



# Evaluation of Nutritional Value and Sensory Analysis of a Composite Flour for Porridge and Biscuits Formulated by Four-Factor Mixing Plan

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## Authors' contributions

This work was carried out in collaboration among all authors. Author BET gave study idea, collected and processed the samples, did formal analysis and drafted and reviewed the original article. Author BCF collected and analyzed the data, wrote and reviewed the manuscript. Author KNC analyzed the study. Author NNDS collected and processed the samples and did formal analysis. Author LBW did data validation and performed the methodology, analyzed the samples, wrote and revised the manuscript. All authors read and approved the final manuscript.

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## ABSTRACT

**Objective:** The aim of this work is to formulate a composite flour for porridges and biscuits based on plantain (*musa paradisiaca*), maize (*zea mays*), sesame (*sesamum indicum*) and N'sangui (*pellonulla leonensis*) in order to diversify the sources of nutrients in infant flours.

**Design of the study:** the plant and fish materials were purchased and processed between 15 September 2022 and February 2023, followed by analyses in two laboratories at the site.

**Methodology:** A mixing plan was carried out with the different flours of each material using well-defined methods. Biochemical analyses were carried out on the composite flour formulations obtained. The porridge and biscuit preparations were subjected to organoleptic tests.

**Results:** The biochemical results of these formulations revealed that the nutrient levels vary from one formulation to another, the humidity level between 10 and 11%, ash between 1.8 and 4.82%, lipids between 6.6 and 16.75%, carbohydrates between 54.55 and 64.10%, proteins between 10.29 and 15.52% and energy values between 374 and 430.47kcal. The formulation coded F6 has the nutrient levels included in the range allowed by the World Health Organization standards on infant flours. The static test carried out on the porridges prepared from the different formulations produced showed that there is no significant difference in the appearance, smell, and taste of the porridges and a significant difference was noted on the color and overall acceptability. The sensory profile carried out on the biscuits prepared from the most appreciated formulation F5 of the porridges was highly appreciated by the tasters.

**Conclusion:** Overall, all formulations are close to the standards in force. The formulation coded F5 stood out as the most appreciated of the others.

**Keywords:** Nutritional value; sensory analysis; four factors; composite flour; formulation.

## 1. INTRODUCTION

Africa is rich in natural resources. However, the populations of this vast continent are generally prey to food and nutritional insecurity. The situation is even more worrying in sub-Saharan Africa, where 12% of the population is acutely food insecure. This is due to the poor use of local food resources, whose nutritional virtues have been documented [1]. Malnutrition is at its worst, and the most vulnerable are children under five, with more than 35% of deaths each year [2]. Porridge is the food most often served to children from the age of 6 months. These may be traditional porridges prepared with local or imported flours [3]. Porridge, like biscuits, is made from flour, milk and sugar, although biscuits are not boiled but baked at an average temperature of around 250°C.

Porridges rich in protein-carbohydrate complex play a key role in protecting weaners after weaning. It can help eradicate malnutrition [4]. In the Congo, the vast majority of porridge flours found on the market are imported and sold at exorbitant prices. Faced with budget constraints, not all households use this flour. To solve this problem, almost the entire population resorts to porridges made from fermented maize paste enriched with groundnut paste [5]. There are also

not many infant flour production plants. Infant flour is produced exclusively outside the nutritional centre. The flour produced is intended for adults as well as infants and young children [6].

The aim of this study is to carry out a four-factor mixing plan, including two basic factors, maize flour and plantain banana, for carbohydrate intake and two complementary factors, sesame, a valuable source of lipids, and nsangui, which contains a significant proportion of proteins, in order to propose a composite flour of nutritional quality that is acceptable for direct consumption as porridge and for the manufacture of biscuits.

## 2. MATERIALS AND METHODS

### 2.1 Study Framework

This study was carried out at the laboratory of the Pole of Excellence for Food Processing of Agro Resources (T2A) of the Faculty of Science and Technology in collaboration with the bromatology laboratory of the National Institute of Agricultural Research (IRA) and the National Institute of Research in Engineering Science, Innovation and Technology (INRSIIT) of Congo Brazzaville.

## 2.2 Material

### 2.2.1 Local food products used

The plantain in the final stage of maturation was purchased in Brazzaville in the Makazou Mfilou district from a farmer. The sesame seeds were purchased in Ouessou in the Sangha department, the corn at the Total market in Brazzaville and the Nsanguï from the fishermen of the Congo River south of Brazzaville (Figs. 1, 2, 3, 4).

