Influence of the soybean flour content (*glycine max L.*) on the nutritional and sensory quality of the dish Konkonde made from composite flour of plantain (*Musa paradisiaca*) and cassava (*Manihot esculenta cranzt*)

.Abstract :

In the context of improving the texture of Konkonde (a traditional African dish) based on plantain, cassava flour is often incorporated. In order to improve the nutritional value of this dish and meet the nutritional balance, soy flour was chosen as an additional ingredient. The aim of this research was to assess the influence of soy flour incorporation on the nutritional, functional and sensory properties of Konkonde. To this end, different Konkonde formulations were prepared by adding 10%, 15%, 20% and 25% soy flour to the base composite flour of cassava and plantain. Results showed that the incorporation of soy flour led to a significant improvement in the nutritional value of Konkonde formulation, notably in terms of protein (1.9% ± 0.1 to 12.9% ± 0.10), lipid (0.9% ± 0.10 to 4.27% ± 0.38), ash (1.9% ± 0.10 to 3.27% ± 0.15) and fiber (1.03% ± 0.15 to 2.6% ± 0.13) content. Functional properties such as, water absorption capacity and solubility index were affected by the addition of soy flour. Sensory evaluation revealed changes in the appearance, texture, taste and overall acceptability of Konkonde enriched with soy flour. After sensory evaluation, tasters showed a preference for the formulation containing 10% soy flour. Ultimately, the incorporation of soy flour improves the nutritional value of Konkonde, but an increasing rate of incorporation also leads to a change in the sensory properties specific to Konkonde. It is clear that the addition of soy flour had an impact on consumer perception

Keywords: Konkonde, cassava, plantain, soy flour, sensory evaluation

1. INTRODUCTION

Plantains (Musa paradisiaca) are used as an inexpensive source of calories in many African countries, particularly in Côte d'Ivoire (Temple and Kwa, 2019). They are an important staple food and a valuable source of income through local and international trade. Global production is estimated at around 44,150,813 tons (FAO, 2023) per year. In Côte d'Ivoire, annual plantain production amounts to more than 2 million tons. With this production, plantains rank fourth among food crops, with an estimated consumption of 120 kg/capita/year (FAOSTAT, 2023).
Nutritionally, plantains are rich in carbohydrates, which account for 84.2% of the unripe plantain fruit (Alonzo-Gómez et al. 2020). Unlike other starchy products such as cassava and yams, which have a long shelf life, plantains suffer significant post-harvest losses. They are

very difficult to store due to their high perishability (Atanda et al., 2011). To overcome this shortcoming, a number of studies have been undertaken to improve the shelf life of plantains and to explore the different dishes that can be made depending on the degree of ripeness of the pulp (Alexandra et al. 2019; Ayeh et al. 2023; Damndja et al. 2023; Apaliya et al. 2024).
In Côte d'Ivoire, the main dishes made from plantains are Konkonde, foutou, claclo, foufou, and many others. Plantains consumed when green have nutritional benefits due to their dietary fiber content. Like cassava flour, unripe plantain flour is used in the preparation of a wide variety of traditional dishes, including Konkonde (Alexandra et al., 2019). Konkonde, also known as Amala in Nigeria and Benin, or Konkonte in Ghana, is prepared from cassava flour, plantain flour, or yam flour. It is a paste made from the flour of the root or tuber cooked in boiling water. Plantain flour is generally not widely used in pasta production due to its low texturing power (Newilah, 2023). Therefore, the incorporation of cassava flour could correct this deficiency in plantain Konkonde in terms of texture, color, and taste, thereby increasing its acceptability for consumption. The cassava variety used for its good cooked dough texture is IAC, according to the work of Akpingny et al. (2017) and Alexandra et al. (2019). This variety is more commonly used in the preparation of derived dishes such as Attiéké and Placali.
Brown Konkonde is eaten with a protein-rich sauce for nutritional balance. The quality and source of protein depend on the consumer's social status. Very often, these sources are leaves, fish scraps, skin of beef, or beef. The level of poverty exacerbated by the current crises makes it difficult for a large part of the population to access protein sources. It is therefore necessary to offer other alternatives based on inexpensive, readily available, protein-rich local products such as soybeans or beans.
Soybeans (*Glycine max* L.) have long been used as a food supplement to enrich human and animal food formulations (Damndja et al. 2023; Olugbuyi et al. 2023; Akinyede et al. 2023; Verma et al. 2024; Dongmo et al. 2024). It also has the advantage of being widely grown and consumed by rural populations (Fasoyiro et al., 2012). This legume is a food with high nutritional and medicinal potential, given its high protein content (40 to 45%) and good essential amino acid profile (Zhang et al. 2022; Li et al. 2022; Alleza et al. 2025).
Furthermore, similar studies (Zhang et al. 2022; Akinyede et al. 2023; Damndja et al. 2023) have shown that adding soy flour to plantain flour improves the protein, essential amino acid, fiber, and mineral content. This substitution could also diversify our sources of dietary protein. While incorporating soy would improve the protein quality of the composite flour,but what would be its impact on the texture of the cooked Konkonde dough? And at what rate of soy flour incorporation would we obtain a composite flour for a Konkonde with an acceptable texture? These are some of the research questions that motivated the present study, whose overall objective is to contribute to making an acceptable soy-enriched composite flour available to the population.

2. MATERIAL AND METHODS

2.1 Preparation of Flour Samples

For the formulation of the Konkonde dish, four flour samples were prepared: one made from Afoto plantain (*Musa paradisiaca*) flour, another from IAC cassava (*Manihot esculenta cranzt*) flour, and a third from yellow soybean (*Glycine Max L*) flour. These flours were obtained from cassava roots, plantain fruit, and soybeans purchased at the local market (municipality of Yopougon Abidjan, Côte d'Ivoire). The plantain flour was prepared using a slightly modified version of the method described by Anajekwu et al. (2020), with the addition of a soaking step (in lemon juice at a ratio of 100 ml of extract to 1000 ml of tap water for 5 hours) for the banana pulp, as well as the temperature and duration of drying. The process can be summarized as follows: washing the plant material, peeling it with a knife (stainless steel), cutting it into slices (2 mm thick), then drying it in an oven at 45°C for 72 hours. After drying in the oven, the dried pulp was ground (BINATONE blender, China), followed by sieving through a 250 µm mesh sieve. Cassava flour was extracted as described above, except for the soaking step. For soybean flour, extraction was carried out according to the method described by Olunlade et al. (2013). The beans were sorted and then soaked in water for 8 hours. After soaking, the beans were oven-dried (45°C, 24 hours). Following drying, the grains were hulled, ground (BINATONE, China), and sieved using a 250 µm mesh sieve. The different flours obtained were stored in airtight containers with hermetic seals.

