

Research Application Summary

**Development and assessment of nutritional quality and sensory properties of orange-fleshed sweetpotato and bambara groundnut-based snacks for school children**

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**Abstract**

Orange-fleshed sweetpotato (OFSP) and bambara groundnut snacks could alleviate under-nutrition among primary school children through food-based approaches. The objective of this research was to develop nutritious snacks from OFSP and bambara groundnut, and evaluate the effect of extrusion cooking on proximate composition, sensory characteristics and consumer acceptability of the snacks. Six formulations of OFSP + bambara groundnut (with OFSP and bambara groundnut ranging from 0 – 100%) were prepared and extruded (feeding rate of 10.15 kg/hr, screw speed of 30 rpm and barrel temperature: 100 °C and 130 °C in first and second zones respectively). Proximate analysis was done using standard methods and pro-vitamin A was analyzed using Atomic Absorption Spectrophotometry. There were significant differences ( $p < 0.05$ ) in proximate composition, mineral content and Pro-vitamin A content between the different snacks. Protein content ranged between  $4.08 \pm 0.26$  g/100g DM (OFSP 100%) to  $15.03 \pm 0.34$ g/100g DM (Bambara groundnut 100%). Pro-vitamin A ranged from  $0.54 \pm 0.05$  mg/100g DM (Bambara groundnut 100%) to  $17.33 \pm 0.48$  mg/100g DM (OFSP 100%). The colour hue (orange) and sweetness were drivers for consumer liking of snacks containing OFSP. Generally the study showed that development of OFSP substituted with bambara groundnut up to 40% enhances nutritional quality of the snacks, retains sensory properties and yields acceptable snacks.

Key words: Bambara groundnut, extrusion, orange-fleshed, quantitative descriptive analysis, school children, sweetpotato, under-nutrition

**Résumé**

Les amuse-gueule ou casse-croûte à base de la patate douce à la chair d'orange (OFSP) et d'arachide bambara pourraient atténuer la sous-alimentation chez les écoliers grâce à des approches alimentaires. L'objectif de cette recherche était de préparer des amuse-gueule nutritifs à partir de patate douce à la chair d'orange et de l'arachide bambara, et d'évaluer l'effet de la cuisson par extrusion sur la composition, les caractéristiques sensorielles et l'acceptabilité par les consommateurs de ces amuse-gueule. Six formulations ont été préparées et extrudées (vitesse d'alimentation de 10,15 kg/h, vitesse de la vis de 30 tr/min et température du fût: 100 °C et 130 °C dans la première et deuxième zones, respectivement). Une analyse approximative a été effectuée en utilisant des méthodes standard alors que la

pro-vitamine A a été analysée en utilisant la spectrophotométrie d'absorption atomique. Des différences significatives ( $p < 0,05$ ) ont été obtenues pour la composition approximative, la teneur en minéraux et la teneur en Pro-vitamine A entre les différents amuse-gueule. La teneur en protéines variait de  $4,08 \pm 0,26$  g/100 g de MS (patate douce à la chair d'orange 100%) à  $15,03 \pm 0,34$  g / 100 g de MS (d'arachide bambara 100%). La Pro-vitamine A variait de  $0,54 \pm 0,05$  mg / 100 g de MS (100% d'arachide bambara) à  $17,33 \pm 0,48$  mg / 100 g de MS (patate douce à la chair d'orange 100%). La teinte de couleur (orange) et la douceur ont été des facteurs influençant la préférence des casse-croûte à base de patate douce à la chair d'orange par les consommateurs. En général, l'étude a montré que la préparation de la patate douce à la chair d'orange substituée à l'arachide bambara jusqu'à 40% améliore la qualité nutritionnelle des casse-croustes, conserve les propriétés sensorielles et produit des casse-croustes acceptables.

Mots clés: arachide bambara, extrusion, orange, analyse quantitative descriptive quantitative, écoliers, patate douce, sous-nutrition

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## Introduction

Under-nutrition associated with inadequate energy intakes and micronutrient deficiencies of iron and vitamin A are becoming a serious problem for school children in many developing countries (Mosha *et al.*, 2010; Manna *et al.*, 2011). According to FAO (2007), school children in Tanzania perform poorly in schools. The poor performance is associated with high dropout rates and is partly due to malnutrition and health related problems. It is estimated that 22% of school age children in Tanzania are stunted owing to chronic inadequate intake of energy and other nutrients (UNICEF, 2003). These nutritional problems adversely affect school children's attendance, scholastic performance and concentration in class (UNICEF, 2003). About one-third of children in Tanzania are deficient in iron and vitamin A, which are required in small amounts but are crucial to children's health and development (TFNC, 2012). Under-nutrition among school children in Tanzania is a result of poverty, food insecurity and lack of school feeding programmes which expose them to short-term hunger (WFP, 2009).

