

Production, Anti-nutritional, Minerals and Sensory Attributes of Soybean (*Awara*) Enhanced with Orange-fleshed Sweet Potato (OFSP) Blends

Shade A. Banigbe¹, Olubodun A. Adebisi², Olanipekun O. Olaleye¹, Olufunmilayo A. Ajayi¹, Stephen O. Oyeyipo¹, Omolola C. Ogunjirin¹, and Amen W. Dawi³.

¹Nigerian Stored Product Research Institutes, Ilorin, Kwara State, Nigeria.

²Department of Nutrition and Dietetics, Federal College of Agricultural Produce Technology, P.M.B. 3013, Kano State, Nigeria.

³Department of Food Science and Technology, Federal University of Agriculture, Mubi, Adamawa State, Nigeria

ARTICLE HISTORY

Received Date: 6th June, 2025

Accepted Date: 10th July, 2025



http: www.njphr.nspri.gov.ng

ISSN: 2630-7022

CORRESPONDING AUTHOR

Shade A. Banigbe

Department of Perishable Crop Research
Department, NSPRI, Ilorin, Kwara State,
Nigeria

banigbesa@nspri.gov.ng,

+2348062849360

CONFLICT OF INTEREST: None

ETHICAL APPROVAL: Not Applicable



This is a publication of the
Nigerian Stored Products
Research Institute (NSPRI)

OPEN ACCESS

Abstract

Orange-fleshed sweet potatoes (OFSP) are considered one of the top sources of Provitamin A. It was incorporated into soybean cheese-like (awara) at varying proportions. Five (5) samples were produced using the following formulation ratio of soy bean and orange fleshed sweet potatoes (OFSP) (80:20, 60:40, 40:60, 20:80) and (100:0) as a control sample. The samples produced were evaluated for mineral content, anti-nutritional factor and sensory attribute, and the results were statistically analysed (ANOVA) for mean and standard deviation. The Anti-nutritional factors and mineral composition of cheese-like (awara) samples showed a significant ($p < 0.05$) difference among all the samples. The oxalate ranged from (2.86 – 4.65 mg/100g), phytate (0.30 – 1.28 mg/100g), tannin (103.58 – 125.78 mg/100g), and the trypsin inhibitor ranged from (7.59 – 18.92 mg/100g). The mineral content, Zn ranged from (1.42 – 2.54 mg/L), Fe (2.58 – 7.45 mg/L), Mg (1.66 – 3.92 mg/L), K (22.55 – 40.05 mg/L) and Na (6.36 – 9.28 mg/L). The sensory attribute of the cheese-like (awara) samples showed significant ($P < 0.05$) difference among the samples, where the appearance ranged from (7.30 – 8.50), taste (6.20 – 8.50), mouth feel (4.50 – 8.30), texture (5.20 – 7.90), general acceptability (6.50 – 8.20), aroma (5.00-8.20) and flavor (5.40 -7.50). In conclusion, the incorporation of orange-fleshed sweet potatoes (OFSP) to soybean cheese-like (awara) increased phytochemical and mineral content of the samples appreciably. Samples D and E had the highest mean of all the parameters evaluated and were most preferred by the panelists.

Keywords: Anti-Nutrition, Nutritional, Orange-Fleshed Sweet Potatoes, Sensory Evaluation, Soybean.

Introduction

Consumers demand nutritious, functional, and sustainable foods for physical and mental development. Cheese (*warankasi or wara*) is a functional food from a protein source. The Fulani first introduced it and later spread it to other parts of Nigeria. Cheese is produced from cow, cattle and goat milk, which is processed by culturing the milk using bacterial culture.

Cow milk is expensive because poor people have limited access to it; hence, it is essential to source a substitute that could be used to produce cheese (Adetunji et al., 2011). Soybean (*Glycine Max*) and orange-fleshed sweet potatoes (*Ipomoea batatas*) are rich in dietary fibre, proteins, vitamins, minerals, beta carotene, and antioxidants, offering a promising nutrient-dense profile

Jafari et al. (2018), which could lower the risk of preventable diseases. Soybean is a leguminous vegetable crop widely grown in temperate, tropical, and subtropical regions. Soybeans can be processed into flour, livestock feed, and raw materials for industrial uses. Milk and *cheese-like* products derived from soybeans are consumed as a substitute for dairy milk and for people with lactose intolerance. Nutritionally, soybean protein is one of the least expensive dietary protein sources; thus, it is consid-

How to cite:

Banigbe, A. S., Adebisi, O. A., Olaleye, O. O., Ajayi, O. A., Oyeyipo, S. O., Ogunjirin, O. C., & Dawi, A. W. (2025). Production, Anti-nutritional, Minerals and Sensory Attributes of Soybean (*Awara*) Enhanced with Orange-fleshed Sweet Potato (OFSP) Blends. *Nigerian Journal of Post-Harvest Research*, 3(3), 45-52.

ered a good substitute for animal protein (Bethke and Janksy, 2008). It is a good source of micro and macronutrients, essential amino acids. Soybeans are high in anti-nutritional compounds such as saponin, phytate, oxalate, tannin, and trypsin inhibitor, which can reduce nutrient digestibility (Lee et al., 2020).