Formulation of the dish "Konkonde"

The base flour consists of a mixture of cassava and banana flours, each accounting for 50% of the total, based on the work of Alexendra et al. (2019), modified by increasing the cassava content from 30% to 50%. Soy flour was added to the mixture at rates of 10%, 15%, 20%, and 25%. The different formulations yielded the proportions shown in Table 1.

Table 1: Formulation table

	Cassava flour (IAC)	**Plantain flour**	**Soya flour**
Commercial Flour for Konkonde (CFK or FK)	100	0	0
Composite flour (CF or FC)	50	50	0
	Composite flour (Plantain + cassava)		**Soya Flour**
FCS1	90		10
FCS2	85		15
FCS3	80		20
FCS4	75		25

CFK / FK) : Commercial Flour for Konkonde (Control) ;
FC / CF : Composite Flour (Plantain + cassava)
FCS : Composite Flour plus Soya,
FIAC = 100% cassava Flour (Test) ;
FCS1 : 90% FC + 10% FSoya : Formulation 1 ;
FCS2 : 85% FC + 15% FSoya : Formulation 2 ;
FCS3 : 80% FC + 20% FSoya : Formulation 3 ;
FCS4 : 75% FC + 25% FSoya : Formulation 4

2.2 Determination of Nutritional Parameters of Flours

The different flours were analyzed by determining their dry matter, protein, lipid, ash, and fiber content. Dry matter was calculated based on the estimated water content using the AOAC (2000) method. Protein content was determined using the Kjeldahl method (AOAC, 2000) in three stages: digestion, distillation, and titration. The nitrogen-to-protein conversion factor is 6.25. The lipid content was estimated using Soxhlet extraction at 100°C with hexane, followed by evaporation of the solvent at 105°C in an oven (AOAC 2000). The ash content was determined by incineration in a muffle furnace at 550°C (AOAC 2000). The carbohydrate content (CC) of the samples was calculated according to the equation provided by AOAC (2000). The fiber content was determined by digestion (dilution of the sample in sulfuric acid followed by boiling for 30 min under reflux), filtration, drying in an oven at 105°C for 8 hours, and then incineration. The fiber content is calculated as the ratio of the mass of the dried and incinerated sample to the mass of the test sample (AOAC 2000).

$$\textbf{Carbohydrate}\ (\%) = 100 - [\textbf{M}\ (\%) + \textbf{P}(\%) + \textbf{L}(\%) + \textbf{Ash}(\%) + \textbf{F}(\%)]$$

2.3 Determination of the water absorption capacity of flours

The water absorption capacity (WAC) and water solubility index (WSI) of the powders were determined using the methods described by Sedláček and Švec. (2023) with small modification. A quantity of 1 g of sample was solubilized in a volume of 10 mL of distilled water contained in a centrifuge tube. This mixture was homogenized for 30 min and then kept in a water bath at 37°C for 30 min. After centrifugation at 4200 rpm for 15 min in a BIOBASE centrifuge (Shandong, China), the sediment obtained (M2) was weighed and then dried at 105°C in a ventilated oven (MEMMERT, Germany) until a constant mass was obtained (M1). The WAC and WSI were calculated using the following mathematical ratios.

$$\mathrm{WAC}\ (\%) = \frac{m_2 - m_1}{m_1} \times 100$$

$$\mathrm{WSI}\ (\%) = \frac{m_0 - m_1}{m_0} \times 100$$

WAC: Water Absorption Capacity
WSI: Water Solubility Index
m_1: dry mass (g) of the sample after drying
m_2: mass (g) of the fresh sediment after centrifugation

2.4 Sensory test

Preparation of Konkonde in different formulations

For the preparation of Konkonde, the technological diagram in Figure 1 was used after several attempts. The preparation steps included dissolving 2/3 of the mass (250 g) of composite flour (FCS1, FCS2, FCS3, and FCS4) in 1/3 of 750 mL of warm water, followed by homogenization until the lumps were completely dissolved. The remaining 2/3 of the water was brought to a boil in a pot, followed by the addition of the homogenized mixture and kneading until a dough was obtained. The remaining 1/3 of the flour was added during kneading. The resulting dough was then cooked over low heat for 5 min.

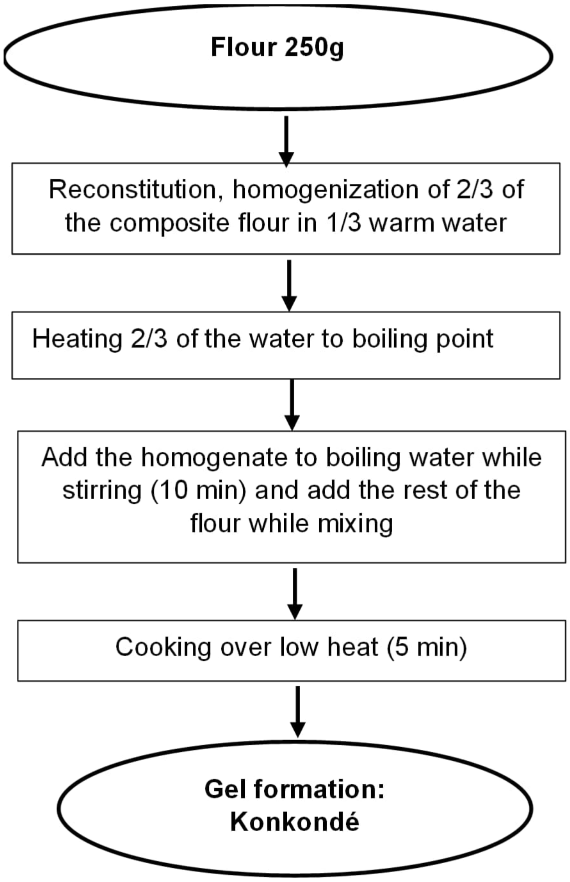

Figure 1: Technological diagram of Konkonde preparation

Sensory test

The sensory evaluation of the various Konkonde products was carried out in two stages: a descriptive test of the product followed by a preference test. Konkonde samples weighing 20 g were served to the panelists. Twelve tasters (students of both sexes) were trained for the descriptive test. For the hedonic test, 30 untrained individuals of both sexes, including administrative staff and students, were recruited.

