The Influence of Drying Techniques on the Proximate, Functional, and Sensory Properties of Soy-plantain Flour

Ojo, Stanley Efosa[1], Oke, Moruf Olanrewaju[1], and [*]Hussein, Jelili Babatunde[2]

[1]*Department of Food Engineering, Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria.*
[2*]*Department of Food Science and Technology, Modibbo Adama University, Yola, Adamawa State, Nigeria.*

***Corresponding author:** *jbhussein01@mautech.edu.ng*

ABSTRACT

Background: *Drying is a crucial food preservation technique because it guarantees a longer shelf life. Unfortunately, almost all drying techniques degrade the product's quality and reduce its value. Therefore, the impact of drying methods on the quality of dried plantain was investigated.* ***Objective****: The study looked at how different drying techniques affect the proximate, sensory, and functional characteristics of plantain flour, as well as the nutritional value and acceptability of the plantain-soy flour mixtures.*

Methods*: The ratios of the plantain-soy flour mixtures were 100:0, 95:5, 90:10, and 85:15. Using acceptable procedures, the samples' proximate compositions and functional characteristics were assessed. A seven-point hedonic scale was used to rate the sensory evaluation of the reconstituted thick paste.*

Results*: The soy-plantain flours' approximate compositions were as follows: moisture content, 8.54–17.73%; crude protein, 3.32–7.86%; crude fat, 1.00–4.00%; ash, 0.56–3.49%; crude fibre, 0.28–1.76%; and carbohydrate, 63.24–78.34%. Functional characteristics included a 2.15–2.29% water absorption capacity, a 36.25–44.75 percent swelling capacity, a bulk density of 0.74–1.78 g/cm^3, and a 40.22–51.19% gelation rate. According to the sensory analysis, the panelists' favourite product was a thick paste made from oven-dried ingredients with a 15% soy flour substitution.*

Conclusion*: The results revealed that oven drying offered a superior alternative to the traditional natural sun and solar drying methods in terms of protein, moisture, fibre, and sensory qualities.*

Keywords: drying methods, proximate properties, sensory evaluation, functional properties, soy-plantain

Received: 13-08-2022
Accepted: 07-11-2022
doi: https://dx.doi.org/10.4314/njns.v44i1.24

INTRODUCTION

Plantains are one of Nigeria's most crucial crops for the food security of farming households (*Musa paradisiaca*) (1). In West and Central Africa, about 70 million people get more than 25% of their carbohydrates from plantains, making it a good source of energy (2). It serves as a good alternative to the typical staple foods with a nutritional value similar to that of yams or potatoes. In Nigeria, plantains are primarily eaten in fried, boiled and roasted forms. It is also processed as snacks like chips, dodo-ikire, etc. It is also processed into flour to produce thick paste by dissolving an appropriate amounts of boiling water (3). Plantains are increasingly being used in composite flour preparations and complementary food formulations.

More than half of the world's plantains are produced in Africa, with Nigeria making up one of the top five producers with an average annual growth rate of 2.69% (4). Thus, plantain production in Nigeria generates a respectable amount of profit. Still, it could grow if more young entrepreneurs were interested in it and the government implemented policies that would encourage the export of plantains to other nations (4). Nigeria's consumption and exportation of plantains have increased significantly in recent years as a result of the country's rapid urbanisation and the high demand for quick and convenient food among the non-farming urban communities (3). In addition to being a well-known staple food for diets, plantains are also a rich source of nutrients, containing 35% carbohydrates, 0.2–0.5% fat, 1.2% protein, and 0.8% ash (2). Notwithstanding these nutritional benefits, total reliance on plantains has been reported not to satisfy daily protein needs (3), therefore protein supplementation becomes a necessity. Soya bean supplementation becomes essential to prevent the problem of malnutrition that could result from plantains' lack of protein. Soybeans are known to be more protein-rich than any common vegetable or animal food source found in Nigeria, with an average protein content of 40% (5). Thus, it is expected that the addition of soybeans to plantain flour will give consumers access to adequate diet and improve the nutritional quality of such products with new functional and sensory characteristics.