Sweet potato (*Ipomoea batatas*) is a root crop belonging to the Convolvulaceae family, 3rd third-largest cultivated root crop after cassava, globally based on its nutritional and agronomic resilience and food security properties (Neela and Fanta, 2019). Continentally, China is the leading producer, followed by Nigeria and Tanzania (FAOSTAT, 2019). Orange-fleshed sweet potatoes are gluten-free; thus, they are a key source of nutrient-dense carbohydrates in the diets of those with celiac disease or gluten sensitivity. The flour is used in bakery products such as cakes, bread, and muffins. Nutritionally, orange-fleshed sweet potatoes are highly nutritious, providing a substantial amount of beta carotene (pro -vitamin A), which is crucial for preventing vitamin A deficiency (VAD) and blindness in young children (Robertson et al., 2018). It contains complex carbohydrates, fibre, vitamin C, iron, magnesium, calcium, zinc, and potassium. Its potassium significantly surpasses bananas, oranges, and broccoli. Its tubers supply iron that exceeds many other iron-rich vegetables with extremely low or non-existent levels of anti-nutrients, chelators and ligands that inhibit iron absorption (e.g., tannins, oxalates, phytates) and high levels of vitamin C, which has been shown to enhance iron absorption (Korada et al., 2010). They are a valuable food crop for combating malnutrition and can supply a significant portion of the daily vitamin A requirements for young children through a moderate serving.

Studies often focus on producing soybean *cheese-like products*, but do not examine the fortification using orange-fleshed sweet potato root. This study addresses that opening by assessing the nutritional quality of a combination of soybean and orange-fleshed sweet potato root. The reason is that soybeans are high in anti-nutritional composition, which can reduce nutrient digestibility, are deficient in beta carotene, and are low in carbohydrate. At the same time, orange-fleshed sweet potatoes have an extremely low or non-existent level of anti-nutrients, presence of chelators and ligands, minerals and vitamin C, which has been shown to enhance iron absorption. The insights aim to improve the nutritional quality of soybean cheese-like products using orange-fleshed sweet potatoes, increasing their market space and acceptability of local crops in underdeveloped countries and Nigeria.

Materials and methods

Material

Raw material used in the preparation of *awara* enriched with orange-fleshed sweet potatoes includes the following: soybean, orange-fleshed sweet potatoes, tamarind, water, cooking utensil, muslin cloth, mechanical hydraulic press and soybean oil.

Sources of materials

The soybean and tamarind fruits were procured. Likewise, orange-fleshed sweet potatoes were obtained from the farmer at Yankaba market, Kano State. All other materials were also standardized.

Preparation of tamarind

Sudha et al. (2022) described that the coagulant was produced from tamarind fruit. Tamarind fruits were sorted to remove extraneous and unhealthy materials. The tamarind was soaked in hot water, then macerated to release the juice, and filtered using a muslin cloth.

Preparation of soybean-orange fleshed sweet potato blends.

With some modifications, the preparation of soybean–orange fleshed sweet potato blends was done as described by James et al. (2016). Soybeans were dehulled after soaking for 8–12 hours to reduce anti-nutritional factors; likewise, the peeled orange fleshed sweet potatoes were also washed, which will ensure the removal of surface contaminants that could interfere with subsequent analyses. Orange-fleshed sweet potatoes were added to the soaked soybeans in different ratios (20, 40, 60 and 80) while 100% serves as control samples were blended to obtain a combined slurry. The blended mixture was strained using a muslin cloth.

Preparation of soybean- orange fleshed sweet potatoes (*Awara*) cheese

Soybean – orange fleshed sweet potatoes slurry was prepared into cheese using the method described by Sanni et al. (2011). Coagulant was added to the mixture after boiling for 10 minutes. The mixture was allowed to curdle for 15 minutes. The local cheese formed was drained using a muslin cloth and pressed with a mechanical hydraulic press to expel the whey. Then, cut into appropriate shapes, and fry for 7-8 minutes. Local cheese (*Awara*) was refrigerated (4°C) until analysis. However, orange-fleshed sweet potatoes (100%) did not coagulate.

