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A Traditional Biscuit Fortified with Orange-Fleshed Sweet Potato Puree and Cowpea Flour

Research Article

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Abstract

Agbozume biscuit is a traditional snack in Ghana made from cassava starch and coconut milk. It is produced at the cottage industry level leading to variability in its production processes and quality. Orange-fleshed sweet potato and cowpea, reportedly rich in beta-carotene and protein respectively could be used to enrich the biscuit. The study aimed to improve on the existing processing methods and develop nutritionally fortified biscuit by substituting cassava starch (C) up to 30%with orange-fleshed sweet potato puree (OFSPP) and cowpea flour (CP). A recipe was developed using Mixture Design of Stat graphics Centurion XVI, from which four different formulations was developed and subjected to a sensory evaluation (5-point Hedonic scale) to assess their acceptance. The most preferred formulation was selected for proximate, mineral, beta-carotene and Glycomics index (GI) determination. The processing method was improved by using specific/accurate measurements of raw materials. The most preferred formulation was80%C: 15%CP: 5% OFSPP. The improved biscuit had a relatively higher beta-carotene (9.44µg/g), protein (7.21%), crude fiber (0.21%), magnesium (33.5mg/100g), potassium (251mg/100g)and calcium value (61.5 mg/100g) but the traditional Agbozume biscuit (control) (100%C) had a higher fat (17.69%), zinc content (33.5 mg/100g) and relatively lower moisture. The GI of the improved biscuit was79.55.Invivo examination may be investigated to ascertain its direct effect on the blood glucose levels of its consumers. The improved biscuit will provide a good source of nutrition for people of all age groups.

Keywords: Snacks; Nutrition; Biscuit; Orange-Fleshed Sweet potato; Glycemic Index

Introduction

Snacks are generally eaten by people from various backgrounds and various age groups [1]. Children and even adults are usually found nibbling on snacks in-between meals at various times of the day. Principal ingredients of biscuit preparation include wheat flour, fat, sugar and water; while other ingredients include milk, salt, flouring agent and aerating agent [2]. These ingredients are comparatively expensive because most of them are processed and others imported [3]. Biscuits however could be made from many other ingredients that can serve as cheaper yet nutritious alternatives such as cassava, sweet potato and cowpea flours. Cassava is rich in starch, and its flour has been widely examined as a local alternative to wheat flour [4]. It can be consumed by those with celiac disease because it does not contain gluten [5]. Sweet potato ranks highly with wheat, rice, maize, barley and cassava as the world's most important food crops and is highly nutritious amongst the other roots and tubers [6]. Agbozume biscuit is an indigenous snack made from cassava starch and coconut milk native to the people of Agbozumein the Volta Region of Ghana. It is crispy and produced at the cottage industry level, at the discretion of its producers, leading to variability in its production process and product quality. The nutritional content of the snack has also not been investigated but could be enriched with other underutilized crop such as sweet potato and cowpea in order to promote and diversify their use. The study aimed to incorporate sweet potato and cowpea into Agbozume biscuit product and assess its proximate, mineral content and glycemic index.

Materials and Methods

Research Design

Traditional Agbozume biscuit was produced under laboratory conditions with accurate measurements (Figure 1) based on interviews at the cottage level. An improved (higher nutrient level) Agbozume biscuit was developed based on this model (Figure 2) and had cassava starch (Plate 1) substituted with cowpea flour (Hewale variety) and orange-fleshed sweet potato (Apomuden variety) puree up to 30% to obtain four new formulations (Table 1). The formulations were generated using Mixture Design of Statgraphics Centurion XV.I software. Biscuits from the new formulations were subjected to sensory analysis. The most accepted formulation was packaged into ziplock bags for proximate, minerals and glycemic index determination. The traditional biscuit was used generally, as a control for the nutritional analysis of the improved biscuit.