## 2.3 Methods

### 2.3.1 Production of different flours from local products

The transformation of local products into flour has been carried out using several methods with some modifications. Thus, plantain flour by the

process dictated by Technical Centre for Agricultural and Rural Cooperation (CTA)/FAO Tanzania in [7] for agricultural products. Maize flour by the method used [8], Sesame flour by the modified method [9] and Nsanguï flour by the method described [10].

### 2.3.2 How to obtain the different formulations

The development of complementary foods requires following a logical approach. For this, the NEMRODW software was used to determine the proportions of each product.

The objective of this operation is to carry out a four-factor mixing plan, including two basic factors, corn flour and plantain, for carbohydrate intake and two complementary factors, sesame for lipid intake and nsanguï for protein intake. (Table 1).



Fig. 1. Plantain Banana



Fig. 2. Sesames Seeds



Fig. 3. Nsanguï Fish



Fig. 4. Yellow Maize

Table 1. Mixing plan for flour formulation

Formulations	Combination	Proportion (%)
F1	FM×FB×FS×FP	50%+30%+15%+5%
F2	FM×FB×FS×FP	50%+30%+5%+15%
F3	FM×FB×FS×FP	40%+40%+10%+10%
F4	FM×FB×FS×FP	35%+40%+12.5%+12.5%
F5	FM×FB×FS×FP	50%+30%+20%+ 0%
F6	FM×FB×FS×FP	50%+30%+ 0%+20%

FM: corn flour; FB: banana flour; sesame flour; FP: fish flour

### 2.3.3 Evaluation of the nutritional value of different formulations

#### 2.3.3.1 Water content

The water content of the sample is the loss in mass that the sample undergoes when subjected to experimental conditions until a constant weight is obtained. The water content is determined according to AOAC Standard 950.01, 1990:

$$H(\%) = \frac{(m_1 - m_2)}{(m_1 - m_0)} \times 100$$

With:  $m_0$ : mass of the watch glass,  $m_1$ : initial mass before drying,  $m_2$ : final mass after drying, H (%): water content

#### 2.3.3.2 Ash content

Raw ash is the residue obtained after incineration at 550 °C in an electrically heated muffle furnace to a practically constant mass. The ash content is one of the characteristics used to judge the purity of a product. It also allows the mineral content in the sample to be assessed. The ash content is determined as follows:

- Weigh the mass of the empty cup ( $m_0$ );
- Weigh 5g of powder into the cup ( $m_1$ );
- Place the sample in the muffle furnace at 550C for 8 hours;
- Remove the sample from the oven and allow to cool and then weigh ( $m_2$ );

The following formula is used to determine the ash content (NF T 76-110 Sep. 1981)

$$\%cendre = \frac{(m_2 - m_0)}{(m_1 - m_0)} \times 100$$

#### 2.3.3.3 Protein content s

Total nitrogen was determined using the Kjeldahl method after sulfuric mineralization in the presence of selenium catalyst. The nitrogen content was multiplied by 6.25 (conversion coefficient of nitrogen into proteins).

$$\%N = \frac{V_{H_2SO_4} \times 0,07}{m} \times 100$$

With: %N: percentage of nitrogen,  $V_{H_2SO_4}$ : volume of titrated sulfuric acid, m: mass of the test sample

Protein content is obtained by multiplying the amount of total nitrogen by 6.25 .

$$\text{Protein (\%)} = \%N \times 6.25$$

#### 2.3.3.4 Lipid dosage

Extraction was done with hexane in a Soxhlet extractor (Unid Tecator, HT2 1045, Sweden).

In a cartridge, introduce 10g of flour previously weighed using a precision electronic balance, in a 500mL flask placed in a heating mantle, pour 350mL of hexane. Place the cartridge in the Soxhlet and adapt the assembly. After extraction, the cartridge is removed and the solvent is recycled by the same principle, the traces of solvent mixed with the oil are poured into a tube whose empty mass is noted then placed in the water bath to evaporate the solvent.

The lipid content is obtained by the following formula:

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

With: %L: lipid content,  $m_1$ : mass of the tube with oil,  $m_0$ : mass of the vacuum tube.