Determination of mineral content of soybean-orange fleshed sweet potatoes (*awara*) cheese

Minerals are micronutrients; they are essential for the body's proper functioning. The ash obtained from the ash analysis determined the mineral content. Ash was placed in a porcelain crucible, and then a few drops of distilled water were added to 2 mL of concentrated hydrochloric acid, 10 mL of 20% HNO₃, and then evaporated on a hot plate. The samples were filtered through Whatman filter paper into a 100 mL volumetric flask. The mineral elements, Ca, Mg, Fe, and Zn, were determined by an atomic absorption spectrophotometer. (AA800 perkin-Elmer, Germany). The phosphorus in the sample filtrate was determined using Vanadomolybdate reagent at 400 nm using a colourimetric method (Colourimeter SP20, Bausch and Lomb) (Chaturvedi and Nagar 2001). At the same time, Na and K were determined using a flame photometer (Sherwood Flame Photometer 410, Sherwood Scientific Ltd., Cambridge, UK) with NaCl and KCl as the standards (Khan et al., 2014).

Determination of oxalate content of soybean-orange fleshed sweet potatoes (*awara*) cheese

A gram of the sample was weighed in a 100-mL conical flask to determine oxalate content. Seventy-five millilitres of 3 mol/L H₂SO₄ was added, and the solution was stirred intermittently with a magnetic stirrer for about one hour and then filtered using Whatman No. 1 filter paper. 25 mL of the sample filtrate (extract) was collected and titrated against hot (80–90°C) 0.1 N KMnO₄ solution to the point when a faint pink colour appeared that persisted for at least 30 s. The concentration of oxalate in each sample was obtained from the calculation (Suma and Urooj 2014).

$$\text{Oxalate content } \left(\frac{\text{mg}}{100\text{g}} \right) = \frac{\text{VT} \times \text{Vme} \times \text{DF} \times 2.4}{\text{ME} \times \text{MF}}$$

Vme = Volume – mass equivalent (i.e 1ml of 0.05 M KMnO₄ solution is equivalent to 0.00225g anhydrous oxalic acid)

DF = Dilution factor (VT/A)

VT = Total volume of filtrate (75 mL), A – Aliquot used, 25 mL

ME = Molar Equivalent of KMnO₄

MF = Weight of sample

Determination of phytate content of soybean-orange fleshed sweet potatoes (*awara*) cheese

Phytate was determined by the Talamond et al. (2000) method. One-half gram of each sample was extracted

with 100mL of 2.4% HCl and shaken for one hour. Colour was developed with 1ml modified reagent (0.03% FeCl₃ · 6H₂O and 0.3% sulphosalicylic acid) and read at 500 nm in a spectrophotometer. One-half gram (0.5) of the sample was weighed into a 500ml flat-bottom flask, placed in a shaker and extracted with 100mL 2.4% HCl for one hour at room temperature, and then decanted and filtered, and 5mL of the filtrate was diluted to 25 mL with distilled water. Fifteen millilitres of 0.1 M sodium chloride was added to 10ml of the diluted sample and passed through an anglet raisin grade 200 – 400 mesh to elute inorganic phosphorus, and 5mL of 0.7 M sodium chloride was also added to elute phytate. The sample solution was read at 500 nm using water to zero the spectrophotometer, and a calibration curve was constructed to calculate the phytate concentration.

$$\text{Phytate} = \frac{X \times \text{dilution} \times \text{original volume of digest}}{\text{weight of sample}} \times 100$$

Where X = value of the curve of optical density x reading from the spectrophotometer.

Determination of tannin content of soybean- orange fleshed sweet potatoes (*awara*) cheese

Tannin was determined using Follins Dennis spectrophotometric method according to (Tabasum et al., 2001). Five grams of the sample were dispersed in 50 mL of distilled water and shaken. The mixture was left for 30 min at room temperature and mixed vigorously every 10 min. The filtrate was used for the experiment after 30 min. Two millilitres (2 mL) of the extract were measured into a 50 mL volumetric flask. Similarly, 5 mL of standard tannic acid solution and 5 mL of distilled water were measured into separate flasks to serve as the standard and blank, respectively. They were further diluted with 35 mL of distilled water separately, and 1 mL of Follin Dennis reagent was added to each flask, followed by 2.5 mL of saturated sodium carbonate solution (Na₂CO₃). The content of each flask was then made up to 50 mL at room temperature. The absorbance of the developed colour was measured at 620 nm wavelength in a spectrophotometer. Readings were taken with the reagent blank at zero.