Moreover, the fresh plantain's high perishability is primarily caused by its moisture content, which is about 59.77% (6). Also, inadequate handling, storage, and transportation of plantains, causes a significant portion of the harvested crop to be lost from the farm gate to the market (3). As a result, the high moisture content will be reduced by drying it, extending its shelf life and making it always available. The dried samples can be processed into flour and added to other products like soy flour to complement their nutritional content. However, adding soy flour to plantain flour might alter the flour's physicochemical characteristics and affect how well the thick reconstituted paste made from this composite flour is received (7). The proximate, functional, and nutritional properties of the flour will undoubtedly be affected differently by the various drying techniques that will be used (8, 9). Therefore, the purpose of this study is to ascertain how different drying techniques affect the proximate, sensory, and functional characteristics of soy-plantain flour.

MATERIALS AND METHODS

Fresh, semi-ripe plantains and soybeans were purchased from a neighbourhood market in the southwest of Nigeria for this study. They were brought to the Ladoke Akintola University of Technology's (LAUTECH) Department of Crop Production and Soil Science in Ogbomoso, Oyo State, Nigeria, for identification.

PREPARATION OF PLANTAIN AND SOYBEAN FLOUR

After being divided into separate bunches, plantains are detached. The fingers were cleaned, peeled, and cut into thin slices measuring 5 mm thick with a stainless kitchen knife. Browning was then prevented by pretreating the slices for 15 minutes at 50°C with sodium metabisulphite water. The pretreated plantain slices were divided into equal batches of the same quantity after being drained with a plastic sieve. The solar, sun, and oven dryers were used to dry each batch separately. The dried plantains were ground into fine flour using a commercial grinding machine after drying, and they were then put through a sieve with a 1 mm mesh screen. For further examination, the plantain flour was contained in a plastic bag.

On the other hand, using the process outlined by Abioye et al. (10) soybean seed was transformed into defatted flour. The defatted soybean was ground into fine flour using a commercial mill and put through a sieve with a 1 mm mesh size. A plastic container containing the soybean flour was used to store it for later analysis.

PREPARATION OF VARIOUS FLOUR BLENDS

The flour blends were produced by combining the necessary amounts of the individual flours in a Kenwood blender (Philips HR 2001, China) until they were homogenous and contained varying percentages of soybean flour (0 to 15%) and plantain flour (100 to 85%). The plantain to soy flour ratios that were obtained were 100:0, 95:5, 90:10, and 85:15.

DETERMINATION OF PROXIMATE AND FUNCTIONAL PROPERTIES

According to the AOAC (11) method, samples produced from various combinations of soy and plantain flour were examined for moisture, crude protein, crude fat, ash, crude fibre, and carbohydrate content. The Hussein et al. (12) method was used to calculate the samples' bulk density and water absorption capacity. The analyses were completed at the LAUTECH, Ogbomoso, food engineering department's food processing laboratory.

SENSORY EVALUATION

Fifty grams of the flour mixture and 15 mL of boiling water were used to create a thick paste (amala). Using a 7-point Hedonic scale, the samples were evaluated for their appearance, taste, texture, flavour, and general acceptability (13). The hedonic scale has seven points, with 1 denoting extreme dislike and 7 denoting extreme like. Twenty semi-trained panelists received the thick paste on clear plastic plates and were instructed to rinse their mouths with fresh, room-temperature water before receiving the next serving. To prevent crowding and to allow for impartial judgement, the containers containing the samples were coded and kept far apart. The panellists were chosen in accordance with the fundamental criteria, including availability for the entire evaluation period, interest, willingness to serve, good health (free of colds), and lack of allergy or sensitivity to the product emulated.

STATISTICAL ANALYSIS

Statistical Analysis of Variance (ANOVA) was used to determine whether the difference in the experimental data was statistically significant ($p < 0.05$). The mean and standard deviation of three replicate analyses are used to calculate all values. The data were examined using one-way ANOVA for multiple comparisons, followed by Duncan's post hoc analysis.

RESULTS

Table 1 shows the outcomes of the soy-plantain flour's proximate compositions made after the drying of the plantain using various drying techniques. The moisture contents ranged from 8.54% to 17.73% and were significantly different ($p<0.05$). The protein content of the mixed samples varied between 3.32 and 7.86%, with a significant difference ($p<0.05$) present. The crude fat content varied significantly ($p<0.05$) and increased the more soy flour was substituted. It ranged from 1.00 to 4.00% for 0 percent to 15 percent soybean substitution levels. The ash contents were significantly different ($p<0.05$). The solar-dried flour blend (whole plantain flour) had the lowest ash content (0.74%), whereas the sun-dried flour blend (15 percent soy flour substitution) had the highest (3.49%).