Sensory evaluation procedure

To conduct the descriptive test, the twelve selected individuals were trained. The training began with preliminary trials using commercial Konkonde dough. These training sessions also allowed the panelists to familiarize themselves with the methodology and rating scale by better discerning the different descriptors. Finally, at the last session, the panelists were asked to evaluate samples of the four formulations made from composite flours, coded in a randomized three-digit order and presented simultaneously, using a form. This method therefore consists of evaluating and quantifying the descriptors, namely visually by evaluating color and appearance, and gustatorily by evaluating sourness and flavor. At the tactile level, elasticity, consistency, cohesiveness, hardness, and firmness. The samples were analyzed using a 9-point linear scale.

For the preference test, thirty untrained individuals were selected. Samples of the dishes made from the coded formulations were presented simultaneously. The panelists were asked to rate their preferences for a number of attributes (appearance, texture, taste, smell, and overall preference). The degree of perceived preference was scored on a 9-point hedonic scale.

2.4 Statistical analysis of data

The collected data were analyzed using STATISTICA software (version 7.1). The comparison of means between the different samples was performed using ANOVA. The specification of differences was performed using Duncan's post-hoc test at a 5% significance level.

3. RESULTS AND DISCUSSION

3.1 Moisture content

The moisture content of the various single-ingredient flours and mixed flours shows a significant difference (p = .05). The lowest content is observed in soy flour (SF), followed by plantain flour (F Plantain), with respective values of 9.48% ± 0.56 and 10.47% ± 0.35 (Figure 2). Among the composite flours, the lowest value is observed in the composite flour with 25% soy (9.97% ± 0.38) and the highest value in the flour with 10% soya (12.0% ± 0.10). The moisture content decreases with the incorporation rate of soybean flour in composite flours.

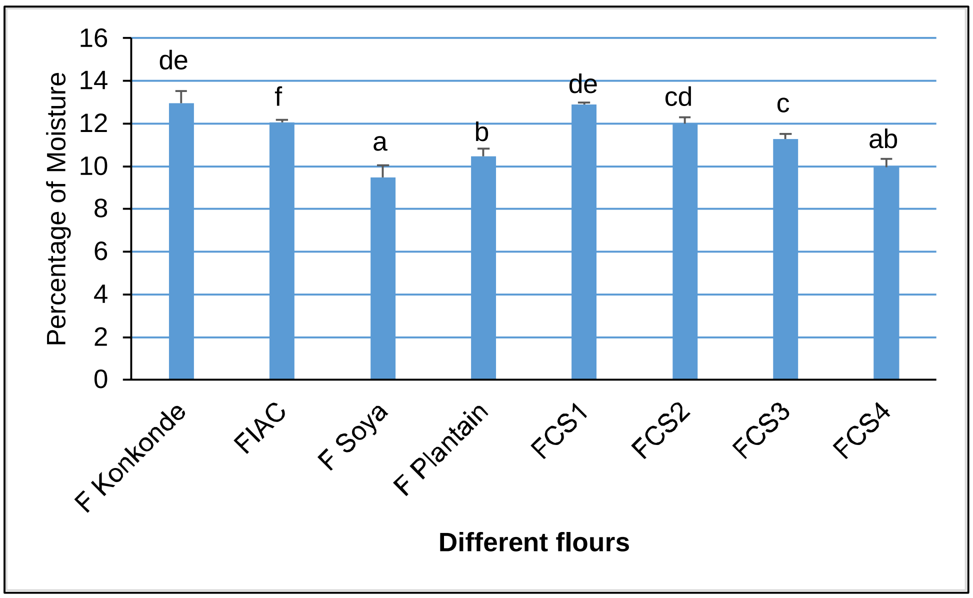

Figure 2: Moisture content of different single and mixed flours

FIAC = 100% cassava Flour (Test); F Konkonde : Commercial Flour for Konkonde (Control) ; F Soya : Soya Flour ; F Plantain : Plantain Flour ; **FCS1 :** 90% FC + 10% FSoya : Formulation 1 ; **FCS2 :** 85% FC + 15% FSoya : Formulation 2 ; **FCS3 :** 80% FC + 20% FSoya : Formulation 3 ; **FCS4 :** 75% FC + 25% FSoya : Formulation 4

3.2 Protein content of basic flours and composite flours

The protein content (Figure 3) of the various basic flours is low, with the exception of soy flour (p = .05). The control flour from Konkonde (commercial), cassava flour, and plantain flour were 1.90% ± 0.10, 2.30% ± 0.44, and 2.97% ± 0.3, respectively. The highest protein content was found in soybean flour (38.67% ± 0.68). As for the protein content of mixed flours, a gradual increase is observed as the amount of soybean flour increases. Mixed flours have a statistically higher content than single-ingredient flours (p = .05).