Determination of Trypsin Inhibitor of soybean-orange fleshed sweet potatoes (*awara*) cheese

The trypsin inhibitor content was determined using a spectrophotometric method. Five grams of the sample were dispersed in 50 mL of distilled water, shaken thoroughly and allowed to stand for 30 minutes at room

temperature with intermittent shaking every 10 minutes. The mixture was filtered using Whatman filter paper, and the clear filtrate was used for the assay. Two millilitres of the extract were pipetted into a 50-mL volumetric flask with 5 mL of standard trypsin inhibitor solution and 5 mL of distilled water for the blank. Each flask was diluted with 35 mL of distilled water, and 1 mL of a reagent (specific details, such as Folin-Dennis or equivalent, depend on the trypsin inhibitor protocol) was added. The solution was further treated with 2.5 mL of saturated sodium carbonate solution. The mixture was topped up to 50 mL with distilled water and left to react at room temperature. The absorbance was measured at the appropriate wavelength (commonly 410 nm or as defined in the protocol) using a spectrophotometer, with a reagent blank set to zero (Kaur et al., 2022).

Sensory parameters of soybean- orange-fleshed sweet potatoes (*awara*) cheese

The evaluation for sensory and acceptability of the *awara* (20, 40, 60, 80 %) using panelists of twenty-five well-trained judges was carried out at Federal College of Agricultural Produce Technology, Kano. The *awara* was evaluated for colour, taste, odour, flavour and overall acceptability using a 10-point hedonic scale (1=dislike extremely to 10=like extremely) according to the method described by Meilgaard et al. (2007).

Statistical Analysis

The Data Obtained were analysed appropriately using Analysis of Variance (Steele and Torrie 1980). The Mean and standard deviation were also calculated. However, where significant differences existed, Tukey's test separated the means.

Results and Discussions

Anti-nutritional composition of soybean – orange fleshed sweet potatoes (*Awara*) cheese

The results of the anti-nutritional composition of *awara* were presented in Table 1. Composite *awara* (samples A, B, C and D) contained high oxalate, tannin, trypsin inhibitors, and low phytate content. At

Table 1: Anti-nutritional content of soybean- orange fleshed sweet potatoes (*awara*) cheese

Parameter (100mg/g)	<i>Awara</i> Samples				
	A	B	C	D	E
Oxalates	3.07±0.02 ^b	2.86±0.03 ^a	4.65±0.06 ^e	4.21±0.03 ^d	3.30±0.0 ^c
Phytates	0.30±0.01 ^a	0.35±0.01 ^b	0.44±0.00 ^c	0.52±0.01 ^d	1.28±0.02 ^e
Tannins	106.93±0.20 ^b	103.58±0.12 ^a	120.04±0.48 ^c	125.78±0.23 ^e	111.08±0.29 ^d
Trypsin Inhibitors (TUI/mg)	18.92±0.02 ^e	15.35±0.03 ^d	9.72±0.01 ^c	8.67±0.02 ^b	7.59±0.043 ^a

Means within row with different letters are significantly different at ($P < 0.05$). A = *Awara* sample with 80% OFSP and 20% Soybean, B = *Awara* sample with 60% OFSP and 40% Soybean, C = *Awara* sample with 40% OFSP and 60% Soybean, D = *Awara* sample with 20% OFSP and 80% Soybean, E = *Awara* sample from 100% Soybean

the same time, soybean cheese (sample E) had high phytate and low oxalate, tannin and trypsin inhibitors. The oxalate composition ranged between 2.86 and 4.65mg/g. There was a significant ($p < 0.05$) difference in the oxalate values, with sample C having a high concentration of oxalate content, while sample B recorded the lowest value. The variation of oxalate concentrations is due to the soil type, rainfall intensity, and geographic location of the crops. This result was comparable to that of a study conducted by Massey et al. (2001)

Phytate composition ranged between 0.30 and 1.28mg/g. There was a significant ($p < 0.05$) difference in the phytate content among the samples. Sample E exhibited high phytate values, while sample A had the lowest. The phytic acid decreased with an increase in OFSP. The value of phytic acid in this investigation agrees with the work of Olayiwola et al. (2009), who reported low levels of phytic acid in sweet potato. On the other hand, Tilahun et al. (2013) and Adane et al. (2013) also reported lower phytic acid values of sweet potato varieties compared with cassava varieties.