For all of the mixes, the crude fibre content varied significantly ($p< 0.05$) and ranged from 0.28 to 2.01%. With increasing amounts of soy flour substituted in the blends, the composite flour's carbohydrate content decreases.

Table 2 shows the *functional properties of soy-plantain flour*. Plantain-soy flours have significantly different bulk densities ($p<0.05$), which varied between 0.7 and 1.7 g/cm^3. The water absorption capacity (WAC) of plantain-soy flours ranged from 2.17% to 2.39% with no discernible difference ($p>0.05$). The percentage of swelling capacity varied from 36.25% to 44.75%. With the substitution of soy flour, the swelling capacity decreased but was not statistically different ($p>0.05$). The percentage of gelation capacity varied from 40.92% to 51.19%. As the substitution of soy flour increased, the gelation capacity fell.

The *amala*'s sensory characteristics varied significantly ($p<0.05$) as shown in Table 3. A significant factor is appearance, which also affects how consumers judge something. The range of the appearance rating is 2.26 to 6.07. The panellists' top pick was a thick paste made from oven-dried ingredients with a 15% soy flour substitution. Foods must also have flavour, which is a crucial ingredient. A thick paste made from oven-dried ingredients with a 5% soy flour substitution received the highest taste ratings, with ratings ranging from 3 to 6.67. The acceptability of the flavour ranged from 2.93 to 6.27; the most favoured was a thick paste made from oven-dried ingredients with a 5% soy flour substitution.

Table 1: *Proximate Composition of Soy-Plantain Flour (%)*

Samples	Moisture contents	Crude protein	Crude fat	Ash	Crude fibre	Carbohydrate
SO_A	11.71 ± 0.58^{bc}	4.43 ± 0.11^{b}	1.00 ± 0.01^{a}	0.74 ± 0.01^{a}	1.16 ± 0.02^{a}	76.95 ± 0.22^{e}
SO_B	14.38 ± 0.01^{cd}	5.85 ± 0.08^{c}	1.00 ± 0.01^{a}	1.21 ± 0.09^{ab}	1.39 ± 0.05^{a}	72.76 ± 0.22^{c}
SO_C	15.83 ± 0.64^{e}	6.65 ± 0.03^{d}	2.00 ± 0.01^{b}	2.65 ± 0.05^{bc}	1.46 ± 0.21^{b}	69.41 ± 0.47^{b}
SO_D	17.73 ± 1.15^{g}	7.54 ± 0.34^{e}	4.00 ± 0.01^{d}	3.41 ± 0.09^{c}	1.43 ± 0.15^{ab}	65.91 ± 0.67^{b}
SU_A	11.97 ± 0.89^{bc}	3.32 ± 0.12^{a}	1.00 ± 0.01^{a}	0.56 ± 0.06^{a}	0.28 ± 0.13^{a}	78.34 ± 0.85^{f}
SU_B	13.48 ± 0.31	5.30 ± 0.33^{ab}	1.66 ± 0.58^{ab}	1.84 ± 0.01^{b}	0.77 ± 0.34^{a}	74.52 ± 0.81^{d}
SU_C	16.15 ± 0.11^{f}	6.04 ± 0.01^{c}	2.00 ± 0.01^{b}	2.12 ± 0.01^{b}	1.47 ± 0.13^{b}	73.52 ± 0.07^{c}
SU_D	14.72 ± 0.27^{d}	6.86 ± 0.15^{d}	3.00 ± 0.01^{c}	3.49 ± 0.01^{c}	1.76 ± 0.09^{b}	72.17 ± 0.23^{c}
OV_A	8.54 ± 0.01^{a}	4.93 ± 0.69^{ab}	1.00 ± 0.01^{a}	0.91 ± 0.01^{a}	1.76 ± 0.89^{b}	69.25 ± 1.09^{b}
OV_B	9.93 ± 0.55^{ab}	5.57 ± 0.24^{c}	1.00 ± 0.01^{a}	1.23 ± 0.47^{ab}	1.11 ± 0.31^{a}	65.18 ± 0.22^{ab}
OV_C	9.93 ± 1.75^{ab}	6.72 ± 0.16^{d}	2.00 ± 0.01^{b}	1.59 ± 0.25^{b}	1.53 ± 0.01^{b}	64.23 ± 1.63^{a}
OV_D	10.47 ± 0.46^{ab}	7.86 ± 0.15^{e}	3.00 ± 0.01^{c}	2.31 ± 0.01^{b}	2.01 ± 0.74^{b}	63.24 ± 0.37^{a}

