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ASSESSMENT OF THE MICROBIOLOGICAL AND PHYSICOCHEMICAL PROPERTIES OF SWEET POTATO TUBERLAC

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ABSTRACT

The development of convenient food products from locally available raw materials has gained significant attention in recent years. However, most studies in this area have focused on cereal-based products, with limited attention given to those based on tubers. Potatoes that are highly perishable tubers undergo continuous massive deterioration in the midst of seasonality. This article presented a study on the production of a convenience product made from sweet potato flour. The main objective was to produce sweet potato tuberlac, then assess sensory parameters, microbiological and physicochemical properties. This experimental research design made use of twenty hospitality management student respondents as the population. Purposive and convenience sampling techniques together with questionnaire was utilised whilst data was analysed using SPSS 22. Most respondents had no idea about sweet potato flour and its state of versatility. There were neither alarming signs of harmful contamination nor quality deterioration when microbiological properties were assessed whilst physicochemical properties were satisfactory. Conclusions revealed that colour, texture, taste, after taste, appearance, smell were good, nutritious and safe for human consumption. This product is a convenience breakfast tuberlac suitable for all age consumption. Commendably, sweet potato tuberlac should be produced on a large scale, packaged and made available in shops and supermarkets. Finally, consumers should be educated to patronise it.

Keywords: Convenience Food, Minerals, Proximate, Sensory, Tubers
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INTRODUCTION

Sugars, starches and fibres found in grains, tubers, fruits and vegetables are all forms of carbohydrates [Szalay, 2017] and macro-nutrients, providing the human body with calories [Venn, 2020]. Root tubers store edible food in their root, corm or tuber as a major staple food [Pearson, 2017; Szalay, 2017 & Venn, 2020]. The most popular ones such as cassava, yam, cocoyam, and sweet potatoes, were used as complementary food in feeding infants

History and Origin of Sweet Potatoes

Domestication of sweet potatoes occurred in either Central or South America [Cartabiano-Leite, *et al.*, 2020]. Sweet potato is categorised into three namely camote, kumara, and batata [Jolimont

& Jolimont, 2019]. Worldwide, sweet potato is ranked as the seventh most important food crop and fifth in the tropics. [FAO, 2016 & Cartabiano-Leite, *et al.*, 2020] Sweet potato fulfils a number of basic roles in the global food system, with vital implications for meeting food rations, to reduce poverty and increase food security [Schuster, 2018; Mohanraj & Sivasankar, 2015].

Sweet potato is mostly fried or boiled for consumption and scarcely processed into flour. Several dishes had been prepared from cereals such as weanimix and cerelac. However, sweet potato had not been explored that much [Nordqvist, 2016] and therefore when it was in season a lot of them got wasted [Mohanraj & Sivasankar, 2015]. In Ghana, the introduction of cereals as convenient food was very common. Similarly, root tubers were gradually gaining some level of popularity due to its gradual high consumption [Venn, 2020]. It was noted that University students had busy schedules as lectures mostly began at 7.00am. As cereals had been processed into cerelac, it was worth experimenting with the production of sweet potato tuberlac.

The purpose of the study was to prepare sweet potato flour and use it to produce sweet potato tuberlac to be consumed by students as a convenience food. The objectives of the study were to produce flour from sweet potato, use it for the production of tuberlac, then assess the sensory, microbiological and physicochemical properties of sweet potato tuberlac.

Nutritional Benefits in Sweet Potato

Sweet potatoes have varieties like white, pale-yellow, red, pink or orange. It contains fat, carbohydrates, proteins, vitamins and minerals; as seen in Table 1 [USDA Database, 2019, Nelson & Elevitch, 2011 & Shine, 2019] and are also very nutritious, low in calories, fat free and cholesterol [Nelson & Elevitch, 2011; Shubrook, 2019 & USDA Database, 2019]

Importance of Sweet Potato Flour

This product being available on the market is a way of creating jobs and new sources of income opportunities for entrepreneurs. It also changed some of the negative attitudes about sweet potato consumption and enabled them to be an important commercial crop with a wide range of use [Julson, 2019; Robbins, 2018; Shine, 2019 & Shubrook, 2019]. Again, it was to reduces bulk and minimises loss of the product.