Tannin content of the samples ranged from 103.58 to 125.78 mg/g, with significant ($p < 0.05$) variations observed among the samples. Sample D had a high tannin content, while sample B recorded the least value. The tannin value shows that OFSP and soybean seeds had considerable tannin. The results aligned with the results reported by Megat Rusydi and Azrina (2012) that tannins are found in plants as defence mechanisms against environmental attacks.

Trypsin inhibitors ranged from 7.59 to 18.92 TUI/mg. There was a significant ($p < 0.05$) difference among the samples. Sample A recorded high values of trypsin inhibitors, while sample D had the lowest value. This result indicates that soybeans and orange-fleshed sweet potato contribute to trypsin inhibition, which is known to interfere with protein digestion. However, processing of *Awara* deactivates the anti-nutrient and trypsin inhibitor, optimising *Awara*'s nutritional quality while minimising the impact of anti-nutritional factors (Vagadia et al., 2017).

Mineral composition of soybean – orange fleshed sweet potatoes (*Awara*) cheese

The results of the mineral composition of the *awara* were presented in Table 2. Composite *awara* (samples A, B, C and D) contained a substantially high value of zinc, iron, and potassium and low magnesium and sodium content. Meanwhile, soybean cheese (sample E) had high magnesium and sodium, and low zinc, iron, and potassium content.

Zinc concentration in *awara* samples ranged from 1.30 to 2.54mg/L. There was a significant ($p<0.05$) difference in the zinc concentration of composite *awara* samples, with sample A having high zinc and sample E having the lowest concentration. The increase in OFSP substitution increased the value of zinc present in the samples. However, the amount of zinc found in OFSP and soybean indicates that the composite may have a considerable effect on the mineral composition of the sample, which would be valuable for consumers, pregnant women and babies in particular (Zhou et al., 2019).

Iron concentration in *awara* samples ranged from 2.58 to 7.45mg/L. There was a significant ($p<0.05$) difference in the iron concentration in the *awara* samples. Sample B had a high iron concentration, while sample E had the lowest iron value. Iron, an essential component of haemoglobin and a significant constituent of blood and enzymes for electron transfer, its deficiency can result in tiredness, weakness, and anaemia. The presence of iron in composite *awara* indicates that increased OFSP increases the iron content of the sample. This was in line with the result reported by (McLaren, 2019).

Magnesium concentration in *awara* samples ranged from 1.66 to 3.92mg/L. Magnesium values were significantly ($p<0.05$) different except for samples B and D, which are not significantly ($p>0.05$) different from each other. This suggests that OFSP and soybean contributed to the magnesium composition of the samples. Magnesium in *awara*, as obtained in this

study, would help calcium metabolism and prevent some diseases (Alinnor and Oze 2011).

Potassium concentration in *awara* samples ranged from 22.55 to 40.05mg/L. Potassium values were significantly ($p<0.05$) different. Sample A had a high value, while sample E recorded the lowest value. Sodium concentration in *awara* samples ranged from 6.36 to 9.28mg/L. Sodium values were significantly ($p<0.05$) different. Sample B recorded the highest sodium content, while sample A had the lowest value. However, values obtained in this study indicate an appropriate ratio of sodium and potassium concentration. Nevertheless, low sodium and high potassium intakes help to reduce high blood pressure in hypertensive patients (Alinnor and Oze 2011).

Sensory attributes of soybean –orange fleshed sweet potatoes (*Awara*) cheese

The result of the sensory attributes of (*awara*) samples produced from OFSP and soybean is depicted in Table 3. The sensory scores for the appearance of samples ranged from 7.30 to 8.50. There are significant ($p<0.05$) differences within samples. Sample E had high appearance values, while sample D recorded the lowest appearance value. Taste scores varied significantly ($p<0.05$) and differed in percentage, ranging from 5.60 to 8.50, respectively. Sample E recorded the highest taste values, while Sample B recorded the lowest. Mouth feel ratings ranged from 4.50 to 8.30cm. Sample E was higher for mouth feel values, while Sample C recorded the lowest values. Texture scores ranged from 4.60 to 7.90, respectively. Sample E had the highest values, while A and B had similar texture values. General acceptability scores ranged from 6.50 to 8.20cm. Sample E value was higher, while B recorded the lowest values of general acceptability. The aroma scores for the *awara* samples ranged from 5.00 to 8.20. Sample D was higher than E and C, followed by sample B and A, which recorded the lowest values. The flavour scores ranged from 5.40

Table 2. Mineral content of soybean- orange-fleshed sweet potatoes (*awara*) cheese