Values are expressed as mean ± standard deviation of triplicate determination, means with the same superscript along the same column are not significantly different ($p>0.05$)

Keys:
SO = Solar dried flour blend,
SU = Sun dried flour blend
OV = Oven dried flour blend at 50 °C
A = 100:0 plantains to soy flour,
B = 95:5 plantains to soy flour,
C = 90:10 plantains to soy flour and
D = 85:15 plantains to soy flour

__Table 2__: Functional Properties of Soy-Plantain Flour

Samples	BD (g/cm^3)	WAC (%)	SC (%)	GEL (%)
SO_A	1.78 ± 0.01^b	2.17 ± 0.25^a	44.42 ± 1.39^a	44.42 ± 1.39^e
SO_B	1.31 ± 0.01^{ab}	2.22 ± 0.03^a	41.87 ± 1.13^a	42.87 ± 1.13^d
SO_C	1.09 ± 0.58^a	2.26 ± 0.21^a	40.91 ± 1.74^a	41.11 ± 1.74^b
SO_D	0.81 ± 0.01^a	2.31 ± 0.02^a	40.23 ± 3.77^a	40.22 ± 3.77^a
SU_A	1.33 ± 0.42^{ab}	2.15 ± 0.01^a	41.19 ± 1.80^a	51.19 ± 1.81^i
SU_B	1.32 ± 0.41^{ab}	2.25 ± 0.01^a	41.20 ± 1.80^a	50.16 ± 1.24^h
SU_C	0.77 ± 0.01^a	2.27 ± 0.01^a	39.31 ± 0.37^a	47.32 ± 0.37^g
SU_D	0.74 ± 0.01^a	2.29 ± 0.02^a	36.25 ± 3.01^a	45.24 ± 3.02^f
OV_A	1.62 ± 0.18^b	2.21 ± 0.01^a	44.75 ± 0.82^a	44.75 ± 0.83^e
OV_B	1.24 ± 0.01^{ab}	2.18 ± 0.01^a	43.45 ± 0.13^a	43.46 ± 0.12^d
OV_C	0.82 ± 0.04^a	2.24 ± 0.53^a	42.13 ± 1.47^a	42.13 ± 1.47^c
OV_D	0.78 ± 0.55^a	2.28 ± 0.01^a	41.92 ± 0.51^a	40.92 ± 0.51^a

Values are expressed as mean ± standard deviation of triplicate determination, means with the same superscript along the same column are not significantly different ($p>0.05$)

Keys:
BD = Bulk Density,
WAC = Water Absorption Capacity,
SC = Swelling Capacity,
GEL = Gelation Capacity,
SO = Solar dried flour blend,
SU = Sun dried flour blend
OV = Oven dried flour blend at 50 °C
A = 100:0 plantains to soy flour,
B = 95:5 plantains to soy flour,
C = 90:10 plantains to soy flour and
D = 85:15 plantains to soy flour

