NUTRITIONAL PROPERTIES OF SAKADA PRODUCED FROM BLENDS OF CASSAVA AND AFRICAN YAM BEAN FLOURS

– Research paper –

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Abstract: This study investigated the effect of African yam bean flour (AYF) inclusion on the quality of *sakada*. Fermented cassava mash (FCM) and AYF were blended at ratios (% w/w) 100:0 (control), 90:10, 80:20, 70:30, and 60:40. *Sakada* was produced using the blends, and its nutritional and sensory properties were determined. Protein, fat, crude fibre, P, Ca, phytate, and oxalate contents of *sakada* increased ($p < 0.05$) with increasing AYF level, while moisture, carbohydrate, and cyanide decreased. The incorporation of 20% AYF in *sakada* resulted in a significant amount (> 4.0 g/100g protein) of arginine, leucine, isoleucine, and phenylalanine. Sensory properties of *sakada* that contained $\leq 20\%$ AYF compared favourably with *sakada* produced using 100% FCM. This study showed that the nutritional quality of *sakada* improved following AYF incorporation.

Keywords: African yam bean, cassava mash, enrichment, *sakada*, snack

INTRODUCTION

Cassava (*Manihot esculentus* Crantz) is a staple food and an excellent energy source in sub-Saharan Africa (Laswai et al., 2017). The bulk of the global cassava tonnage, roughly 291 million tons, is produced in West Africa and South America (FAO, 2020). With an annual production of 59 million tons, Nigeria accounts for approximately 20% of the global production (IITA, 2020). Carbohydrate is the predominant nutrient in cassava. Besides, other nutrients such as protein, carotene, calcium, and phosphorus are present in considerable quantity (Aristizabal et al., 2017). Cassava contributes significantly to food security in third world countries (Chadare et al., 2019).

In West Africa, cassava is subjected to operations, such as drying, fermentation, and cooking, to obtain different food products (Laya et al., 2018). Important cassava products in this region are *gari*, cassava flour, *lafun*, and *fufu* (Ajani et al., 2016). These products form part of the main diets of the people, especially those in rural communities (IITA, 2020). In recent times, the use of cassava for snacks, bread, and biscuit production, is increasing. This is

due to the high cost of wheat as well as health-related issues associated with its consumption (Ocheme et al., 2018). Furthermore, there is an increase in the rate of urbanization, which has resulted in changes in feeding and dietary patterns (Maziya-Dixon et al., 2017). Several studies have shown the potential of cassava as an ingredient for the production of snacks and bakery products (Eduardo et al., 2013; Maziya-Dixon et al., 2017; Wordu and Akusu, 2016; Okoye and Ezeugwu, 2019). Cassava-based snacks such as *sakada*, *ajogun*, and *gurudi* are currently being marketed in rural markets in the Southern part of Nigeria (Obadina et al., 2013; Wordu and Akusu, 2016).

Sakada is a cassava-based snack that is highly relished by school-age children in the Southwestern part of Nigeria. The traditional production involves peeling and grating of cassava roots to produce a mash. The mash is subjected to simultaneous dewatering and solid-state fermentation for 4-5 days. The fermented mash is formed to a desired shape and size and roasted using a charcoal stove. Like many cassava-based foods of sub-Saharan Africa, *sakada* is deficient in essential nutrients such as proteins, amino acids, and minerals. Therefore, the continuous consumption of *sakada* may result in protein-energy malnutrition.

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Consequently, efforts aimed at improving the nutrient density of *sakada* is highly imperative. In the past few decades, the incorporation of vegetable proteins into many staple foods of African origin, to complement their nutrients, is increasing. Many studies have shown an improvement in the nutrient density of cassava-based products after their fortification or enrichment with vegetable proteins such as soybean, groundnut, cowpea, and African yam bean (Jisha et al., 2010; Wordu and Akusu, 2016; Maziya-Dixon et al., 2017; Akinwale et al., 2017).