Parameter (mg/100g)	<i>Awara</i> Samples				
	A	B	C	D	E
Zinc	2.54 ±0.03 ^e	1.51±0.01 ^d	1.42±0.02 ^b	1.50±0.01 ^c	1.30±0.02 ^a
Iron	6.03 ± 0.02 ^d	7.45±0.03 ^e	2.76±0.02 ^b	4.52±0.01 ^c	2.58±0.03 ^a
Magnesium	1.66±0.01 ^d	2.88±0.00 ^b	1.74±0.07 ^c	2.88±0.01 ^b	3.92±0.01 ^a
Potassium	40.05±0.39 ^e	34.50±0.28 ^c	36.05±0.10 ^d	30.56±0.30 ^b	22.55±0.18 ^a
Sodium	6.36±0.76 ^a	9.28±0.33 ^e	7.03±0.32 ^c	6.58±0.22 ^b	8.44±0.33 ^d

Means within row with different letters are significantly different at ($P<0.05$), A = *Awara* sample with 80% OFSP and 20% Soybean, B = *Awara* sample with 60% OFSP and 40% Soybean, C = *Awara* sample with 40% OFSP and 60% Soybean, D = *Awara* sample with 20% OFSP and 80% Soybean, E = *Awara* sample from 100% Soybean.

Table 3: Sensory attributes of soybean- orange fleshed sweet potatoes (*awara*) cheese

Attributes	(Awará) Samples				
	A	B	C	D	E
Appearance	7.80 ± 1.40 ^a	7.50 ± 1.84 ^a	7.50 ± 1.40 ^a	7.30 ± 0.48 ^a	8.50 ± 0.74 ^b
Taste	6.60 ± 1.37 ^a	6.20 ± 1.81 ^a	7.70 ± 1.35 ^b	8.10 ± 0.57 ^c	8.50 ± 0.53 ^c
Mouthfeel	6.00 ± 0.26 ^b	6.40 ± 1.41 ^b	4.50 ± 1.08 ^a	7.20 ± 0.79 ^c	8.30 ± 0.68 ^d
Texture	5.20 ± 0.46 ^a	5.20 ± 1.23 ^a	7.00 ± 1.16 ^b	7.20 ± 0.79 ^b	7.90 ± 0.74 ^b
General acceptability	6.70 ± 1.54 ^a	6.50 ± 1.37 ^a	7.50 ± 1.56 ^b	7.60 ± 0.63 ^b	8.20 ± 0.9 ^c
Aroma	5.00±0.00 ^a	6.60 ± 0.70 ^b	7.60 ± 2.46 ^c	8.20±0.79 ^d	7.90±0.74 ^c
Flavor	7.00±0.02 ^c	5.40±1.17 ^a	6.60±2.37 ^b	7.10±0.57 ^c	7.50±0.53 ^c

Means within row with different letters are significantly different at ($P < 0.05$), A = Awará sample with 80% OFSP and 20% Soybean, B = Awará sample with 60% OFSP and 40% Soybean, C = Awará sample with 40% OFSP and 60% Soybean, D = Awará sample with 20% OFSP and 80% Soybean, E = Awará sample 100% soybean.

to 7.50. Samples E, A and D were higher in flavour values and were not significantly ($p < 0.05$) different from each other, while samples C and B recorded the lowest values.

Meanwhile, samples with higher soybean content, particularly D and E, were consistently rated higher across all sensory parameters. This preference may be attributed to the smoother texture, taste, and enhanced mouthfeel contributed by soybeans. Soybeans' familiarity and favourable sensory properties likely enhanced the appeal of these samples. However, in variation, samples B and A consistently received the lowest scores for taste, mouthfeel, texture and general acceptability. The higher inclusion of OFSP in this sample may have introduced a distinct and unfamiliar taste and coarse texture, which were less appealing to the panelists. This suggests that OFSP, when used in higher proportions, can negatively influence the sensory qualities of *awara*. However, the general acceptability scores mirrored the trends in individual sensory attributes, with samples D and E being the most preferred and sample B being the least acceptable. The findings emphasise that an optimal balance between OFSP and soybean is crucial to produce *awara* with desirable sensory qualities. Furthermore, due to nutritional benefits, OFSP can be a valuable fortification ingredient, but its proportion must be carefully managed to maintain the sensory appeal of the product. However, incorporating soybeans in higher proportions enhances the overall sensory experience, making the product more acceptable to consumers.