***Table 3**: Sensory Qualities of Reconstituted Plantain Soy Thick Paste (Amala)*

Samples	Appearance	Taste	Texture	Flavor	Overall acceptability
SO_A	3.60 ± 0.04^{e}	3.07 ± 0.04^{a}	3.33 ± 0.12^{cd}	3.60 ± 0.06^{ab}	3.13 ± 0.06^{ab}
SO_B	3.13 ± 0.02^{cd}	3.20 ± 0.06^{a}	2.53 ± 0.27^{a}	2.93 ± 0.04^{a}	3.33 ± 0.12^{c}
SO_C	3.33 ± 0.08^{d}	3.26 ± 0.04^{a}	3.46 ± 0.18^{d}	3.73 ± 0.05^{ab}	2.93 ± 0.02^{a}
SO_D	4.92 ± 0.05^{f}	4.21 ± 0.23^{c}	4.35 ± 0.07^{e}	3.85 ± 0.06^{ab}	4.42 ± 0.06^{e}
SU_A	2.26 ± 0.07^{a}	3.26 ± 0.02^{a}	2.86 ± 0.05^{ab}	3.46 ± 0.02^{ab}	3.00 ± 0.06^{a}
SU_B	3.00 ± 0.07^{b}	3.53 ± 0.06^{ab}	3.57 ± 0.17^{d}	3.86 ± 0.28^{ab}	3.20 ± 0.07^{bc}
SU_C	3.66 ± 0.01^{e}	3.00 ± 0.08^{a}	3.06 ± 0.02^{bc}	3.80 ± 0.07^{ab}	2.93 ± 0.04^{a}
SU_D	3.33 ± 0.04^{d}	3.93 ± 0.02^{bc}	4.33 ± 0.06^{e}	3.86 ± 0.11^{ab}	3.86 ± 0.07^{d}
OV_A	5.66 ± 0.02^{h}	4.80 ± 0.07^{d}	5.93 ± 0.01^{g}	4.66 ± 0.03^{ab}	5.73 ± 0.02^{f}
OV_B	5.87 ± 0.08^{i}	6.67 ± 0.19^{f}	5.93 ± 0.04^{g}	6.27 ± 0.25^{b}	6.47 ± 0.02^{h}
OV_C	5.33 ± 0.17^{g}	6.13 ± 0.08^{e}	5.53 ± 0.03^{f}	6.07 ± 0.04^{b}	6.27 ± 0.09^{g}
OV_D	6.07 ± 0.04^{i}	6.00 ± 0.13^{e}	5.67 ± 0.12^{fg}	5.73 ± 0.16^{ab}	6.60 ± 0.06^{h}

Values are expressed as mean ± standard deviation of triplicate determination, means with the same superscript along the same column are not significantly different ($p>0.05$)

Keys:
SO = Solar dried flour blend,
SU = Sun dried flour blend
OV = Oven dried flour blend at 50 °C
A = 100:0 plantains to soy flour,
B = 95:5 plantains to soy flour,
C = 90:10 plantains to soy flour and
D = 85:15 plantains to soy flour

DISCUSSION

The amount of moisture in food indicates how long they should last on the shelf. The moisture content of the soy-plantain flour is somewhat higher than the malted sorghum-soy composite flour reported by Bolarinwa et al. (14) but fall within range reported for dried water yam and cocoyam (15). Higher moisture may affect the foods' ability to be stored properly (16). The oven dried samples from this is within the recommended safe limit of less than 10% by FAO/WHO but the sun and solar dried samples exceeded the FAO/WHO advised safe limit. According to Msheliza et al. (16), materials like flour and starch with moisture contents of over 12.5 percent are less stable in storage than those with lower moisture contents. A low moisture content is necessary for a long storage life. Fungal growth will undoubtedly be seen on moist food samples during storage. Food poisoning, such as aspergillosis, may be made more likely by fungi contaminating food. Oven-dried flour has a lower residual moisture content, making it the better choice because it resists fungal and other microbial infestations during storage better than undried food samples. As a result, the shelf life of oven-dried flour blends will be longer than that of sun-dried and solar-dried flour blends.

As the amount of soybean flour increased from 0% to 15%, the protein content increased, indicating nutrient enhancement. This might be a result of the substantial amount of protein in soybeans (10). Since high-protein foods can be expensive, the soy-plantain mixes' high protein content will be crucial for nutrition, especially in developing nations like Nigeria, where protein-energy malnutrition is a serious problem. The soy plantain flour produced by the oven drying method had a significantly higher crude protein content than flour created by the solar and sun drying methods. This might be a result of the oven drying process' consistency and quick drying time. Hussein et al. (9) reported a similar finding for oven-dried okra in comparison to sun-dried and solar-dried varieties. Due to this, oven drying is a suitable technique for the creation of nutrient-dense foods. Due to the rising percentage of soy flour substitution, the crude fat, ash, and crude fibre contents followed the same trend as the protein content. As the percentage of soy flour substitution increased, the amount of carbohydrates decreased.