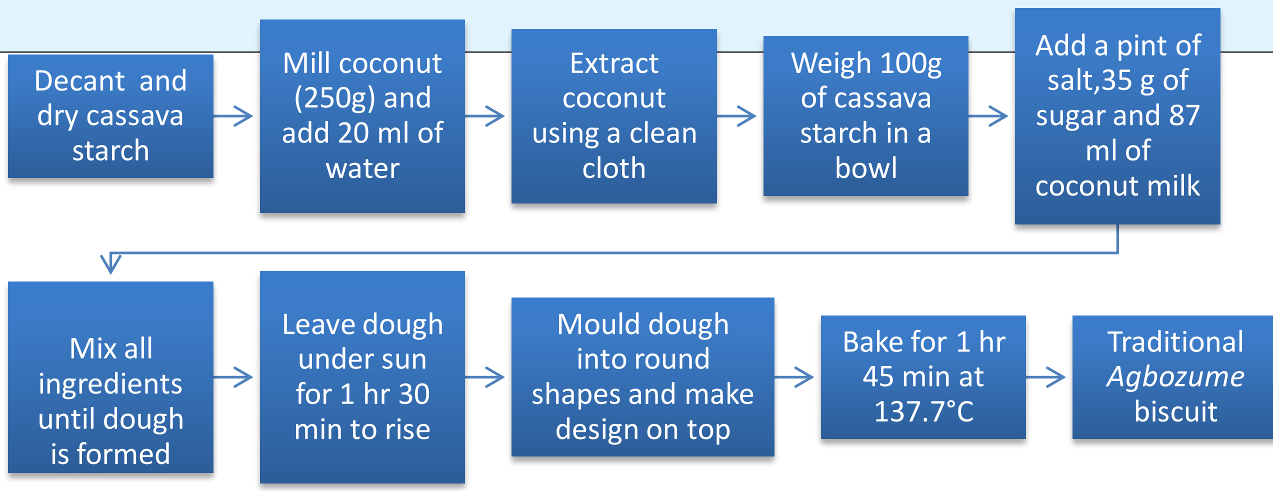


Figure 1: Flow diagram showing *Agbozume* biscuit production process under laboratory conditions.

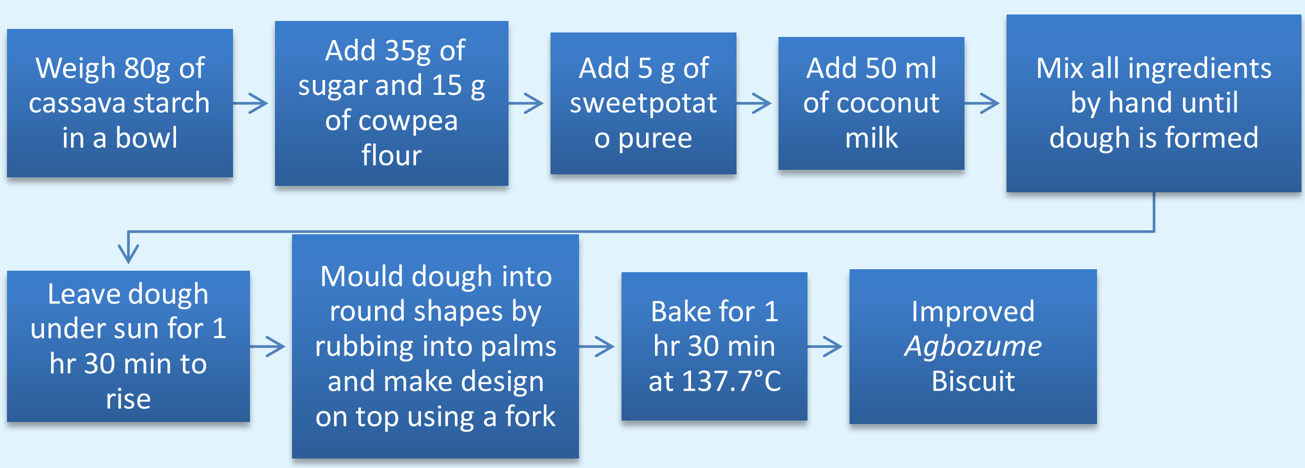


Figure 2: Flow diagram showing the Improved *Agbozume* biscuit production process.