Conclusion

The study has shown that combining orange-fleshed sweet potatoes with soybeans in specific proportions can create cheese-like products with high minerals and appreciable anti-nutritional profile compared with

soybean *cheese-like* (100%). Hence, OFSP has tremendous potential as an ingredient for functional food. It has iron, zinc, potassium and magnesium. Iron is essential for electron transfer; its deficiency can result in tiredness, weakness, and anaemia. Zinc is desirable for pregnant women for safe baby delivery, and for the body's defensive (immune) system, protein and nucleic acid synthesis. Potassium helps regulate the body's fluid balance, which is required to transmit nerve impulses. Also, high potassium intake is associated with lowering blood pressure, and increasing potassium as an additive reduces sodium intake.

Nevertheless, the combined effect of potassium, calcium and magnesium has been associated with lowering the rate of cardiovascular diseases. Likewise, orange-fleshed sweet potatoes have extremely low levels of anti-nutrients, chelators, and ligands that inhibit some mineral absorption to increase their bioavailability. The sensory properties of the samples still maintain their acceptability when compared with the control (soybean cheese-like) samples. Hence, cheese-like (*awara*) derived from blends of orange fleshed sweet potatoes with soybeans from different agricultural produce is achievable and reduces dependence on soybeans while improving the nutritional status of consumers.

References

- Adane, T., Shimelis, A., Negussie, R., Tilahun, B., & Haki, G. D. (2013). Effect of processing method on the proximate composition, mineral content and anti-nutritional factors of taro (*Colocasia esculenta L.*) grown in Ethiopia. *African Journal of Food, Agriculture, Nutrition and Development*, 13(2).
- Adetunji, V. O., & Babalobi, O. O. (2011). A comparative assessment of the nutritional

- contents of wara, a West African soft cheese, using *Calotropis procera* and *Cymbopogon citratus* as coagulants. *African Journal of Food, Agriculture, Nutrition and Development*, 11(7), 5573–5585.
- Alinnor, I. J., & Oze, R. (2011). Chemical evaluation of the nutritive value of *Pentaclethra macrophylla Benth* (African oil bean) seeds. *Pakistan Journal of Nutrition*, 10(4), 355–359.
- Appel, L. J., Brand, M. W., Daniels, S. R., Karanja, N., Elmer, P. J., & Sacks, F. M. (2006). Dietary approaches to prevent and treat hypertension: A scientific statement from the American Heart Association. *Hypertension*, 47(2), 296–308.
- Bethke, P. C., & Jansky, S. H. (2008). The effects of boiling and leaching on the content of potassium and other minerals in potatoes. *Journal of Food Science*, 73(5), H80–H85.
- Chaturvedi, Y., & Nagar, R. (2001). Levels of β -carotene and effects of processing on selected fruits and vegetables of the arid zone of India. *Plant Foods for Human Nutrition*, 56(2), 127–132.
- Food and Agriculture Organization of the United Nations. (2019). FAOSTAT. <https://www.fao.org/faostat/en/#data>
- Jafari, M., Koocheki, A., & Milani, E. (2018). Physicochemical and sensory properties of extruded sorghum–wheat composite bread. *Journal of Food Measurement and Characterization*, 12(1), 370–377.
- James, S., Nwokocha, L., Tsebam, B. C., Amuga, S. J., Ibrahim, A. B., & Audu, Y. (2016). Effects of different coagulants on the physico-chemical, microbial and sensory properties of wara, a Nigerian soft soy-cheese. *Agro-Science*, 15(3), 41–45.
- Kaur, J., & Singh, P. K. (2022). Trypsin detection strategies: A review. *Critical Reviews in Analytical Chemistry*, 52(5), 949–967.
- Khan, N., Choi, J. Y., Nho, E. Y., Hwang, I. M., Habte, G., Khan, M. A., & Kim, K. S. (2014). Determination of mineral elements in milk products by inductively coupled plasma-optical emission spectrometry. *Analytical Letters*, 47(9), 1606–1613.
- Korada, R. R., Naskar, S. K., Palaniswami, M. S., & Ray, R. C. (2010). Management of sweet potato weevil [*Cylas formicarius* (Fab.)]: An overview. *Journal of Root Crops*, 36(1), 14.
- Lee, K., & Brennand, C. P. (2005). Physicochemical, textural and sensory properties of a fried cookie system containing soy protein isolate. *International Journal of Food Science and Technology*, 40(5), 501–508.
- Low, J. W., Arimond, M., Osman, N., Cunguara, B., Zano, F., & Tschirley, D. (2007). Food-based approach introducing orange-fleshed sweet potatoes increased vitamin A intake and serum retinol concentrations in young children in rural Mozambique. *Journal of Nutrition*, 137(5), 1320–1327.
- Malnutrition, M. (2012). Biofortification: Leveraging agriculture to reduce hidden hunger (S. Fan & R. Pandya-Lorch, Eds.). International Food Policy Research Institute.
- Massey, L. K., Palmer, R. G., & Horner, H. T. (2001). Oxalate content of soybean seeds (*Glycine max*: Leguminosae), soyfoods, and other edible legumes. *Journal of Agricultural and Food Chemistry*, 49(9), 4262–4266.
- McLaren, C. E., Garner, C. P., Constantine, C. C., McLachlan, S., Vulpe, C. D., Snively, B. M., & McLaren, G. D. (2011). Genome-wide association study identifies genetic loci associated with iron deficiency. *PLoS One*, 6(3), e17390. <https://doi.org/10.1371/journal.pone.0017390>
- Megat Rusydi, M. R., & Azrina, D. A. (2012). Effect of germination on total phenolic, tannin and phytic acid contents in soybean and peanut. *International Food Research Journal*, 19(2), 673–678.
- Meilgaard, M., Civille, G. V., & Carr, B. T. (2007). Sensory evaluation techniques (4th ed.). CRC Press.
- Neela, S., & Fanta, S. W. (2019). Review on nutritional composition of orange-fleshed sweet potato and its role in management of vitamin A deficiency. *Food Science & Nutrition*, 7(6), 1920–1945.
- Ogunbanwo, S. T., Sanni, A. I., & Onilude, A. A. (2011). Effect of bacteriocinogenic *Lactobacillus* spp. on the shelf life of fufu, a traditional fermented cassava product. *World Journal of Microbiology and Biotechnology*, 20(1), 57–63.
- Olayiwola, I. O., Abubakar, H. N., Adebayo, G. B., & Oladipo, F. O. (2009). Study of sweet potato (*Ipomea batatas Lam*) foods for indigenous consumption through chemical and anti-nutritive analysis in Kwara state, Nigeria. *Pakistan Journal of Nutrition*, 8(12), 1894–1897.