African yam bean (*Sphenostylis stenocarpa*) is a leguminous crop, which is found in many parts of the Tropics (Olawuni et al., 2014). It is rich in

macro- and micro nutrients. According to Ndidi et al. (2014), African yam bean contains 21.78% protein, 220.95 mg/100g Ca, 152 mg/100g K, 33.28 mg/100g P, and 3.75 mg/100g Zn. According to Esan and Fasasi (2013), African yam bean is rich in lysine and threonine. Recent studies have shown an improvement in the nutritional compositions of some staple foods following the incorporation of African yam bean (Idowu, 2015; Banigo and Kiin-Kabari, 2016). However, studies on the incorporation of African yam bean on the quality of cassava-based snacks are sparse. In this present study, the effect of African yam bean flour inclusion on the nutritional qualities of *sakada* was investigated.

MATERIALS AND METHODS

Materials

Cassava, *Manihot esculentus* Crantz (sweet variety), roots were procured from the International Institute for Tropical Agriculture while African yam bean was provided by the Institute of Agricultural Research and Training, both at Ibadan, Nigeria. Analytical grade reagents were used for experiment.

Methods

Production of fermented cassava mash

The method of Ajani et al. (2016) was used for the production of fermented cassava mash (FCM). Freshly harvested cassava roots were peeled, washed with clean water, and reduced into mash in a mechanical grater (Henan, Nigeria). The mash was poured into a sac and dewatered with the aid of locally fabricated screw press. The dewatering operation was done for 4 days to give room for spontaneous fermentation of the mash. Subsequently, the fermented mash was pulverized manually and sieved with a 1.18 mm sieve (United States Pharmacopoeia Standard Sieves). The over-tail was discarded and the resulting mash was used for *sakada* production immediately.

Production of African yam bean flour

The method of Ndidi et al. (2014) was used for the production of African yam bean flour (AYF). African yam beans were dry-cleaned, washed with water, and de-hulled manually. The de-hulled beans were boiled in water (1:6, % w/v) for 45 min, cooled, and dried at 60 °C for 18 h. The dried beans were milled and sieved to obtain a flour with average particle size of 0.25 mm.

Preparation of fermented cassava mash and African yam bean flour blends for *sakada* production

Fermented cassava mash was blended with AYF at levels (% w/w) 100:0 (control), 90:10, 80:20, 70:30, and 60:40. Each blend was properly mixed to form a dough-like mass and sized with a 9.0 cm plastic doughnut cutter (Generic, China). The dough-like mass was roasted in a locally fabricated gas oven at 110 °C for 20 min. *Sakada* samples were rapidly cooled to room temperature (28 ± 2 °C) and subjected to analyses immediately.

Analyses of *sakada* samples

AOAC (2005) methods were used for proximate, mineral (P, Na, K, Mg, and Ca), and cyanide contents while AOAC (2000) methods were used for phytate and oxalate contents.

Quantification of amino acids in *sakada* was performed with an amino acid analyzer (Technicon TSM 1, UK) (Margier et al., 2018). *Sakada* sample was ground in a mortar and pestle and subjected to different hydrolyses. These included acid hydrolysis and oxidation using 6 N HCl for 24-48 h at 110 °C to liberate branched and sulphur-containing amino acids. These were followed with basic hydrolysis using 4 N Ba(OH)₂ for 20 h at 100 °C. Norleucine was used as a standard.

A 9-point Hedonic scale was used for the sensory evaluation of *sakada* (Akinwale et al., 2017). For the analysis, fifty panellists were recruited to rate the *sakada* samples for taste, aroma, colour, texture, and overall acceptability. *Sakada* samples were served to the panellists at 70 °C in individual booths under white fluorescent light. Potable water was provided for palate cleansing in between samples.