Plate 1: Decanted starch ready to be dried.

Sample code	Cassava starch (g)	Orange-fleshed Sweet potato puree (g)	Cowpea flour (g)	Sugar(g)	Coconut milk(ml)
154 (A)	80	5	15	35	50
935 (B)	75	10	15	35	50
378 (C)	70	10	20	35	50
287 (D)	75	5	20	35	50
608 (E)	100	0	0	35	50

Key: E is control sample (traditional agbozume biscuit)
Table 1: Formulation for the improved *Agbozume* biscuit.

Cowpea Flour Preparation

Cowpea (2kg) was sorted and soaked in water (2 L) (Plate 2) for 18 h. It was then de-hulled by palm rubbing and then oven dried at 60°C for 24 h. The dried cowpea was then milled and sieved using a sieve of 250μm aperture.

Plate 2: Sorted cowpea soaked in water.

Sweet Potato Puree Preparation

Orange-fleshed sweet potatoes (5 tubers) were washed and cleaned. Each tuber was divided into two and wrapped in aluminum foil and baked for 1 h at 204°C. The sweet potatoes were then peeled and mashed into a puree using a Kenwood hand mixer at speed 3 for 5 min (Plate 3).

Plate 3: Preparation of sweet potato puree.

Sensory Evaluation of the Improved Biscuit

The sensory evaluation was conducted amongst people from the Ewe ethnic group of Ghana, who were familiar with the traditional Agbozume biscuit. The biscuit samples were served in disposable plates in a random order and codes for panelists to assess in an enclosed room at AffulNkwanta in Kumasi, Ghana. The enclosed room had adequate lighting from the sun and panelists were seated on individual seats (Plate 4).

Plate 4: Panelists for the sensory evaluation.

The untrained panelists were 52 in number and were asked to assess the coded biscuit samples in terms of colour, hardness, crunchiness, sweetness, aftertaste and overall acceptability using a 5-point hedonic scale (1-dislike very much and 5-like very much). A 5-point hedonic scale which is a simple scale was used because the sensory evaluation was conducted in a traditional setting and some of the panelists were illiterates. Water was provided as a palate cleanser.

Nutritional Analysis

Moisture content, Ash, Fat, Crude Fiber, protein and carbohydrate were determined using standard methods [7]. The concentrations of Calcium (Ca), Magnesium (Mg), Potassium (K), Zinc (Zn) and Iron (Fe) were determined using Atomic Absorption Spectrometer (Spectra AA220FS Model) and results expressed in mg/kg [8]. Beta-carotene was determined using the method described by [9] using the HPLC. Glycemic index (GI): In vitro glycemic index was determined using [10] protocol based on [11] methodology. The Hydrolysis index (HI) which represents the rate of starch digestion and a good predictor of glycemic response was calculated as (AUC of treatment/sample)/ (AUC of reference sample). Using the HI, the Estimated Glycemic index (EGI) was calculated using the formula; GI = 39.71 + 0.549 * HI. All the determination was done in triplicate and statistically analyzed using SPSS version 20.

Results and Discussion

Overview of Interview with Traditional Agbozume Biscuit Producers

There were two oral interviews and one practical session with the traditional Agbozume biscuit producers who volunteered to help. The interactions revealed that the production process between the three producers were similar however, all the three producers did not weigh their ingredients but used them at their own discretion. This implies that there were likely to be differences in the quantities of their ingredients since they were not weighed. This could therefore result in differences in the formulation of their biscuits.

Improved Biscuit

Four new improved biscuits were prepared as shown in (Figure 2). They were named A, B C, D and E for sample code 154, 935, 378, 287 and 608 (control) respectively, to facilitate the sensory discussion. (Plate 5) and (Plate 6) shows the traditional Agbozume biscuit before and after baking.

Plate 5: Moulded *Agbozume* biscuit ready to be baked.

Plate 6: *Agbozume* biscuit.

Plate 6: Improved *Agbozume* biscuit.

