objective, a structured approach to the design of recipe development processes seems crucial. It was therefore recommended that more of such recipes should be developed to popularize the use of unripe plantain and other Ghanaian farm produce in our hotels and restaurants and also develop products to meet international market standards.

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