Micronutrient supplements are commonly used to alleviate malnutrition but the approach is not sustainable because of inaccessibility in the rural areas. Food-based approaches are part of a strategy for reducing under-nutrition in Tanzania (Temu *et al.*, 2014; Helen Keller International, 2012). Increasing consumption of key micronutrients (vitamin A and Iron) food sources is a sustainable approach to alleviate under-nutrition (Bengtsson *et al.*, 2009). The use of orange-fleshed sweetpotato (OFSP) as a source of energy and means of fighting vitamin A deficiency in Tanzania and other African countries has been of significance (Waized *et al.*, 2015). However, in some cases the high preference for local varieties of sweetpotato has resulted in underutilization of OFSP (Temu *et al.*, 2014). Incorporation bambara groundnut which is a good source of carbohydrates, proteins, minerals and fats (Bamshaiye *et al.*, 2011) can be used to alleviate under-nutrition among school children

because it is readily available and affordable. Therefore, the development of Ready-to-Eat (RTE) extruded snack products using a combination of OFSP and bambara groundnut could serve as a means of alleviating short-term hunger and under-nutrition among school children. The study evaluated the effect of varying these two ingredients on the nutritional quality, sensory characteristics and consumer acceptability of the formulated snacks.

## **Materials and Methods**

**Study area and materials.** This study was conducted at the Department of Food Science and Technology, Sokoine University of Agriculture (SUA). Orange-fleshed sweet potato was purchased from the Ukiliguru Agricultural Research Institute, Mwanza. Bambara groundnuts, ingredients and materials for sensory evaluation were purchased from markets and supermarkets in Morogoro, Tanzania. Analytical grade chemicals and reagents for chemical analysis were purchased from suppliers in Morogoro and Nairobi.

**Research design.** A Completely Randomized Design (CRD) was used in this study using the different formulations as treatments. Proximate composition, mineral contents, Pro-vitamin A, sensory quality and consumer acceptability of the snacks were determined.

**Extrusion of the formulations.** The experimental composite flour was formulated using a substitution method. The formulated composite flour was extruded using co-rotating twin screw extruder with L/D ratio of 16:1 and screw diameter of 60 mm, model Js-60D, China. The extruder conditions were: feeding rate of 10.15 kg/hr, screw speed of 30 rpm and barrel temperature was set at 100 °C and 130 °C in first and second zones respectively. After extrusion the samples were collected, cooled to room temperature under natural convection conditions, sealed in polyethylene bags and stored at -18 °C prior to analysis.

## **Chemical analyses**

**Proximate analysis.** Proximate analysis was done using AOAC, 1995 procedures. Pro-vitamin A was determined using the Atomic Absorption Spectrophotometry method described by Rodriguez-Amaya and Kimura (2004).

**Mineral content.** The analysis of minerals was also done according to the AOAC (1995) procedures. Mineral content was determined by the use of Unicam 919 Atomic Absorption Spectrophotometer (AAS). Test portions were dried and then ashed at 450 °C under a gradual increase (about 50 °C/hr) in temperature.

## **Sensory evaluation**

**Quantitative descriptive analysis (QDA).** Descriptive sensory profiling was conducted at the Department of Food science and Technology using a trained sensory panel of 10 assessors, comprising of 7 male and 3 female aged 22 - 27 years according to a method described in Lawless and Heyman (2010).

**Statistical data analysis.** Data obtained were analyzed using the R statistical package (R Development Core Team, Version 3.0.0 Vienna, Austria). Analysis of variance (ANOVA) was used to determine significance of differences between the main factors. Means were separated using Tukeys Honest Significant difference ( $P < 0.05$ ).

## Results and Discussion

### Nutritional quality of formulated OFSP and Bambara groundnut-based snacks

**Proximate composition.** Ingredient concentration had a significant ( $P < 0.05$ ) effect on the proximate composition of the formulated snacks. Increasing the concentration of bambara groundnut in the formulations resulted in reduction of moisture, carbohydrate and pro-vitamin A and an increase in protein, fat, fibre and ash content (Table 1).

**Mineral content.** Minerals content of the formulated snacks were significantly different ( $p < 0.05$ ) between treatments. Results showed that increased amount of Bambara groundnut in the formulation resulted in higher magnesium, phosphorus, potassium and iron and a decrease in calcium and sodium (Table 2).

**Relationship between descriptive data and hedonic liking by partial least square regression.** Result from a partial least square regression (PLSR) using descriptive data as X-variables and liking rated by consumers as Y-variables showed that majority of the consumers fell to the right of the vertical Y-axis. This means the acceptance values of these consumer go in the direction of liking associated with sweetness and colour hue (Figure 1).