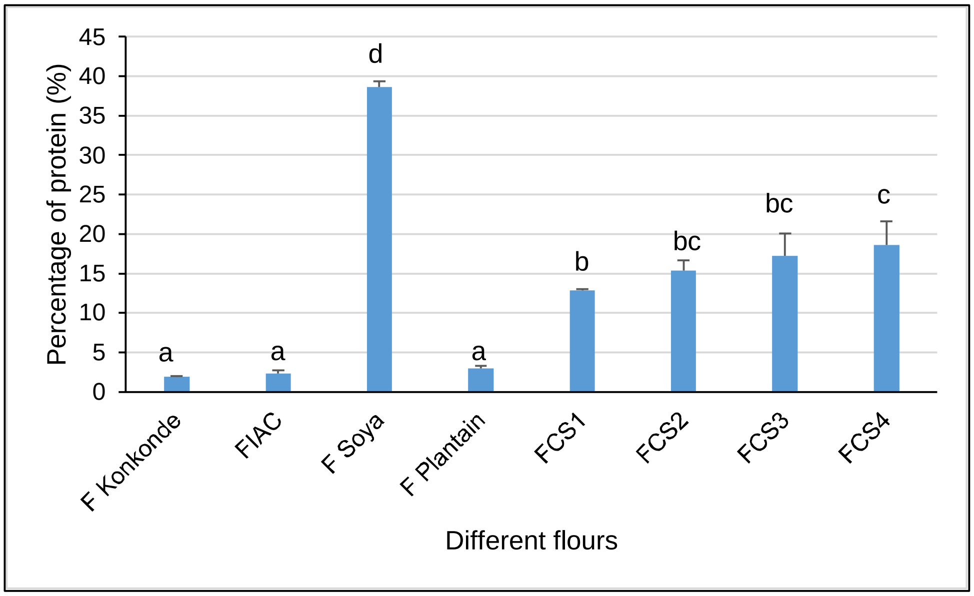

Figure 3: Protein content of different single and mixed flours

FIAC = 100% cassava Flour (Test); F Konkonde : Commercial Flour for Konkonde(Control) ; F Soya : Soya Flour ; F Plantain : Plantain Flour ; **FCS1 :** 90% FC + 10% FSoya : Formulation 1 ; **FCS2 :** 85% FC + 15% FSoya : Formulation 2 ; **FCS3 :** 80% FC + 20% FSoya : Formulation 3 ; **FCS4 :** 75% FC + 25% FSoya : Formulation 4

3.3 Lipid content of basic flours and composite flours

The lipid content of (Figure 4) elementary and mixed flours shows significant differences (p = .05). Cassava and plantain flours have the lowest values, 0.81% ± 0.11 and 1.67% ± 0.15, respectively, compared to soybean flour (19 ± 0.36). The lipid content of mixed flours (FCS1, FCS2, FCS3, and FCS4) increases with the incorporation rate (10-25%) of soybean flour. The values are as follows: 4.27% ± 0.38; 5.63% ± 0.25; 6.83 ± 0.15 and 7.30% ± 0.20. The incorporation of soybean flour increases the lipid content of composite flours.

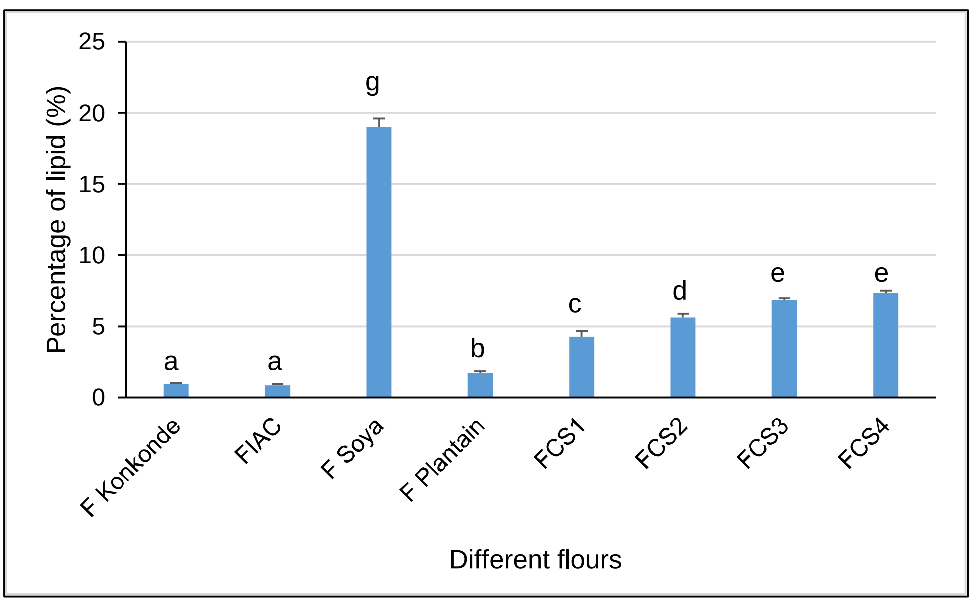

Figure 4: Lipid content of different single and mixed flours

FIAC = 100% cassava Flour (Test); F Konkonde : Commercial Flour for Konkonde (Control) ; F Soya : Soya Flour ; F Plantain : Plantain Flour ; **FCS1 :** 90% FC + 10% FSoya : Formulation 1 ; **FCS2 :** 85% FC + 15% FSoya : Formulation 2 ; **FCS3 :** 80% FC + 20% FSoya : Formulation 3 ; **FCS4 :** 75% FC + 25% FSoya : Formulation 4

3.4. Ash content of elementary flours and composite flours

The ash content (Figure 5) of the elemental and mixed flours shows a significant difference (p = .05). The values observed for the basic plantain flour (1.83% ± 0.15) and cassava flour (2.83% ± 0.15), as well as the commercial Konkonde flour (1.90 ± 0.10), do not show a significant difference (p = .05). The ash content of soybean flour was the highest (6.83 ± 0.25). However, the values observed for mixed flours (FCS1, FCS2, FCS3, and FCS4) varied depending on the soybean flour content (10-25%) incorporated. The values are 3.27 ± 0.15, 3.80 ± 0.10, 4.50 ± 0.20, and 5.07 ± 0.21, respectively.