Sensory

Biscuit A, B and E (control) had the highest score (4) for sweetness (Figure 3). Biscuits A and B contained 15% of cowpea flour, 5% and 10% of orange-fleshed sweet potato puree (OFSPP), respectively.

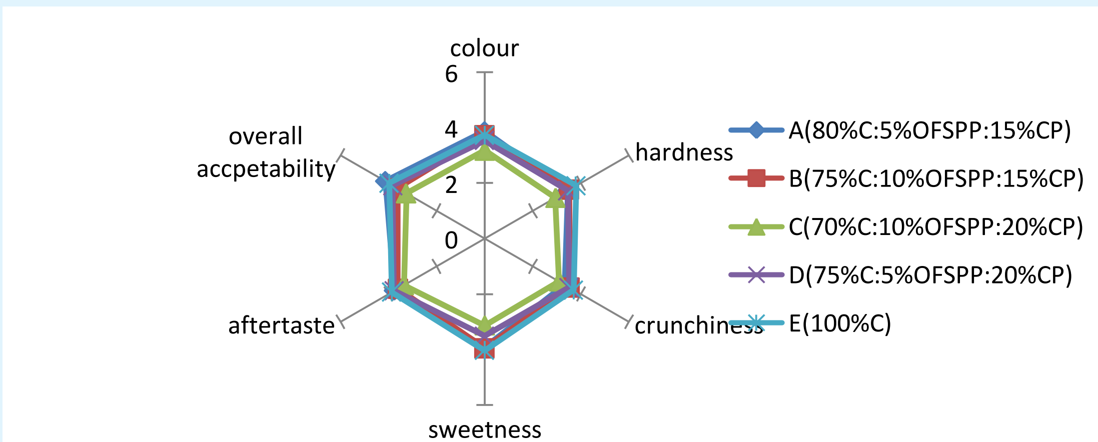


Figure 3: Preference of Consumers on the Improved *Agbozume* biscuit.

These combinations may have attributed to the sweetness level of the biscuits; especially since OFSPP is sweet. The least liked biscuit was C which contained 20% cowpea flour and 10% orange-fleshed sweet potato puree. Although, sample C also had 10% OFSPP as that of sample B, the cowpea content was higher and may have affected the sweetness. The crunchiness of all five biscuits had a similar score on the Hedonic do not scale which corresponded to neither like nor dislike (Figure 3). The consumers preferred the crunchiness of the control biscuit E, to those of the improved biscuits. The low score for crunchiness in biscuit C may be attributed to the substitution level of 10% orange-fleshed sweet potato puree and 20% cowpea flour which affected the texture. A similar trend was observed by [1] in their biscuits produced. The score for colour for all the biscuits were in the range 'neither like nor dislike' and 'like moderately', suggesting that, the colour of the biscuits were generally acceptable (Figure 3).

With the exception of biscuit C, four of the formulations had a similar score for hardness. The trend observed was that the higher the percentage of cassava starch, the higher the score for hardness. The aftertaste of all 5 formulations ranged between "neither like nor dislike" and "like moderately" (Figure 3). Generally, biscuits with lower substitution of cowpea flour were more preferred. Biscuit A (Table 1) had the highest score which corresponded to "like moderately" and "like very much" on the 5-pt hedonic scale and the least was biscuit C (Figure 3). Biscuit A was more preferred by panelists to the control. It had the least substitution of cassava starch (20%), thus was similar to the control. There was no significant difference (p>0.05) between the most preferred biscuit, A, and the control, E, in all the sensory attributes assessed.

Proximate Composition of Cassava Starch Biscuit (Agbozume) and Improved Agbozume Biscuit

The traditional Agbozume biscuit had the highest fat content (17.69 %) compared to biscuit A (11.13%) as shown in (Table 2).