RESULTS AND DISCUSSION

Proximate composition of *sakada*

The proximate composition of *sakada* produced using FCM and AYF is presented in Table 1. The inclusion of AYF in FCM caused a reduction ($p < 0.05$) in the moisture content of *sakada*. Besides, moisture content decreased with an increasing level of AYF. This could be due to the low moisture content of AYF and the effectiveness of the drying operation. This implied an improvement in the stability of *sakada* containing AYF because low moisture content ($< 8.50\%$) of products would reduce microbial spoilage (Iwe et al., 2016). A similar result was reported for wheat-groundnut protein concentrate blends (Ocheme et al., 2018). The *sakada* produced using 100% FCM (SAYF0) and the one produced using 60% FCM and 40% AYF (SAYF4) having the lowest and the highest values, respectively. The result implied that the protein content of *sakada* increased following the addition of AYF. Maziya-Dixon et al. (2017) also reported that the protein content of a cassava-based snack increased after enrichment with soybean and cowpea flours. According to Olawuni et al. (2014), African yam bean has a high protein content (22.50%), therefore, its inclusion in carbohydrate-based foods will help combat nutrition insecurity that arises from protein-energy malnutrition. The fat content of *sakada* increased, from 0.99 g/100g (in SAYF0) to a maximum value of 2.03 g/100g, consequent to the incorporation of AYF. The increase could be due to the high fat content of AYF. Uzo-Peters et al. (2008) also reported fat increase in *kokoro* (a maize-based snack) following its enrichment with groundnut cake. This is advantageous because, the shortening effect of fat will improve the sensorial properties, especially texture and appearance (Ayele et al., 2017). Ash content followed a similar trend. This could be attributed to the high ash content of African yam

bean (Olawuni et al., 2014). This agreed with Igbabul et al. (2019), who reported that mineral content of wheat-based bread increased consequent to the addition of hamburger bean. Crude fibre did not differ ($p > 0.05$) among SAYF0, *sakada* produced using 90% FCM and 10% AYF (SAYF1), and *sakada* produced using 80% FCM and 20% AYF (SAYF2). However, crude fibre decreased significantly ($p < 0.05$) when the level of AYF exceeded 30%. Significantly ($p < 0.05$) higher crude fibre obtained for the *sakada* samples that contained $\leq 20\%$ AYF indicated better glycemic and prebiotic properties (Igbabul et al., 2019). The carbohydrate content of *sakada* decreased as the level of AYF increased. The increase in protein and fat contents of *sakada*, following AYF inclusion, might be responsible for the decrease. Reduction in carbohydrate content could imply better digestibility of the product (Iwe et al., 2016).

Mineral composition of *sakada*

The mineral profile of *sakada* produced from blends of FCM and AYF is presented in Table 2. The blending of FCM and AYF increased ($p < 0.05$) P, Na, K, Mg, and Ca contents of *sakada*. Also, the increment was dependent on the level AYF in the blends. This finding indicated the low mineral content of *sakada*, hence, the need for macro-element fortification (Chadare et al., 2019). High mineral profile of African yam bean could be responsible for the increase in the mineral profile of *sakada*. Ndidi et al. (2014) had reported a high concentration of minerals, such as Na, Ca, K, Fe, Cu, Zn, and Mg, in African yam bean. Ayele et al. (2017) also reported that Ca and Fe of wheat-based bread increased following the addition of soybean flour. Mineral elements function in various metabolic responses in the body, therefore, the high mineral profile of *sakada* enriched with AYF indicated an improved nutrient density of the product (Ayele et al., 2017).

Table 1. Proximate composition of *sakada* produced from blends of fermented cassava mash and African yam bean

<i>Sakada</i>	Moisture content (g/100g)	Protein (g/100g)	Fat (g/100g)	Crude fibre (g/100g)	Ash (g/100g)	Carbohydrate (g/100g)
SAYF0 (control)	11.43 ^a ±0.02	1.97 ^e ±0.02	0.99 ^e ±0.02	3.67 ^a ±0.01	1.32 ^e ±0.02	80.61 ^a ±0.03
SAYF1	8.64 ^b ±0.01	5.06 ^d ±0.06	1.23 ^d ±0.02	3.65 ^a ±0.01	2.37 ^d ±0.01	79.15 ^b ±0.06
SAYF2	8.25 ^c ±0.01	7.98 ^c ±0.01	1.58 ^c ±0.02	3.63 ^a ±0.02	2.43 ^c ±0.01	76.31 ^c ±0.01
SAYF3	8.14 ^d ±0.01	10.34 ^b ±0.01	1.84 ^b ±0.02	2.98 ^b ±0.02	2.78 ^b ±0.01	73.73 ^d ±0.03
SAYF4	8.14 ^d ±0.02	12.08 ^a ±0.01	2.03 ^a ±0.01	2.82 ^c ±0.01	2.99 ^a ±0.01	71.95 ^e ±0.01