#### 2.3.3.5 Determination of carbohydrate level

The determination was carried out according to the formula:

$$\%Carbohydrates = 100 - (\%Moisture + \%Protein + \%Fat + \%Ash).$$

#### 2.3.3.6 Determination of energy value

The overall energy value is the energy released by the combustion of proteins, lipids and carbohydrates contained in the diet, taking into account the digestibility of each and their ATWATER coefficients. The energy value was calculated using the specific Atwater coefficients for proteins, lipids and carbohydrates.

$$\text{Energy value (Kcal)} = [(\% \text{ Carbohydrates} \times 4) + (\% \text{ Protein} \times 4) + (\% \text{ Fat} \times 9)]$$

### 2.3.4 Sensory analyses

Sensory analysis is a multidisciplinary science that uses tasters and their senses of sight, smell, taste, touch and hearing to measure the sensory

characteristics and acceptability of food and many other products.

Sensory analysis was carried out by [11].

Two sensory evaluations were carried out in total. A first evaluation which consisted in establishing a sensory profile of the 6 formulations of the porridges, the second evaluation consists of a hedonic test.

### 2.3.5 Statistical processing of results

The statistical results of the sensory data were processed on Excel and MiniTab. The sensory profile was performed on Excel and the student P value test was performed on MiniTab.

## 3. RESULTS AND DISCUSSION

### 3.1 Nutritional Values of Flour Formulations

The results of biochemical analyses of composite flour formulations based on Plantain ( *Musa paradisiaca* ), Corn ( *Zea Mays* ), Sesame ( *Sesamum indium* ) and Nsangu ( *Pellonula leonensis* ) are presented in Table 2.

For the different flour formulations, the carbohydrate content varies from one formulation

to another. It ranges from 54.55 to 64.1%. Formulation F4 has the lowest carbohydrate content (54.55%) while formulation F3 has the highest carbohydrate content (64.1). Ash content ranged from 1.87 to 4.82%. Formulation F3 has the lowest ash content (1.87%), while formulation F2 has the highest ash content (4.82%). The lipid content of the different formulations ranged from 6.64 to 16.75%. The lowest lipid content was observed in formulation F5 (6.64%), while the highest content was observed in formulation F5 (16.75%). For protein content, fairly significant differences were observed. The values obtained ranged from 10.29% to 15.52%. The highest value was observed in formulation F6 (15.52%) and the lowest in formulation F5 (10.29%). With regard to moisture, no significant differences were observed, with moisture levels varying between 10.31 and 11.17%.

### 3.2 Sensory Profile of Porridges and Biscuits

#### 3.2.1. For prepared porridges

The graphs below show the assessment range for colour, odour, appearance, mouthfeel and overall acceptability for each formulation at 95% (Figs. 5 and 6).