Proximate Components	Tradtional *Agbozume* Biscuit	Improved biscuit (Biscuit A) (80%C:5%OFSPP:15%CP)
% Moisture	1.30^{a}	4.48^{d}
% Crude fat	17.69^{d}	11.13^{d}
% Crude fiber	0.13^{a}	0.21^{ab}
% Crude protein	5.14^{a}	7.21^{a}
% Ash	0.33^{a}	0.58^{b}
% Carbohydrate	75.42^{c}	76.39^{c}

Values are represented as mean (standard deviation).
Values with different superscripts along columns are significantly different at 95% confidence level.
Key: C-cassava starch, OFSPP-orange-fleshed sweet potato puree, CP-cowpea flour
Table 2: Proximate Composition of the traditional *Agbozume* Biscuit and the Improved *Agbozume* Biscuit.

Both were however, higher than that of a biscuit (5.25%) with 70% sweet potato flour and 30% soybean flour [1]. The differences could be attributed to the different ingredients (cassava starch, coconut milk, coconut meat, cowpea flour, orange-fleshed sweet potato puree) used for the biscuits in this study (Table 3).

Proximate Components (%)	Samples		
	COC	COP	OFSPP
Moisture	14.30^{b}	7.29^{f}	24.90^{g}
Crude fat	54.50^{b}	4.29^{a}	3.45^{a}
Crude fibre	10.67^{c}	3.52^{c}	0.16^{a}
Crude protein	7.79^{b}	27.42^{b}	5.19^{a}
Ash	2.69^{d}	2.69^{d}	3.65^{e}
Carbohydrate	11.18^{c}	54.79^{b}	62.66^{b}

Values with different superscripts across columns are significantly different at 95% confidence level.
Key: COC-coconut meat,, COP-cowpea flour, OFSPP-orange-fleshed sweet potato puree
Table 3: Proximate components of major ingredients of the biscuits.

The moisture content of biscuit A(4.48%) was similar to biscuits prepared with soft wheat flour replaced with 30% cashew nut flour (4.4%)[12]. It had higher moisture content than the traditional Agbozume biscuit (1.30%) suggesting, the traditional biscuit, may have a longer shelf-life than biscuit A. The moisture content of biscuit A was however, also lower than 7.24%-9.85%reported for Cassava starch biscuit substituted with wheat [13]. Low moisture content of baked products is critical for shelf life [14]. The traditional Agbozume biscuit had the least amount of protein (5.14%), crude fiber (0.13%) and ash (0.33%) as shown in (Table 2). Biscuit A had a protein content of 7.21%, similar to 7.53% reported [13]. This was in contrast with17.65-21.65% for biscuits produced from sweet potato flour and soybean flour [1,12]. There was no significant difference (p>0.05) between the crude protein, carbohydrate contents, crude fiber and fat contents of the traditional Agbozume biscuit and biscuit A. Proteins are important food components, necessary for growth and for the repair of damaged tissues [15]. Children consuming these snacks will therefore benefit immensely.

The crude fiber content of the control biscuit (0.13%) and biscuit A(0.21%) were lower than 2.71-8.50%[16] and 3.29-5.73%[13]. Fiber in food facilitates easy digestion in the colon and reduces constipation [17]. Similarly, ash was lower in the control biscuit (0.33) and biscuit A (0.58) when compared with 2.20-2.57% [1]. The presence of ash is an indication of minerals present in the sample [12]. The carbohydrate content of biscuit A (76.39%) slightly exceeded that of the control sample (75.42%). The high carbohydrate content of the biscuits is an indication of their energy content. The biscuit will serve as a good source of energy for children and all its consumers.

Mineral Composition of Cassava Starch Biscuit (Agbozume) and Improved Agbozume Biscuit

The results of the mineral determination have been presented in (Table 4).

Minerals	Samples	
	Traditional *Agbozume* biscuit	Improved Biscuit (80% C:5% OFSPP:15% CP)
Iron (mg/100g)	21.70[a]	18.75[a]
Zinc (mg/100g)	33.50[b]	29.05[b]
Calcium (mg/100g)	50.50[ab]	61.50[c]
Magnesium (mg/100g)	12.50[a]	33.15[b]
Potassium (mg/100g)	115.00[c]	251.00[a]

Values with different superscripts across columns are significantly different at 95% confidence level
Key: C-cassava starch, OFSPP-orange-fleshed sweet potato puree, CP-cowpea flour
Table 4: Mineral composition of the traditional *Agbozume* biscuit and the improved *Agbozume* biscuit.