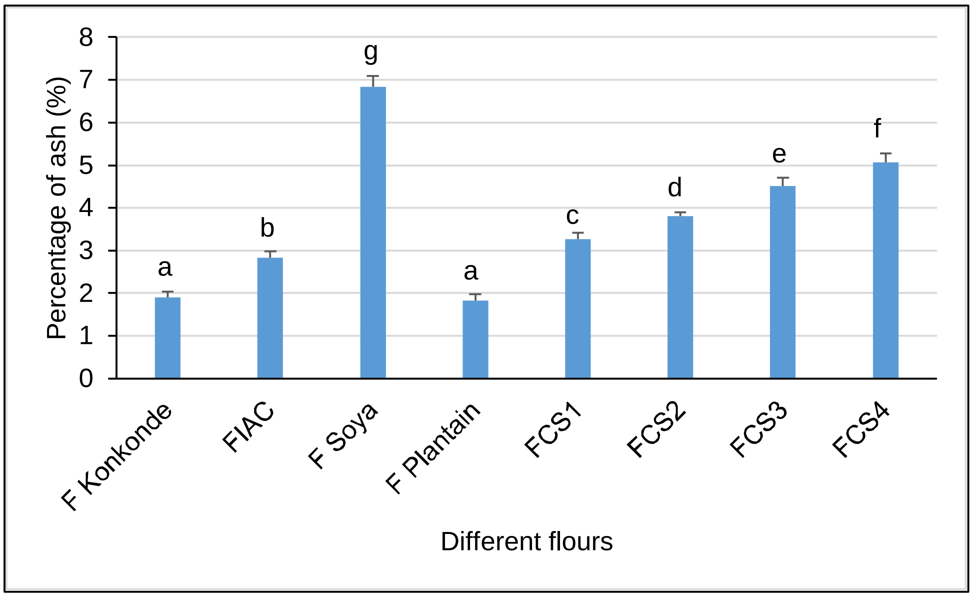

Figure 5: Ash content of different single and mixed flours

FIAC = 100% cassava Flour (Test); F Konkonde : Commercial Flour for Konkonde (Control) ; F Soya : Soya Flour ; F Plantain : Plantain Flour ; **FCS1 :** 90% FC + 10% FSoya : Formulation 1 ; **FCS2 :** 85% FC + 15% FSoya : Formulation 2 ; **FCS3 :** 80% FC + 20% FSoya : Formulation 3 ; **FCS4 :** 75% FC + 25% FSoya : Formulation 4

3.5 Fiber content of basic flours and composite flours

The fiber content of the elemental and mixed flours (Figure 6) shows a significant difference (p = 5%). Soybean flour has a higher content (5.77% ± 0.76) compared to the other samples of IAC single-ingredient flours (1.03% ± 0.15) and commercial Konkonde flour (1.60% ± 0.30) (p ≤ 5%). The contents of the composite flours are 2.60% ± 0.30, 3.70% ± 0.26, 4.03% ± 0.32, and 4.77% ± 0.25 for FCS1, FCS2, FCS3, and FCS4 flours, respectively.

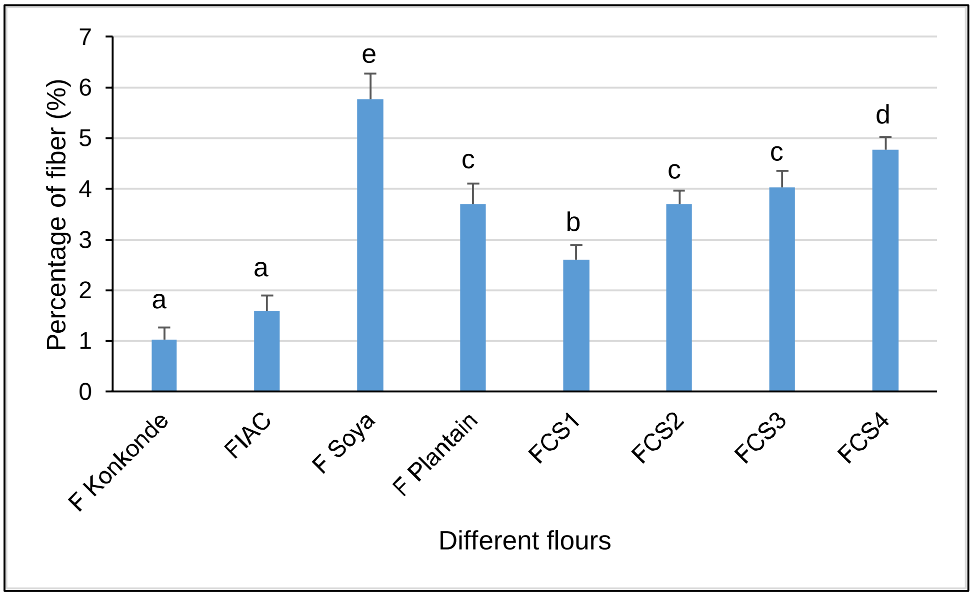

Figure 6: Fiber content of different single and mixed flours

FIAC = 100% cassava Flour (Test); F Konkonde : Commercial Flour for Konkonde (Control) ; F Soya : Soya Flour ; F Plantain : Plantain Flour ; **FCS1 :** 90% FC + 10% FSoya : Formulation 1 ; **FCS2 :** 85% FC + 15% FSoya : Formulation 2 ; **FCS3 :** 80% FC + 20% FSoya : Formulation 3 ; **FCS4 :** 75% FC + 25% FSoya : Formulation 4

3.6 Total carbohydrate content of basic flours and composite flours

The carbohydrate content (Figure 7) of the single-ingredient and mixed flours shows a significant difference (p = .05). Soybean flour has the lowest carbohydrate content among the single-ingredient flours (20.25% ± 1.39). Commercial Konkonde, cassava, and plantain flours have high values of 81.54% ± 0.57, 80.40% ± 0.54, and 79.37% ± 0.55, respectively. As for mixed flours, they have lower values, with significant differences (p = .05) between FCS1 flours (64.40% ± 0.31), FCS2 flours (58.47% ± 2.8); FCS3 (56.17% ± 4.22), and FCS4 (54.30% ± 4.94).