Health Benefits of Sweet Potato and Milk

Sweet potatoes are high in fibre and starch supports healthy vision, promotes the enhancement of brain function, rich in antioxidant, fights against cancer prevents low-density lipoprotein and cholesterol [Shine, 2019, Shubrook, 2019, Kubala, 2018, Gunnars, 2018, FAO, 2022]. Milk is an excellent source of nutrients which prevents stunted growth, bone diseases like osteoporosis [USDA database, 2019] and optimises bone health [Gunnars, 2018, FAO, 2022]. It also aids in the growth of muscles, immunity, cold and congestion in the body.

Sensory Analysis

Sensory analysis surveys the properties (texture, flavour, taste, appearance, smell, amongst others) of a product or food through the sense of sight, smell, taste, touch and hearing (Ruiz-Capillas &Herrero, 2021). These analytical measurement parameters used to sensory analyse a product give respondents the opportunity to primarily provide feedback.

Microbiological Quality

The microbiological quality of any fresh or processed product is a major concern in the food industry due to the acute risk to health mostly posed by bacteria, mold and yeast. It is important to ensure that flour products meet microbiological standards to prevent food borne illnesses and ensure consumer safety. The basic quality of foods depends on the viable numbers of microorganisms that may be present in a particular product. In food producvtion, microbial contamination occurs mostly during production, processing and distribution [Erkmen, 2022; El Menyiy, *et al.*, 2020].

Physicochemical Properties

The physicochemical properties of food are principally accountable for the final quality of the product. Physical and chemical changes in each constituent and ingredient result from processing operations often lead to physical, sensory, and nutritional changes in food and in the quality (Martínez-Monzó, & Igual, 2022; El Menyiy et al., 2020). The physical and chemical properties of drum dried sweet potato include moisture, ash, carbohydrate, protein, fat, fibre, (Sanoussi, *et al.*, 2013; Tang, *et al.*, 2003). Likewise, orange fleshed sweet potato has higher protein content (10.57g) and the protein content increases anytime another protein is added (Dansby & Bovell-Benjamin, 2003; Kamal, *et al.*, 2013). Furthermore, study on the orange flesh sweet potato root has been given prominence because of its high β-carotene content as a means to enhance the nutritive value of the product (Bonsi, *et al.*, 2014).

MATERIALS AND METHODS

The experimental research made use of a quantitative approach for the production of tuberlac using sweet potato. The population was Bachelor of Technology students from the Hospitality Management Department who were thirty two in totality. A sample size of twenty respondents were purposively and conveniently selected for the study. At the Hospitality Management Department Food Laboratory at Takoradi Technical University, sweet potato tuberlac was produced through a series of experiments. Pre-testing was initially undertaken and assessed by five Hospitality Technicians. Based on the comments two final recipes were derived with a formulation ratio of 4:1:1 and 2:1:1 representing sweet potato flour, milk powder and lemon juice. A structured questionnaire was given to respondents to sensory analyse the product. The two samples were coded for blind assessment and results were analysed using SPSS version 22, mean and frequency tables. Further analysis was undertaken to ascertain the microbiological quality and physicochemical properties at the Research Laboratory, of the Department of Laboratory Technology at the University of Cape Coast, Ghana. The analysis was carried out on sweet potato tuberlac according to Ghana Standards Authority (GSA) standards. The results were compared to established standards and to results reported in other studies.

Production of Sweet Potato Powder

Tools and Equipment **-** Oven, baking sheets, grater, weighing scale, blender, bowls, potato peeler and plastic containers with lids for storage.

Ingredients: Potato flour 100g (A) 200g (B), Powdered milk 50g, Lemon juice 50ml

Method:

- ❖ Wash the potatoes to remove sand particles,
- ❖ De-skin and soak in water for a while with lemon juice to prevent discolouration.
- ❖ Slice sweet potatoes onto a baking sheet and spread to prevent sticking.
- ❖ Dry in an oven (70℃) for 2 hours, stir occasionally to prevent sticking together.
- ❖ Remove from the oven, cool, mill and sift to get a smooth consistency.
- ❖ Measure 100g of sweet potato flour and mix well with 50g of dried milk powder.
- ❖ Sweet potato tuberlac is ready for consumption.