The oven-dried flour had the lowest value for crude fat among the complemented flours. Although the flours' fat contents were found to be lower, the fortified flour's fat content increased, which may have been brought on by the addition of soybean flour. For malted sorghum-soy composite flour, Bolarinwa et al. (14) reported a similar increase as the level of substitutions increased. According to Bolarinwa et al. (14), fat has a big impact on how long food products stay fresh, so flour products may not want to have a lot of fat in them. Because all fats and foods containing fats have the potential to become rancid due to oxidation, the storage life of oven-dried soy plantain flour may be prolonged as a result of its low-fat content (17). High mineral content in the flour blend is indicated by the high ash content. The fibre contents found in this study were considerably lower than those found in the wheat and soy composite flour reported by Ndife et al. (18) and the malted sorghum-soy composite flour reported by Bolarinwa et al. (14), which had fibre contents ranging from 3.64 to 4.66%. Falola et al. (19) reported a lower fibre content (1.20-1.72%) for rice and soybean flour blends.

There are claims that eating foods high in fibre will improve the digestive system's functions (20). Additionally, fibre eliminates some diseases like obesity, diabetes, gallstones, and coronary heart disease and lowers the incidence of colon cancer (20). Therefore, the significant amount of fibre in these flour blends as soy inclusions rise suggests that they may aid in maintaining the digestive system's health and proper operation. The amount of carbohydrates in the flour blends varied significantly ($p < 0.05$), and the amount of sorghum-soy flour in the blends decreased as the proportion of sorghum-soy flour increased. This demonstrated that, when compared to other legumes, soybeans are not a good source of carbohydrates. The findings of Okoye et al. (21), who reported a decrease in carbohydrate content (73.40-34.90%) of wheat-soy bean flour with increasing soy flour substitution, are similar to the findings of this study. According to Oluwamukomi et al. (22), the carbohydrate content of wheat-cassava-and-soy composite flour decreased by 74.50% to 69.20%. For malted sorghum-soy composite flour, Bolarinwa et al. (14) also noted a 73.83-69.50% decline in the amount of carbohydrates.

When compared to flour made using other drying methods, the oven-drying method's carbohydrate content showed a significant decrease. This might be as a result of the oven drying process's consistency, higher moisture loss, and quick drying time. Hussein et al. (9) reported a similar finding for oven-dried okra in comparison to sun-dried and solar-dried varieties. The oven-dried plantain soy flour has a low carbohydrate content, making products made from these flour blends suitable for people with diabetes and other related health issues.

The application and use of food ingredients for different food products is determined by their functional properties. The bulk densities obtained were higher than the results (0.42-0.46 g/cm^3) for plantain-soy flour reported by Abioye et al. (10). With increasing levels of soy flour substitution, it was found that the bulk density decreased, with 100% plantain flour being the densest of all the samples. Food packaging and transportation are affected by bulk density; products with a higher bulk density have better packaging characteristics than those with a lower bulk density. High bulk density is preferable because it provides a better packaging advantage, allowing for the packaging of a larger volume of product (23).

The WAC was considerably lower than the 8.00–8.25% range for fermented and roasted sorghum–soy flour reported by Msheliza et al. (16). The plantain-soy flour substitution raised the WAC because of the higher protein content. By combining soy flour with plantain flour, the plantain flour gains a high capacity to bind water, which enhances its textural and reconstitution properties (24). Due to the presence of protein and the damage that the milling process causes to starch, the addition of soybean flour aids in the water-binding properties.

Swelling capacity is the amount of space, expressed in millilitres, that 1 g of food material will occupy during swelling under particular circumstances. The addition of soybean flour to the plantain flour may have reduced the ability to swell. High swelling capacity has reportedly been listed among the requirements for a quality product *(25)*. However, drying techniques do not appear to have a big impact on these characteristics. This depends on how much starch is in the flour. According to *Awuchi et al. (26),* starches with a higher concentration of branched amylopectin have a greater capacity to cause foods and flours to swell. However, depending on the plant source, different amounts and ratios of amylose and amylopectin can be found in starch. This explains why the swelling capacities of various flours derived from various plant sources and species vary. As a result, the findings indicated that adding soybean flour to plantain flour significantly reduced the flour's ability to swell, which may be related to the flour's lower starch content.