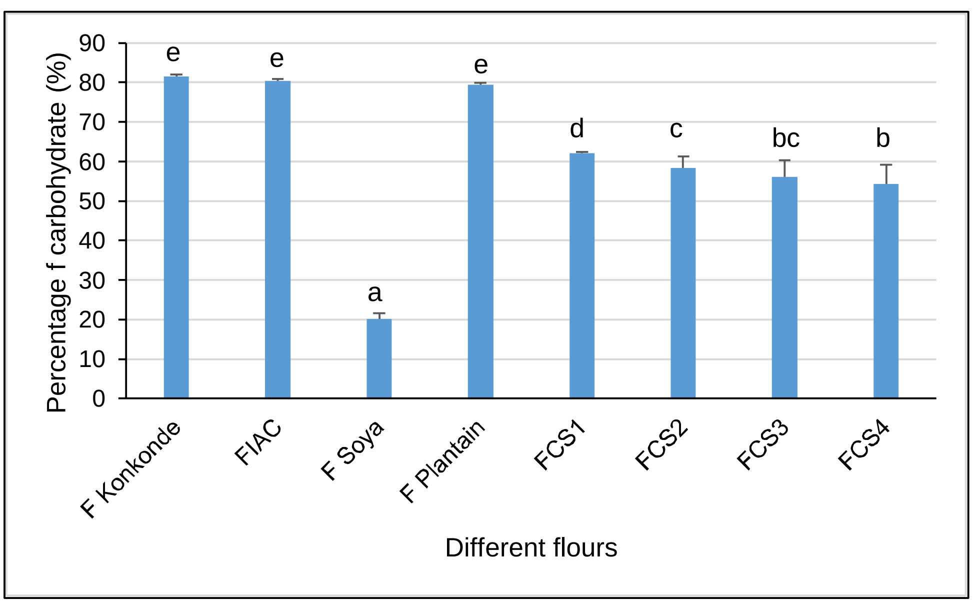

Figure 7: Carbohydrate content of different single and mixed flours

FIAC = 100% cassava Flour (Test); F Konkonde : Commercial Flour for Konkonde (Control) ; F Soya : Soya Flour ; F Plantain : Plantain Flour ; **FCS1 :** 90% FC + 10% FSoya : Formulation 1 ; **FCS2 :** 85% FC + 15% FSoya : Formulation 2 ; **FCS3 :** 80% FC + 20% FSoya : Formulation 3 ; **FCS4 :** 75% FC + 25% FSoya : Formulation 4

3.7. Water absorption capacity and water solubility index

The water absorption capacity of elementary and mixed flours (Figure 8) shows a significant difference (p = .05). Among the single-ingredient flours, the highest value was observed for soybean flour at 206.3% ± 4.93, followed by cassava flour at 178.00% ± 3.46 and plantain flour at 174.7% ± 1.53. Commercial Konkonde flour had the lowest value, at 172.3% ±2.5. However, mixed flours showed increasing values with increasing soy flour content for formulations FCS1, FCS2, FCS3, and FCS4, with values ranging from 163.00% ± 1.00 to 191.33% ± 2.08.

The ISE water solubility index (Figure 9) of elemental and mixed flours shows significant differences between certain samples (p ≤ 5%). Soybean flour has the highest value for single-ingredient flours at 22.7% ± 4.51. There is no significant difference between commercial Konkonde flour (16% ± 0.96), plantain flour (17% ± 2.38) and IAC cassava flour (18.67 ± 1.71%). In mixed flours, the ISE increases with the incorporation rate of soybean flour. The highest indices were observed with FCS3 (22 ± 2.98%) and FCS4 (27% ± 1.00) flours (p = .05).

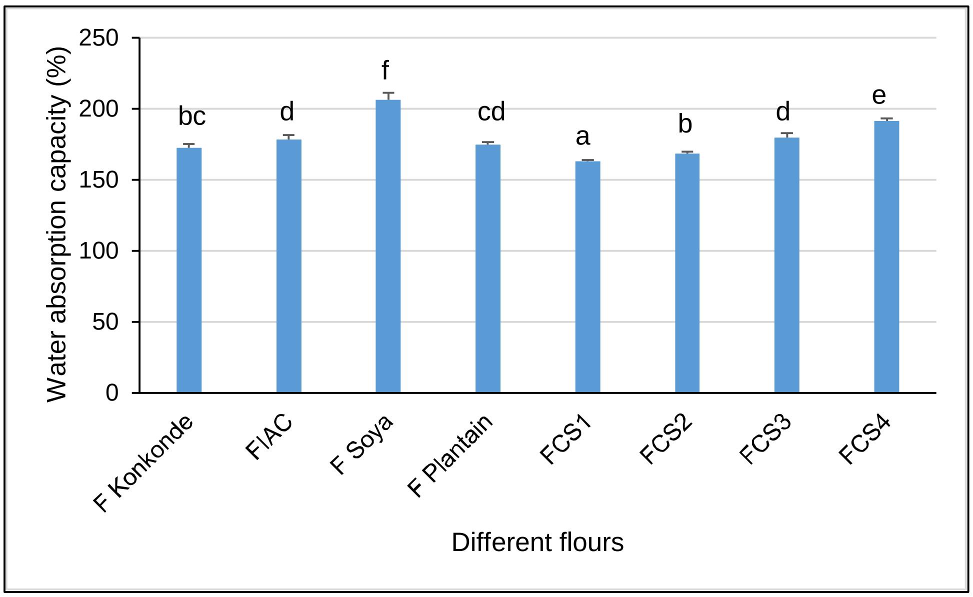

Figure 8: Water absorption capacity of different flours

FIAC = 100% cassava Flour (Test); F Konkonde : Commercial Flour for Konkonde (Control) ; F Soya : Soya Flour ; F Plantain : Plantain Flour ; **FCS1 :** 90% FC + 10% FSoya : Formulation 1 ; **FCS2 :** 85% FC + 15% FSoya : Formulation 2 ; **FCS3 :** 80% FC + 20% FSoya : Formulation 3 ; **FCS4 :** 75% FC + 25% FSoya : Formulation 4