Biscuit A had the highest calcium content (61.5mg/100g) and the control biscuit had the highest zinc content (33.5mg/100g) but the least potassium content (115mg/100g),calcium content (50.5mg/100g) and magnesium content(12.5 mg/100g).The high iron content of the traditional Agbozume and biscuit A could be attributed to the high iron content of the coconut meat (22.25mg/100g), cowpea (75mg/100g) and coconut milk (55mg/100g) used in the preparation. The World Health Organization (WHO) estimates that approximately half of the 1.62 billion cases of anemia worldwide are due to iron deficiency [18]. This deficiency is more common among children and adolescents in food-insecure households [17,19]. The zinc content of the traditional Agbozume biscuit (33.5mg/100g) and biscuit A (29.05mg/100g) were higher than biscuits made from wheat flour and soya bean flour [13] which ranged from 2.74mg/100g-4.4mg/100g. The high zinc values of the traditional Agbozume biscuit and biscuit A could be attributed to the high amount (87mL and 50mL respectively) of coconut milk added which had a zinc content of 43mg/100g.A daily intake of zinc is required to maintain a steady state because the body has no specialized zinc storage system [20].

The calcium content of the traditional biscuit (50.5mg /100g) and biscuit A(61.5mg/100g) were lower than values obtained for cassava-wheat crackers(623 mg/100g) and cassava-bean-soybean-wheat cracker 2 (415.22mg/100g) [21]. The low calcium content of the biscuits in this study could be attributed to the low calcium content of its ingredients used (Table 5).

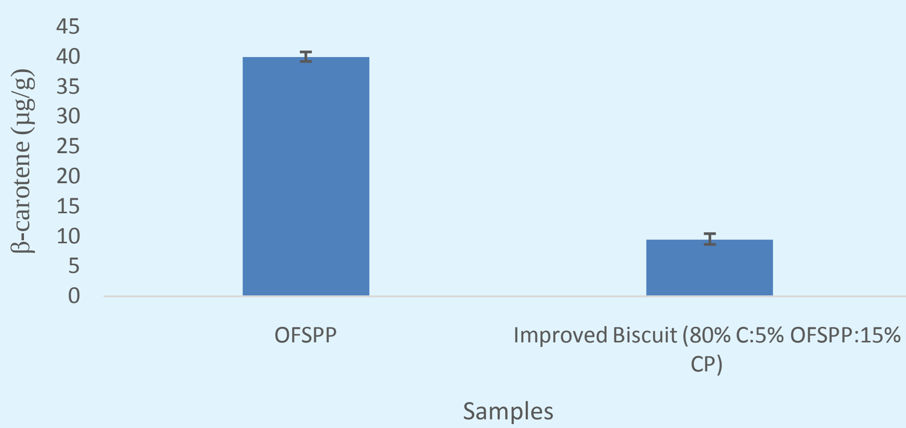
Minerals	Samples			
	COC	COC MILK	COP	OFSPP
Iron (mg/100g)	22.25[a]	55.00[d]	75.00[c]	8.30[b]
Zinc(mg/100g)	31.50[b]	43.00[c]	20.50[a]	30.00[b]
Calcium(mg/100g)	56.00[a]	88.00[b]	65.00[c]	64.50[c]
Magnesium(mg/100g)	173.50[a]	52.00[b]	21.50[c]	52.00[b]
Potassium(mg/100g)	639.00[a]	4113.00[b]	1418.50[c]	3123.00[d]

Values with different superscripts across columns are significantly different at 95% confidence level.
Key: COC-coconut meat, COC milk-coconut milk, COP-cowpea flour, OFSPP-orange-fleshed sweet potato puree
Table 5: Mineral content of major ingredients of the biscuits.