The ability to form a gel from a food system using biopolymers like starch or protein is referred to as gelation capacity, also known as gel transition property or gelation property (26). According to Sun et al. (27), the rate at which proteins gel is influenced by temperature, heating time, and protein concentration. The result showed that increasing the soy flour inclusion lowers the carbohydrate level and lowers the flour blends' ability to gel. This supported the finding of Awuchi et al. (26) that proteins and carbohydrates, particularly starch, are responsible for good gelling properties. Additionally, the presence of carbohydrates lowers the protein's thermodynamic affinity for an aqueous solution. It improves the gelling capacity by increasing the degree of protein molecule interactions (26).

The findings suggest that flavour influences whether a consumer has a pleasant or unpleasant sensory experience by increasing their appetite and possibly causing satiety. A reconstituted thick paste made from oven-dried ingredients (15% soy flour substitution) was rated the best overall among the samples because it had the highest mean sensory score from the panelists. Of all the sensory attributes considered, a thick paste made from oven-dried flour was the most preferred.

CONCLUSION

The study's results demonstrated that adding soy flour to plantains improved their nutritional value. The highest nutrient content is found in flour with the highest substitution ratio. This suggests that adding soy flour to plantains will help prevent nutritional deficiencies. The obtained plantain-soy mixtures have some useful qualities that might be useful in industrial applications, such as bulk density and water holding capacity. The outcome also made it clear that oven drying was a superior technique for drying plantain flour than the conventional natural sun and solar techniques, particularly in terms of enhancing protein, moisture, fibre, and sensory qualities. However, more research needs to be done on the products' shelf stability and micronutrient content.

ACKNOWLEDGMENTS: *Nil.*

REFERENCES

1. Lescot, T. (2020) Banana Genetic Diversity – Estimated World Production by Type of Banana. Fruit Tropical, 269: 98-102.
2. IITA, (2014) Plantain/Banana; Youth Agripreneurs. International Institute of Tropical Agriculture: Ibadan.
3. Adegunwa, M., Adelekan, E., Adebowale, A., Bakare, H. and Alamu, E. (2017)