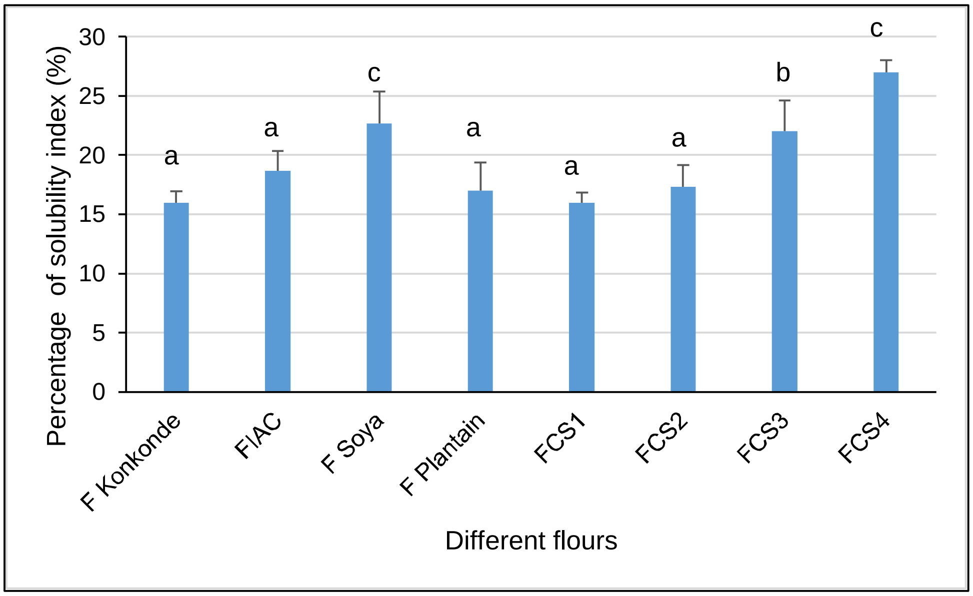

Figure 9: Water solubility index of different flours

FIAC = 100% cassava Flour (Test); F Konkonde : Commercial Flour for Konkonde (Control) ; F Soya : Soya Flour ; F Plantain : Plantain Flour ; **FCS1 :** 90% FC + 10% FSoya : Formulation 1 ; **FCS2 :** 85% FC + 15% FSoya : Formulation 2 ; **FCS3 :** 80% FC + 20% FSoya : Formulation 3 ; **FCS4 :** 75% FC + 25% FSoya : Formulation 4

3.8. Sensory profile of Konkonde formulations

The sensory profile evaluation showed statistically that the sensory characteristics of Konkonde vary significantly depending on the soy flour incorporation rate (Figure 10). The appearance in terms of surface gloss shows relatively different intensities. The dish made with IAC cassava flour has a higher surface gloss, followed by commercial Konkonde and the one with 10% soy flour. Regarding the brown color of the pastes obtained, increasing the soybean flour content has the opposite effect in terms of intensity. Thus, the Konkonde paste with 10% soybean flour (FCS1) is browner than those with 15% (FCS2), 20% (FCS3), and 25% (FCS4). The orange-yellow color is more pronounced in the reference samples: dishes made with IAC cassava flour and those made with commercial flour.

The texture of the dishes, evaluated on the basis of four attributes, namely firmness, hardness, cohesiveness, and adhesiveness, was influenced by the incorporation of soy flour. The Konkonde formulation with 10% soy (6.10/9) was very firm, followed by the formulation with 15% soy (4.30/9), and the softest was the formulation with 25% soy flour. The highest intensity of cohesiveness of the dishes was recorded with the 10% soy formulation (7.2/9), followed by the 15% soy formulation (5.10/9). Cohesiveness decreases with soybean flour content. However, adhesiveness, which expresses the stickiness of the dishes, is more noticeable in the reference samples (dishes made with IAC cassava flour and commercial flour). The adhesiveness of pasta made from mixed flour decreases as the amount of flour incorporated increases. Hardness also decreases in the same way as the previous attribute for the 15% (FCS2), 20% (FCS3), and 25% (FCS4) formulations. The 10% soybean flour formulation has the same hardness as the reference samples.

The sour taste was not very pronounced in any of the formulations. The vegetable aroma was perceived depending on the level of soy flour incorporation. The responses obtained for formulations ranging from 10 to 25% ranged from 1 to 3.

The overall acceptability of the product was assessed on the basis of certain criteria specific to this type of food, namely texture based on dough hardness and elasticity.

In the hedonic test (table 2), after the commercial Konkonde, preference decreased as the percentage of soy flour incorporated increased (table). Appearance was more appreciated for the 10% (FCS2) and 15% (FCS2) formulations compared to the reference sample. The texture of the commercial Konkonde and the 10% (FCS2) and 20% (FCS3) formulations were more appreciated than the others. The reference sample had the best taste, followed by the formulation with 10% soybean flour (FCS1). The aroma of the reference sample and the formulation with 15% soybean flour (FCS2) were the most appreciated.

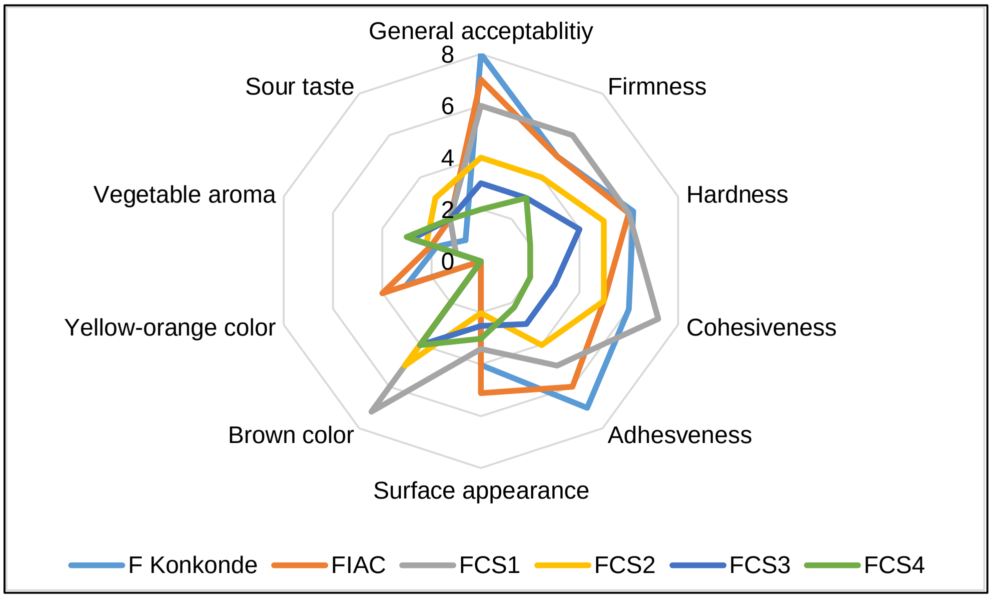

Figure 10: Sensory profile of Konkonde formulations

FIAC = 100% cassava Flour (Test); F Konkonde: Commercial Flour for Konkonde (Control); **FCS1:** 90% FC + 10% FSoya : Formulation 1; **FCS2:** 85% FC + 15% FSoya : Formulation 2; **FCS3:** 80% FC + 20% FSoya: Formulation 3; **FCS4:** 75% FC + 25% FSoya: Formulation 4