RESULTS AND DISCUSSION

General information and Production of Sweet Potato Flour

The study revealed that the majority of respondents had no idea that sweet potatoes could be used for breakfast convenience food called tuberlac. The soaking of potatoes in lemon juice prevented discolouration. Grating of the potatoes induced speed drying. Baking with a temperature of 70℃ for two hours dried the potatoes and got it cooked without much change from the original colour.

Sensory Analysis

The sensory analysis focused on taste, texture, colour, smell, appearance and aftertaste. A five point likert scale ranging from excellent, very good, good, fair and poor were used to rate respondents' responses. The two samples labelled A and B were presented to the respondents. For the formulation ratio of 4:1:1, representing sample B, none of the responses was up to 10% in agreement and so analysis focused on only the preferred product which had the formulation ratio of 2:1:1 representing sample A. The agreed percentages were further calculated to attain the mean scores. Respondents rated the majority of variables as good with the mean scores ranging from 4.54 to 3.75. From the majority, overall grading of the product was good as it had a mean response of 4.04. This was a true reflection of the results of the various means except smell (3.45) that was less than the standard 3.5 as shown in Table 3. The appearance of a product is what motivates consumers to smell and taste, therefore attaining 55% responses provided a positive feedback. Again, the after-taste of a product is dependent on whether it will be patronised or not.

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Microbiological Responses

From the assessment, the result showed no alarming signs of microbiological contamination or deterioration. This can be seen in Table 4 where the results of the microbiological analysis of the most preferred samples of sweet potato tuberlac are presented. The microbial loads in the sweet potato tuberlac was within an acceptable range or limit as compared to GSA standards. The APC/TPC was found to be log10 cfu/g which was lower than the one reported in Table 4 (Sanoussi et al., 2013). Yeast and mold counts were also within acceptable limits. Sweet potato tuberlac scored a total aerobic plate count ranging significantly ($p < 0:05$) from 1:33 ± 0:03 to 3:00 ± 0:01 Log CFU/g. Values were averages of duplicate determinations.

Physicochemical Responses

Furthermore, with the physicochemical properties, sweet potato had very high carbohydrate (83.84g) and fat (1.89g) content. Protein content (10.57g) and ash (3.53g) together with minerals; phosphorus, iron, zinc, copper, calcium and manganese were all nutrients present (Table 5). Here, only vitamin components were not analysed, however, sweet potato tuberlac is a perfect food. The mean score from the results affirmed that the product was accepted after respondents sensory analysed the product with a blend of 100g of sweet potato flour and 50g of milk powder. This product had significantly ($p < 0.05$) higher protein (16.96%) and βcarotene (0.53 mg/100g) contents than the control complementary foods.

The TPC microbial load or levels in the most preferred samples of sweet potato tuberlac was within acceptable limits as compared to GSA standards. Although TPC was detected, their loads were all lower than the threshold value recommended rendering the product suitable for human consumption. Pathogens such as E. coli, total coliforms and Staphylococcus spp were not detected in the samples (Table 4). Also, ND Staphylococcus aureus (cfu/g) ND values were averages of duplicate determinations. Data represented as mean ± standard deviation for the most preferred sample ratio was represented as 2:1 (Orange-fleshed sweet potato flour: milk powder). Similarly, ND - Not Detected E. coli count and that of Staphylococcus aureus was not detected as confirmed by Sanoussi et al. (2013). However, the standard for E. coli in complementary foods should be 0 as reported by CAC (2008). The most preferred sample coincidentally the one safe for consumption had a low microbial count. The drum drying process by Tang et al., (2003) was described as the one with a clean and hygienic process, so all manufacturing practices ought to adapt the drum drying process in the formulation of complementary foods.

Proximate composition of the most preferred samples of sweet potato tuberlac contains all nutrients except vitamins that could not be analysed. Among the three categories of sweet potatoes available, the type used naturally possessed a higher protein content of 10.57g, whilst the addition of milk used for the formula also increased the protein quantity. These naturally increased the standard that was reported by Dansby and Bovell-Benjamin (2003). Here, they reported a protein content of 1g for only the orange-fleshed potato flour. Protein content of sweet potato could also be as high as 9.21 to 9.80g depending on the variety and combination (Kamal et al., 2013). Carbohydrate content of sweet potato reported by Dansby and Bovell-Benjamin (2003) was, however, higher (90.60g) than that reported in this study (83.84g). The ash which met the standard was relatively higher (3.53g) than what was reported by Bonsi, *et al.*, (2014) (1.39 – 1.98%) in their complementary foods prepared. The fibre content (3.93g) of the most preferred complementary foods was appreciative since fibre content should be less than 5g. The mineral composition of the most preferred sweet potato-based complementary food had a significantly ($p < 0.05$) higher iron (15.26µg), Zinc (92.35µg), calcium (1.78µg) and copper (74.69µg). Finally, the magnesium content of 0.16µg compared to the most preferred sweet potato tuberlac sample of ($p > 0.05$) had no significant difference.