The data presented are means and standard deviations of triplicate scores. Different superscripts on mean values within a column indicated that the data were significant ($p < 0.05$) different. SAYF0- *Sakada* produced using 100% cassava mash, SAYF1- *Sakada* produced using 90% cassava mash and 10% African yam bean, SAYF2- *Sakada* produced using 80% cassava mash and 20% African yam bean, SAYF3- *Sakada* produced using 70% cassava mash and 30% African yam bean, SAYF4- *Sakada* produced using 60% cassava mash and 40% African yam bean.

Cyanide, phytate, and oxalate contents of *sakada*

The cyanide, phytate, and oxalate contents of *sakada* produced using blends of FCM and AYF is presented in Table 3. *Sakada* samples produced from blends of FCM and AYF had lower cyanide content compared to the SAYF0. The lowest value (0.014%) was obtained for SAYF4. The low cyanide content of African yam bean (Ndidi et al., 2014) could be responsible for this. One of the impediments of cassava utilization is the high concentration of cyanogenic glycosides, which breaks down to give toxic cyanide when linamarase enzymes are elaborated (Laswai et al., 2017). Therefore, cassava processing is often targeted to reduce its cyanide content. This study has shown that the incorporation of low-cyanide vegetable proteins, such as African yam bean, could prove effective for cyanide reduction in cassava-based products. The phytate and oxalate contents increased ($p < 0.05$) as AYF level increased. This increase could be due to the liberation of phytates and oxalates during the roasting operation. Ayele et al. (2017) had attributed high anti-nutrients of heat-processed products to the liberation of Maillard products following the interaction between amino acids and sugars. The results obtained showed that the incorporation of AYF ($\leq 20\%$) did not increase the phytate and oxalate contents of *sakada* above the permissible level. This agreed with the findings of Awolu and Oseyemi (2016) who reported that the

phytate level of wheat-based composite flour that had up to 18.83 % of Bambara groundnut flour was within a safe limit.

Anti-nutrients are known to bind with essential minerals, thus making them unavailable to the body (Awolu and Oseyemi, 2016), therefore, the low phytate and oxalate contents of SAYF1 and SAYF2 implied that they will not interfere with mineral bio-absorption in the body.

Amino acid profile of *sakada*

The amino acid profile of *sakada* as influenced by AYF inclusion is presented in Figure 1. The incorporation of AYF into *sakada* increased ($p < 0.05$) all the amino acids studied. Amino acids are the building blocks of protein molecules (Margier et al., 2018), therefore, the increase in the amino acid composition of *sakada* produced using FCM and AYF could be connected to their high protein content (Olawuni et al., 2014). This aligned with an increase in the amino acid content of wheat flour following the incorporation of soy flour (Khan et al., 2009). The high amino acid profile of *sakada* enriched with AYF could imply a high hydrolytic potential of AYF proteins. This will result in a high rate of digestibility, bioavailability, and absorption of AYF proteins in the body (Khan et al., 2009). This aligned with the findings of Esan and Fasasi (2013) who reported a high rate of *in vitro* hydrolysis of African yam bean proteins.