Table 2: Preference of panelists

	Konkonde formulations				
Attributs	Konkonde Commercial	FCS1	FCS2	FCS3	FCS4
Preference	$8,1\pm0,9^{e}$	$6,2\pm0,8^{d}$	$5,1\pm0,2^{c}$	$4,2\pm0,3^{b}$	$3,3\pm0,7^{a}$
Appearance	$7,2\pm0,3^{b}$	$8,3\pm1,0^{c}$	$8,3\pm0,4^{c}$	$7,1\pm0,4^{b}$	$5,2\pm0,8^{a}$
Texture	$7,3\pm0,3^{b}$	$7,2\pm0,8^{b}$	$6,3\pm0,3^{a}$	$7,1\pm0,3^{b}$	$6,2\pm0,7^{a}$
Taste	$8,2\pm0,2^{d}$	$6,1\pm0,9^{c}$	$4,2\pm0,4^{b}$	$4,3\pm1,0^{b}$	$3,1\pm0,2^{a}$
Aroma	$6,3\pm0,4^{c}$	$4,3\pm0,5^{b}$	$6,1\pm0,9^{c}$	$3,4\pm0,8^{a}$	$4,1\pm0,3^{b}$

The means assigned different letters in the same row are significantly different ($p = .05$).

FCS1: 90% FC + 10% FSoya: Formulation 1; **FCS2:** 85% FC + 15% FSoya: Formulation 2; **FCS3:** 80% FC + 20% FSoya: Formulation 3; **FCS4:** 75% FC + 25% FSoya: Formulation 4

4. DISCUSSION

The protein content of the different Konkonde flour formulations increases with the soybean content. The increase in protein content could be due to the soybean fraction in the composite flours of the different Konkonde products, as soybeans contain more protein (38.67%) than plantain flour (2.97%) and cassava flour (2.30%). Soybeans are an excellent source of vegetable protein, and the addition of soybean flour improves the quantity and quality of protein in protein-poor food products. This change in protein content is similar to that observed by Akinyede et al. (2023) in the supplementation of plantain flour with soybean meal in increasing proportions. This was also the case when soybean meal was incorporated into a mixture of corn and cassava flour (Adejo et al., 2024).

With regard to lipid content, the results showed that the lipid content of the different formulations changes with the incorporation of soybean meal with the highest lipid content (19%). This increase in lipid content is thought to be due to the fraction of soybean incorporated. Soybean improves the lipid content of Konkonde. Similar results were obtained by Damndja et al. (2023).

The ash content of the different Konkonde flour formulations increases with the incorporation of soybean (6.83%). The increase in ash content is thought to be due to the soybean fraction added. Flour mixtures improve the nutritional value of the resulting products (Olugbuyi et al., 2023).

Like protein, fat, and ash content, fiber content changes in a similar way. That is, an increase in soybean meal improves fiber content (Akinyede et al. 2023). As for carbohydrate content, the opposite effect has been observed. This decrease could be due to the low carbohydrate content of soybean meal as observed this study.

The water absorption capacity (WAC) of flours produced by mixing plantain, cassava, and soybean flours increases with the level of soybean flour incorporation (206.33%). The increase in water absorption capacity is thought to be due to the incorporation of soybean flour. The increase in water absorption capacity is thought to be due to the increase in protein content. In fact, hydroxyl groups establish hydrogen bonds with water molecules. This tends to increase the absorption capacity of flours (Schopf and Scherf, 2021). As a result, a high WAC is thought to be due to the solubilization of proteins and carbohydrates.

The sensory results of the Konkonde formulations reveal significant variations in sensory attributes depending on the incorporation rate of soybean flour. These results demonstrate the influence of soybean flour on the sensory characteristics of the final product, while also demonstrating the complexity of the interactions between the different ingredients.

When examining the visual appearance of the products, it is interesting to note that formulations containing 10% soy flour were perceived as having the most brightness surface. This could be due to an appropriate mix in proportion of the different flours.

For texture evaluation, the results show that formulations with higher incorporation rates of soy flour were perceived as being the least firm, dense, and cohesive. This could be due to the high-water absorption capacity of these flours induced by soy flour. The same applies to paste adhesiveness. The vegetable flavor and aroma were more pronounced with an increase in soybean meal content.

The acceptability test indicates a marked preference for the formulation containing 10% soy flour. This preference could be due to an optimal balance between sensory characteristics and texture in these formulations, as observed by Akter et al. (2021) on soya-based cakes.

4. CONCLUSION

The results showed that the addition of soybean flour significantly improved the nutritional composition of Konkonde, increasing its protein, lipid, ash, and fiber content. This clearly indicates that soybean flour-enriched Konkonde could be a more nutritious food option, meeting the protein and nutrient needs of the population. However, these nutritional improvements were accompanied by changes in the functional properties of the product. Water absorption capacity was all influenced by the incorporation of soy flour.

Sensory results revealed changes in the appearance, texture, taste, and overall acceptability of Konkonde enriched with soy flour. The 10% soy flour formulation yielded satisfactory results. This highlights the importance of considering not only nutritional aspects but also consumer sensory preferences when enriching traditional foods. Ultimately, this study provides essential information for the food industry and researchers interested in improving traditional food products in terms of nutritional value.

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