CONCLUSIONS

It was evident that the health benefits derived from sweet potato tuberlac consumption were enormous. The preferred formulation ratio for sweet potato tuberlac was 2:1:1 of sweet potato flour, milk powder and lemon juice respectively. The sensory assessment was good with respect to colour and taste, whilst the texture, appearance and aftertaste were excellent. Finally, the overall mean of 4.04 attested conclusively that the product was worth patronising. The most preferred sweet potato tuberlac is microbiologically safe for consumption as it does not exhibit signs of spoilage or any form of contamination. Sweet potato tuberlac is nutritious as the physicochemical properties attest that it contains twelve nutrients. Finally, mass production ought to commence since it is a suitable convenience food for students.

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LIST OF TABLES

Table 1. Nutritional Value of Sweet Potatoes - 100g

Food Nutrients	Quantity
Energy	360 kj
Carbohydrates	20.1 g
Starch	12.7g
Sugars	4.2g
Dietary fiber	3.0g
Fat	0.1g
Protein	1.6g
Vitamin A equivalent	709.1g
-Beta-carotene	9.1g
-Lutein and zeaxanthin	0.1g
Thiamine (vitamin B_1)	0.1mg
Riboflavin (vitamin B2)	0.1mg
Niacin (vitamin B3)	0.61mg
Pantothenic acid (vitamin B5)	0.8 mg
Vitamin B6	0.2 mg
Folate (vitamin B9)	11.1g
Vitamin C	2.4mg
Vitamin E	0.26mg
Calcium	30.0mg
Iron	0.6mg
Magnesium	25.0mg
Phosphorus	47.0mg
Potassium	337.0mg
Sodium	55.0mg
Zinc	0.3mg

Source: Mohanraj & Sivasankar, 2015, USDA, 2019, Shine, 2019,

Field Survey, 2023

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Table 2. Pictorial view for the Production of Sweet Potato Tuberlac and Respondents'

Raw potatoes

Peeled potatoes

Baking of sweet potatoes

Baked sweet potatoes

Blending of sweet potatoes

Blended sweet potatoes and milk

Packaged sweet potato tuberlac

Students assessing sweet potato tuberlac

Source: Field Survey, 2023

Table 3: Sensory Response on Sweet Potato Tuberlac

Variables	Agreed %	Grade	Mean
Taste	50%	Good	3.95
Texture	40%	Excellent	4.51
Colour	45%	Good	3.75
Smell	35%	V. Good	3.45
Appearance	65%	Excellent	4.54
After-taste	55%	Excellent	4.15

Field Survey, 2023

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Table 4: Microbiological Analysis

PARAMETERS	Unit	GSA Standards	Sample Measured Value
Aerobic Plate Count	CFU/mL	$<5.0x10^2$	0
Coliforms Count	CFU/mL	0	0
E. coli	CFU/mL	0	0
Staphylococcus aureus	CFU/mL	0	0
Yeast and Molds	CFU/mL	$<5.0x10^1$	$5x10^0$

Field Survey, 2023

Table 5: Physicochemical Analysis

PARAMETER	UNIT	GS 883:2008	SAMPLE MEASURED VALUE
Moisture content	g/100g		3.52
Ash content	g/100g		3.53
Protein content	g/100g		10.57
Crude fibre	g/100g		3.93
Fat content	g/100g		1.89
Total carbohydrate	g/100g		83.84
HEAVY METALS			
Phosphorus	µg/g		3720.59
Iron	µg/g		15.26
Zinc	µg/g		92.35
Copper	µg/g		74.69
Calcium	G		1.78
Magnesium	G		0.16

Field Survey, 2023