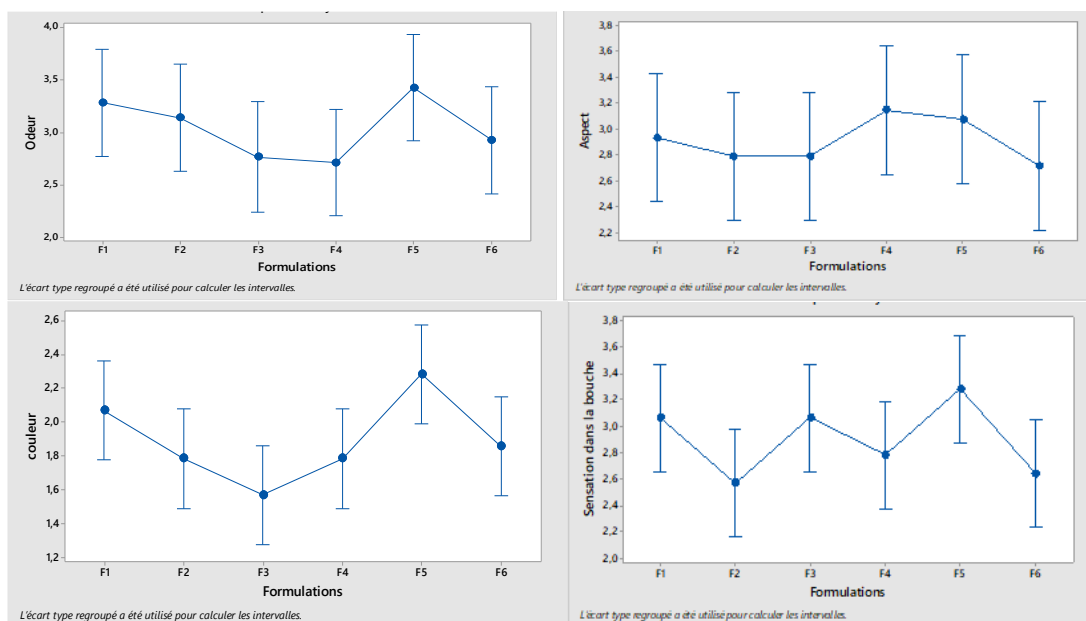


Fig. 5. Graph of colour ranges for odour, appearance and mouthfeel as a function of formulation at 95% CI

**Table 2. Nutritional values of different flour formulations**

<b>Nutritional value per 100g</b>	<b>F1</b>	<b>F2</b>	<b>F3</b>	<b>F4</b>	<b>F5</b>	<b>F6</b>	<b>FAO/WHO Standards 2006</b>	<b>Recommended contributions UNICEF</b>
Humidity (%)	10.93	10.82	11.15	11.17	11.22	10.31	<12	
Ash (%)	3.35	4.82	1,875	3.55	2.1	4,425	3	
Lipids (%)	13.86	11,925	9,905	15.79	16,755	6.64	8	6 to 10
Protein (%)	12.37	14.55	12.97	14.99	10.29	15.52	15	10 to 15
Carbohydrates (%)	59.49	57.88	64.10	54.55	59.64	63.1	68	55 to 70
Energy (kcal)	413	397	397.41	420	430.47	374.24	400	360 to 440

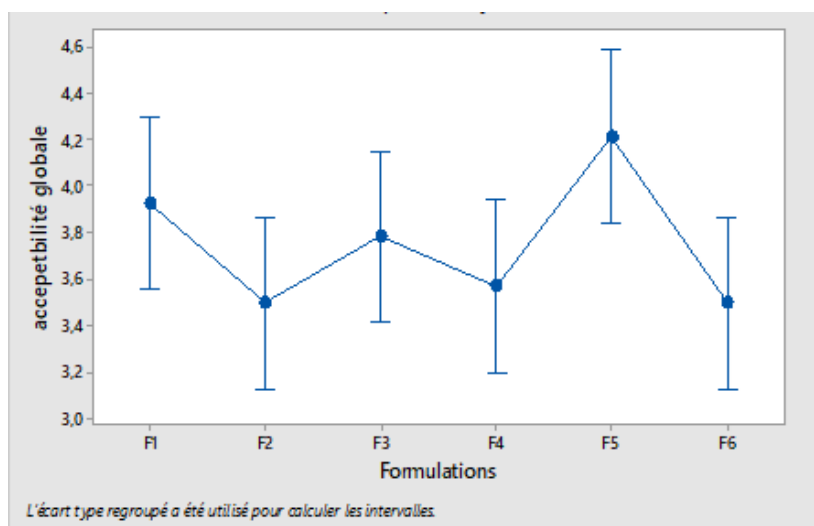


Fig. 6. Graph of overall acceptability intervals as a function of formulation at 95% CI