Evaluation Of Nutritional and Functional Properties of Plantain (*Musa paradisiaca* L.) and Tigernut (*Cyperus esculentus* L.) Flour Blends For Food Formulations. Cogent Chemistry, 3(1): 1383707.
4. FAO, (2012) Food and Agriculture Organization Faostat Data Base. Available: http://faostat.fao.org/ (accessed 15.04.2021).
5. Omoigui, L. O., Kamara, A. Y., Kamai, N., Dugje, I. Y., Ekeleme, F., Lava Kumar, P., Ademulegun, T. and Solomon, R. (2020) Guide to Soybean Production in Northern Nigeria. International Institute of Tropical Agriculture: Ibadan, pp. 23.
6. Adepoju, O. T., Sunday, B. E. and Folarami, O. A. (2012) Nutrient Composition and Contributions of Plantain, (*Musa paradisiaca*) Products to Dietary Diversity of Nigerian Consumers. African Journal of Biotechnology, 11(71): 13601-13605.
7. Abata, G. D., Abata, E. O., Lene, D. B. and Akande, Y. O. (2019) Proximate, Mineral and Sensory Properties of Plantain–Soy Flour Blends. International Journal of Research and Scientific Innovation, 6(3): 2321–2705.
8. Falodun, A., Ayo-Omogie, H. and Awolu, O. (2019) Effect of Different Drying Techniques on the Resistant Starch, Bioactive Components, Physicochemical and Pasting Properties of Cardaba Banana Flour. Acta Universitatis Cibiniensis. Series E: Food Technology, 23(1): 35-42.
9. Hussein, J. B., Ilesanmi, J. O. Y., Filli, K. B. and Sanusi, M. S. (2018) Effects of Drying Methods on the Chemical Properties of Okra (*Abelmoschus Esculentus* L. Moench) Slices. Current Journal of Applied Science and Technology, 26(6): 1-10.
10. Abioye, V. F., Ade-Omowaye, B. I. O., Babarinde, G. O. and Adesigbin, M. K. (2011) Chemical, Physico-Chemical and Sensory Properties of Soy-Plantain Flour. African Journal of Food Science, 5: 176-180.
11. AOAC, (2016) Official Method of Analysis of AOAC International. 20th Ed.; Association of Official Analytical Chemist: 2016.
12. Hussein, J. B., Usman, M. A. and Filli, K. B. (2016) Effect of Hybrid Solar Drying Method on the Functional and Sensory Properties of Tomato. American Journal of Food Science and Technology, 4(5): 141-148.
13. Iwe, M. O. (2010) Some Sensory Methods And Data Analysis. In Handbook of Sensory Methods and Analysis, 2nd Ed.; Rojoint Communication Services LTD: Enugu, Nigeria, pp 80 – 85.
14. Bolarinwa, I. F., Olaniyan, S. A., Adebayo, L. O. and Ademola, A. A. (2015) Malted Sorghum-Soy Composite Flour: Preparation, Chemical and Physico-Chemical Properties. Journal of Food Process and Technology, 6(8): 467-474.
15. Agoyero, B. O., Akpiroroh, O. O., Osaweren, O. R. and Owabor, C. N. (2011) The Effect of Various Drying Methods on the Nutritional Composition of Musa Paradisiacal, Dioscorea Rotundata and Colocasia Esculenta. Asian Journal of Biochemistry, 6: 458-464.
16. Msheliza, E. A., Hussein, J. B., Ilesanmi, J. O. Y. and Nkama, I. (2018) Effect of Fermentation and Roasting on the Physicochemical Properties of Weaning Food Produced From Blends of Sorghum and Soybean. Journal of Nutrition and Food Sciences, 8: 681.
17. Vieira, S., Mcclements, D. and Decker, E. (2015) Challenges of Utilizing Healthy Fats in Foods. Advances in Nutrition, 6(3): 309S-317S.
18. Ndife, J., Kida, F. and Fagbemi, S. (2014) Production and Quality Assessment of Enriched Cookies From Whole Wheat and Full Fat Soya. European Journal of Food Science and Technology, 2: 19-28.
19. Falola, A. O., Olatidoye, O. P., Balogun, I. O. and Opeifa, A. O. (2013) Evaluation of Nutritional, Physicochemical Properties and Acceptability of Un-Dehulled 'Ofada' Rice and Soy Bean Flour Blends. Journal of Agriculture and Veterinary Science, 5: 118-128.

20. Schneeman, B. O. (2002) Gastrointestinal Physiology and Functions. British Journal of Nutrition, 88(2): 159-163.
21. Okoye, J. I., Nkwocha, A. C. and Ogbonnaya, A. E.(2008) Production, Proximate Composition and Consumer Acceptability of Biscuits from Wheat-Soybean Flour Blends. Journal of Food Science and Technology, 2: 6-13.
22. Oluwamukomi, M. O., Oluwana, I. B. and Akinbowale, O. F. (2011) Physicochemical and Sensory Properties of Wheat-Cassava Composite Biscuit Enriched with Soy Flour. African Journal of Food Science, 5(2): 50-56.
23. Arinola, S. O., Ogunbusola, E. M. and Adebayo, S. F. (2016) Effect of Drying Methods on the Chemical, Pasting and Functional Properties of Unripe Plantain (*Musa paradisiaca*) Flour. British Journal of Applied Science and Technology, 14(3): 1-7.
24. Adebowale, A. A., Sanni, S. A. and Oladapo, F. O. (2008) Chemical, Functional and Sensory Properties of Instant Yam Breadfruit Flour. Nigerian Food Journal, 26: 2-12.
25. Ibrahim, D. G. and Ani, J. C. (2018) Evaluation of the Nutritional and Functional Properties of Talia made from Wheat/Sorghum Flour Blends. Journal of Tropical Agriculture, Food, Environment and Extension, 17(2): 1-8.
26. Awuchi, C. G., Igwe, V. S. and Echeta, C. K. (2019) The Functional Properties of Foods and Flours. International Journal of Advanced Academic Research, 5(11): 139-160.
27. Sun, X., Shi, D., Lan, Y., Yao, X., Zhang, R., Zhang, Y., Su, P. and Shan, H. (2017)Factors Influencing Gelation Properties of Corn Germ Proteins. Journal of the Science of Food and Agriculture, 97(13): 4445-4450.