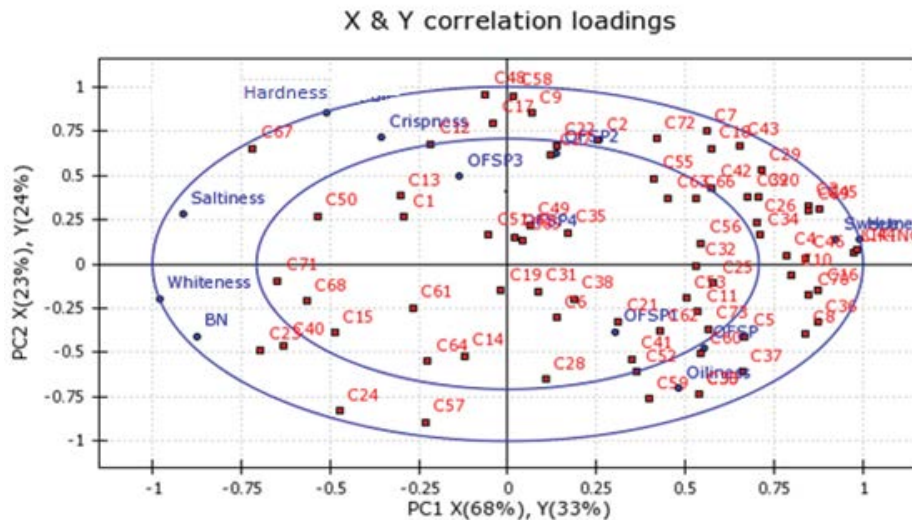


Figure 1. Correlation loading from partial least squares regression of formulated snack samples with descriptive data as X-variables and hedonic rating as Y variables

Table 1. Effect of ingredient concentrations on the proximate composition of orange-fleshed sweetpotato (OFSP) and bambara groundnut extruded snacks

Product	Proximate composition (g/100g DM)							
	Moisture	Protein	Fat	Fibre	Ash	CHO	Energy (kcal)	Vitamin A $\mu\text{g RE}/100\text{gDM}$
OFSP_ (0%)	8.34±0.50d	4.08±0.26a	4.20±0.092a	5.29±0.03ab	0.09±0.02a	78.00±0.67f	366.13±2.43a	1365±0.48e
OFSP_1 (20%)	5.16±0.20a	6.94±0.09b	5.91±0.04b	5.42±0.09a	2.31±0.31b	72.35±0.56e	368.63±0.23a	929±0.20d
OFSP_2 (40%)	6.60±0.29bc	8.06±0.09c	7.48±0.09c	5.81±0.17b	4.51±0.13b	67.53±0.77d	369.71±1.90a	724±0.09c
OFSP_3 (60%)	6.72±0.12c	9.58±0.39d	8.42±0.13d	6.75±0.06c	4.66±0.04b	63.87±0.61c	370.37±2.23a	321±0.19b
OFSP_4 (80%)	4.74±0.38a	12.93±0.31e	9.91±0.12e	6.45±0.00c	4.48±0.06b	61.50±0.10b	386.90±1.90b	300.5±0.23b
BN_(100)	5.43±0.24ab	15.03±0.34f	12.74±0.02f	6.46±0.31c	4.80±0.26b	55.53±0.15a	396.94±0.90c	42.5±0.05a

Values are means  $\pm$  standard deviations (n = 2). Mean values with different superscript letter along the column are significantly different (p<0.05).

Table 2. Effect of ingredient concentrations on the mineral content of orange fleshed sweet potato (OFSP) and Bambara groundnut extruded snacks

Product	Mineral contents (mg/100g DM)					
	Ca	Mg	P	K	Fe	Na
OFSP_ (0%)	73.01±0.35b	71.12±0.21a	215.96±0.09a	649.89±0.32a	5.26±0.09a	453.08±0.17f
OFSP_1 (20%)	71.70±0.44b	82.22±0.13b	220.61±0.62b	838.03±0.42b	5.99±0.10d	429.98±0.32e
OFSP_2 (40%)	71.63±0.30b	102.16±0.26c	262.05±0.37c	846.32±0.49c	6.07±0.67ab	364.24±0.44d
OFSP_3 (60%)	67.03±0.44a	106.15±3.38d	285.98±0.68d	867.18±0.42d	6.62±0.19b	323.84±0.41c
OFSP_4 (80%)	66.09±0.65a	119.79±0.61e	302.84±0.41e	1007.31±0.45e	7.06±0.20b	310.93±0.38b
BN_(100%)	65.70±0.54a	121.09±0.31f	311.00±0.38f	1015.95±0.99f	8.66±0.13c	201.16±0.61a

Values are means  $\pm$  standard deviations (n = 2). Mean values with different superscript letter along the column are significantly different (p<0.05).



OFSP

OFSP1

Figure 2. Photographs of the extruded RTE snacks from OFSP and bambara groundnut (OFSP = 100% OFSP, OFSP1 = 80% OFSP + 20% Bambara)

### Conclusion

The formulated snacks have significant amounts of nutrients required to provide the RDI requirements for school children. Snacks with their high level of pro-vitamin A and good performance in sensory assessment could therefore play a very crucial complementary role to fight against micronutrient deficiency (vitamin A and iron) in several communities of Tanzania and other developing countries where sweet potatoes is a staple food. Preference mapping results showed colour and sweetness as the most important drivers of consumer liking of the formulated snacks.

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