Table 2. Mineral profile of *sakada* produced from blends of fermented cassava mash and African yam bean

<i>Sakada</i>	P (mg/100g)	Na (mg/100g)	K (mg/100g)	Mg (mg/100g)	Ca (mg/100g)
SAYF0 (control)	16.02 ^e ±0.01	51.22 ^e ±0.03	51.29 ^e ±0.01	8.58 ^e ±0.24	8.74 ^e ±0.01
SAYF1	32.24 ^d ±0.02	57.33 ^d ±0.12	212.44 ^d ±0.01	126.16 ^d ±0.02	10.87 ^d ±0.01
SAYF2	40.13 ^c ±0.03	62.28 ^c ±0.42	267.51 ^c ±0.01	132.82 ^c ±0.02	15.81 ^c ±0.06
SAYF3	45.62 ^b ±0.01	68.16 ^b ±0.01	299.33 ^b ±0.01	148.62 ^b ±0.01	25.42 ^b ±0.01
SAYF4	51.62 ^a ±0.02	72.73 ^a ±0.03	352.74 ^a ±0.01	154.04 ^a ±0.01	31.16 ^a ±0.01

The data presented are means and standard deviations of triplicate scores. Different superscripts on mean values within a column indicated that the data were significant ($p < 0.05$) different. SAYF0- *Sakada* produced using 100% cassava mash, SAYF1- *Sakada* produced using 90% cassava mash and 10% African yam bean, SAYF2- *Sakada* produced using 80% cassava mash and 20% African yam bean, SAYF3- *Sakada* produced using 70% cassava mash and 30% African yam bean, SAYF4- *Sakada* produced using 60% cassava mash and 40% African yam bean.

Table 3. Cyanide, phytate, and oxalate of *sakada* produced from blends of fermented cassava mash and African yam bean

<i>Sakada</i>	Cyanide (%)	Phytate (%)	Oxalate (%)
SAYF0 (control)	0.029 ^a ± 0.001	0.563 ^e ± 0.002	0.350 ^e ± 0.010
SAYF1	0.025 ^b ± 0.001	0.597 ^d ± 0.00	0.720 ^d ± 0.020
SAYF2	0.021 ^c ± 0.001	0.766 ^c ± 0.001	1.450 ^c ± 0.011
SAYF3	0.018 ^d ± 0.001	0.782 ^b ± 0.001	2.087 ^b ± 0.015
SAYF4	0.014 ^e ± 0.001	0.795 ^a ± 0.002	2.650 ^a ± 0.010

The data presented are means and standard deviations of triplicate scores. Different superscripts on mean values within a column indicated that the data were significant ($p < 0.05$) different. SAYF0- *Sakada* produced using 100% cassava mash, SAYF1- *Sakada* produced using 90% cassava mash and 10% African yam bean, SAYF2- *Sakada* produced using 80% cassava mash and 20% African yam bean, SAYF3- *Sakada* produced using 70% cassava mash and 30% African yam bean, SAYF4- *Sakada* produced using 60% cassava mash and 40% African yam bean.

High concentration (>4.0 g/100g protein) of essential amino acid, arginine, was recorded for SAYF1 and SAYF2. Other important essential amino acids, i.e. leucine, isoleucine, and phenylalanine, were obtained in high concentration (>4.0 g/100g protein) in SAYF2. Cysteine and methionine, which are limiting in African yam bean, were detected in an appreciable quantity in *sakada* produced using the blends FCM and AYF. This could be due to the complementation effect of amino acids in FCM and AYF, which probably led to more balanced amino acids in *sakada*. This is of high nutritional benefit because AYF-enriched *sakada* will be a carrier of essential amino acids that are not readily synthesized in the body (Margier et al., 2018).

Sensory properties of *sakada*

The sensory properties of *sakada*, in terms of the degree of liking, is presented in Table 4. A higher consumer acceptance in terms of taste and aroma was recorded for SAYF1 and SAYF2 compared to SAYF0. However, panellists showed a low preference for *sakada* produced using 70% FCM and 30% AYF (SAYF3) and SAYF4. This implied that the incorporation of $\leq 20\%$ AYF into FCM improved the taste and aroma of *sakada*. This could