The magnesium value of biscuit A (33.50mg/100g) was similar to that reported by [13] whereas that of the traditional Agbozume biscuit (12.5mg/100g) was lower. The high magnesium content of biscuit A may be attributed to the high magnesium content of the coconut (173.5 mg/100g) and orange-fleshed sweet potato puree (52mg/100g). Magnesium is an enzyme cofactor that regulates diverse biochemical reactions in the body [18,22]. The potassium content of biscuit A (251mg/100g) was higher than the traditional biscuit (115mg/100g) but lower than 412.47 mg/100g [13] and 460.82 mg/100g [12]. The high potassium content of the biscuit may have been from the coconut milk, orange-fleshed sweet potato puree and cowpea flour (Table 3). Orange-fleshed sweet potato is reported to be high in potassium [23]. Potassium is required in the body for regulation of fluid, muscle control and normal functioning of the nerves [24]. From the mineral results, the improved biscuits therefore would serve as a good source of iron, zinc and potassium.

Β-Carotene Content of Biscuit A and Orange-Fleshed Sweet Potato Puree

The orange-fleshed sweet potato is noted for its high beta-carotene content, a potent source of Vitamin A [23]. This was confirmed by the beta-carotene content of the orange-fleshed sweet potato puree used in the study (Figure 4).



Key: C-Cassava starch, OFSPP-Orange-Fleshed sweet potato puree, CP-Cowpea flour
Figure 4: β- Carotene content of the Improved *Agbozume* biscuit and OFSP puree.

Children, including infants and adults are encouraged to eat more of orange-fleshed sweet potato in order to protect the immune system [25,26]. The β-carotene content of biscuit A (9.44µg/g) was higher than other biscuits [2] that had wheat flour replaced with 30% orange-fleshed sweet potato flour. The improved biscuits, if consumed, may compliment other sources of vitamin A in Ghana.

Glycemic Index

The glycemic index (GI) of the improved *Agbozume* Biscuit was lower than the traditional *Agbozume* Biscuit (Table 6).

	Sample	Glycemic Index
Biscuit Samples	Reference Food (Wheat Bread)	95.99
	Traditional *Agbozume* Biscuit	91.16
	Improved *Agbozume* Biscuit (80% cassava starch: 5% OFSP puree mixture: 15%cowpea flour)	79.55

Table 6: Glycemic index of the traditional *Agbozume* biscuit and the improved *Agbozume* biscuit.

The GIcompares equal quantities of carbohydrate and provides a measure of carbohydrate quality but not quantity. The Glycomics index (GI) of a typical serving of food is the product of the amount of available carbohydrate in that serving and the GI of the food. The higher the GI, the greater the expected elevation in blood glucose and in the insulinogenic effect of the food [27]. Consumption of the improved biscuit may provide quality carbohydrate that may contribute to reducing blood glucose. Studies have shown that slowly digested and absorbed carbohydrates were independently associated with the decreased risk of developing type-2-diabetes [28,29].

Conclusion

Four new formulations of an improved cassava starch-based (*Agbozume*) biscuit were produced using cowpea flour, coconut milk and orange-fleshed sweet potato puree. The most preferred formulation was biscuit with 80% cassava starch, 5% orange-fleshed sweet potato puree and 15% cowpea flour. This biscuit was rich in potassium and beta-carotene. It was also higher in crude protein, crude fiber, potassium, calcium, magnesium and iron in comparison with the traditional *Agbozume* biscuit. The traditional *Agbozume* biscuit was however higher in fat and zinc in comparison to its improved form. It also had a high carbohydrate content which will serve as a good source of energy and a low moisture content which could result in a longer shelf-life of the biscuit. There was no significant difference ($p>0.05$) between the improved biscuit and the traditional *Agbozume* biscuit (control) in terms of sensory attributes assessed. Nutritionally, the improved biscuit would be ideal for people of different age groups and can be consumed by gluten-intolerant people. An in-vivo examination may be conducted to study its direct effect on blood glucose levels of its consumers. Also, the higher moisture content of the improved biscuit may influence its shelf life, thus the need for further studies.

Acknowledgement

Danida roots and tuber value chain project.

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