- Oyeyinka, A. T., Odukoya, J. O., & Adebayo, Y. S. (2019). Nutritional composition and consumer acceptability of cheese analog from soy and cashew nut milk. *Journal of Food Processing and Preservation*, 43(12), e14285.
- Robertson, T. M., Alzaabi, A. Z., Robertson, M. D., & Fielding, B. A. (2018). Starchy carbohydrates in a healthy diet: The role of the humble potato. *Nutrients*, 10(11), 1764.
- Sanni, A. I., Onilude, A. A., & Momoh, M. O. (2011). Selection of starters and a starter-mediated novel procedure for production of wara, a West African soft cheese. *International Journal of Food Science and Technology*, 34(3), 325–333.
- Steele, R., & Torrie, J. (1980). *Principles and procedures of statistics*. McGraw-Hill.
- Sudha, P., Rajkumar, P., Joice, A. A., Sudagar, I. P., & Arulmari, R. (2022). Postharvest technology of tamarind. In *Postharvest technology—Recent advances, new perspectives and applications* (pp. 1–21). IntechOpen. <https://doi.org/10.5772/intechopen.107564>
- Suma, P. F., & Urooj, A. (2014). Nutrients, anti-nutrients and bioaccessible mineral content (in vitro) of pearl millet as influenced by milling. *Journal of Food Science and Technology*, 51(4), 756–761.
- Tabasum, S., Ahmad, S., Akhlaq, N., & Rahman, K. (2001). Estimation of tannins in different food products. *Pakistan Journal of Nutrition*, 10(1), 1–6.
- Talamond, P., Doulebeau, S., Rochette, I., Guyot, J. P., & Trèche, S. (2000). Anion-exchange high-performance liquid chromatography with conductivity detection for the analysis of phytic acid in food. *Journal of Chromatography A*, 871(1–2), 7–12.
- Tilahun, A., Shimelis, A., Gulelat, D., & Tilahun, B. (2013). Effect of processing on physicochemical composition and anti-nutritional factors of cassava (*Manihot esculenta Crantz*) grown in Ethiopia. *International Journal of Science Innovations and Discoveries*, 3(2), 212–222.
- Vagadia, B. H., Vanga, S. K., & Raghavan, V. (2017). Inactivation methods of soybean trypsin inhibitor: A review. *Trends in Food Science & Technology*, 64, 115–125.
- Zhou, Z., Zhang, B., Liu, H., Liang, X., Ma, W., Shi, Z., & Yang, S. (2019). Zinc effects on cadmium toxicity in two wheat varieties (*Triticum aestivum* L.) differing in grain cadmium accumulation. *Ecotoxicology and Environmental Safety*, 183, 109562.