be due to the elaboration of flavour compounds from the interaction between the sugars and proteins in FCM and AYF during the roasting operation. Laswai et al. (2017) also reported that the incorporation of 20% soybean improved the sensory properties of cassava-based pancakes. The low aroma and taste preference recorded for SAYF3 and SAYF4 could be due to the high level of AYF in *sakada*, which probably caused a beany flavour. According to Ocheme et al. (2018), high legume composition in foods causes a strong beany flavour, which can result in low consumer preference for the products. SAYF0 and SAYF1 did not differ ($p > 0.05$) in terms of colour, however, the incorporation of $>10\%$ AYF caused a reduction in the preference for colour. This could be due to the increased rate of elaboration of colour compounds owing to the browning reaction resulting from the high level of protein in AYF and sugars in FCM (Ayele et al., 2017). The incorporation of AYF in *sakada* caused a reduction in its degree of liking in terms of texture. This could be due to the reduction of starch in *sakada*, consequent to AYF enrichment, and this probably caused the softening of the product. Laswai et al. (2017) also reported the softening of cassava-based pancakes following the incorporation of soy flour.

Figure 1. Amino acid profile of *sakada* enriched with African yam bean. SAYF0- *Sakada* produced using 100% cassava mash, SAYF1- *Sakada* produced using 90% cassava mash and 10% African yam bean, SAYF2- *Sakada* produced using 80% cassava mash and 20% African yam bean.

Results showed a higher level of SAYF1 and SAYF2 acceptance in terms of texture compared to SAYF3 and SAYF4. This could imply a higher softening of *sakada* that contained a high level (>20%) of AYF. The highest overall acceptability (8.26) was recorded for SAYF0 probably due to the familiarity of the panellists to *sakada* produced

solely from cassava mash. SAYF1 and SAYF2 did not differ ($p > 0.05$) in terms of overall acceptability. Significantly ($p < 0.05$) higher scores were recorded for the samples compared to SAYF3 and SAYF4. This implied that consumers would tolerate up to 20% of the AYF level in *sakada*.

Table 4. Sensory properties of *sakada* produced from blends of fermented cassava mash and African yam bean

<i>Sakada</i>	Taste	Aroma	Colour	Texture	Overall acceptability
SAYF0 (control)	7.00 ^b ±0.20	7.43 ^b ±0.20	6.96 ^a ±0.30	8.40 ^a ±0.10	8.26 ^a ±0.20
SAYF1	7.86 ^a ±0.20	7.13 ^c ±0.30	6.93 ^a ±0.20	6.36 ^b ±0.20	7.83 ^b ±0.20
SAYF2	7.90 ^a ±0.30	7.80 ^a ±0.30	6.63 ^{ab} ±0.10	6.36 ^b ±0.10	7.78 ^b ±0.10
SAYF3	4.53 ^c ±0.40	4.70 ^d ±0.20	6.50 ^{ab} ±0.10	4.40 ^c ±0.10	5.23 ^c ±0.10
SAYF4	3.46 ^d ±0.20	4.46 ^e ±0.20	6.40 ^b ±0.20	3.40 ^d ±0.20	3.46 ^d ±0.30

The data presented are means and standard deviations of fifty scores. Different superscripts on mean values within a column indicated that the data were significant ($p < 0.05$) different. SAYF0- *Sakada* produced using 100% cassava mash, SAYF1- *Sakada* produced using 90% cassava mash and 10% African yam bean, SAYF2- *Sakada* produced using 80% cassava mash and 20% African yam bean, SAYF3- *Sakada* produced using 70% cassava mash and 30% African yam bean, SAYF4- *Sakada* produced using 60% cassava mash and 40% African yam bean.

CONCLUSIONS

The incorporation of African yam bean improved the nutritional and sensory qualities of *sakada*. There was a significant ($p < 0.05$) increase in the protein, fat, P, Na, Ca, Mg, and Ca contents of *sakada* as the level of AYF increased while ash and carbohydrate decreased. The toxicity (cyanide) level of *sakada* reduced following the incorporation

AYF. The incorporation of AYF ($\leq 20\%$) did not increase the phytate and oxalate content of *sakada* beyond safety limit. This level of AYF inclusion also resulted in a high concentration of important amino acids such as arginine, leucine, isoleucine, and phenylalanine. The sensory evaluation result showed that the *sakada* samples that had up to 20% AYF were acceptable by the panelists in terms of taste, aroma, texture, and overall acceptability.

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