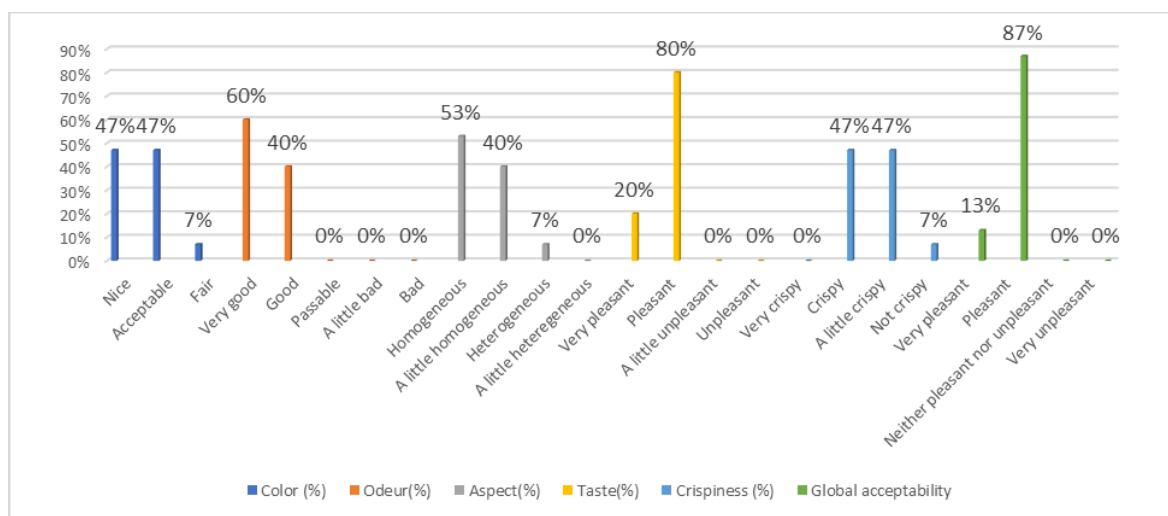


Fig.7. graph of tasters' appreciation rate by descriptor

### 3.3 Discussion

#### 3.3.1 Nutritional value

As far as nutritional value is concerned, the value of carbohydrates varies from one formulation to another and this is explained by the proportion of maize flour and plantains, the main sources of starch in each formulation. These results of 50 to 65% for incorporations between 30 and 50% are close to those found by [12] for plantain and to the results of [13] for maize. For ash and protein, the variation is proportional to the incorporation of Nsanguis in each formulation, the higher the nsanguis content, the higher the ash and protein content. These results confirm the high levels of ash and protein found by [14]. The variation in

lipid content is proportional to the amount of sesame in each formulation. The greater the quantity of sesame in a formulation, the higher the lipid content. There is therefore more lipid in sesame than in the other products used, and this high level coincides with the results found by [15].

#### 3.3.2 Sensory profile of porridges and biscuits

##### 3.3.2.1 For prepared porridges

**Colour :** The colour of a food is the first thing that strikes the mind. It inspires taste, edibility and the desire to eat. The colour of a food is important in choosing what to eat. For each

formulation, the range of appreciation of the colour is represented in the graph above (Fig. 5). The results of this graph show a significant difference between the samples with a P-value of less than 5% ( $p < 0.05$ ). In this case, at least one formulation is different from the others. Compared to the average,  $F_5 = 2.286$  is the formulation most appreciated by the tasters.

**Odour :** The odour assessment range for each formulation (Fig. 5) shows the same pattern with a few modifications. The results of this graph do not show a significant difference between the samples, as shown by  $p > 0.05$ . In this case, no formulation is significantly different from the others. Compared to the average,  $F_5 = 3.286$  is the formulation most appreciated by the tasters.

**Appearance :** A product's appearance plays an important role in consumers' perception of its quality. In addition to the functions it must fulfil, a product must have an impeccable appearance. Fig. 5 shows the range of ratings for the appearance of each formulation. This graph does not show a significant difference between the formulations, as shown by  $p > 0.05$ . In this case, no formulation is significantly different from the others. Compared to the average,  $F_4 = 3.143$  is the formulation most appreciated by the tasters.

**Sensation in the mouth :** Mouthfeel or taste is a set of sensations associated with each food. However, the taste buds can be more or less sensitive depending on the individual. This part of the process is very decisive, if not fundamental, in determining the acceptance of a food. Fig. 5 shows the range of mouthfeel ratings for each formulation. This graph does not show a significant difference between the formulations, as shown by  $p > 0.05$ . In this case, no formulation is significantly different from the others. Compared to the average,  $F_5 = 3.286$  is the formulation most appreciated by the tasters. Overall, all the formulations showed a pleasant mouthfeel despite the difference from the average.

**Overall acceptability :** Fig. 6 shows the range of overall acceptability for each formulation. The results of this graph show a significant difference between the samples as shown by  $p = 0.05$ . In this case, at least one formulation is different from the others. Compared to the average,  $F_5 = 4.318$  is the formulation most appreciated by the tasters.

#### **For biscuits made with the F5 formulation:**

Fig. 7 shows the appreciation rates for each sensory parameter and its descriptors. For the color, 47% of tasters appreciated it as "beautiful" and "acceptable"; and only 7% judged the color as "poor". The color of the biscuits is therefore "acceptable" and "beautiful". 60% of tasters judged the smell of the biscuits as "very good", 40% as "good". The appearance of the biscuits is appreciated by 53% as "homogeneous", 40% as "a little homogeneous" and 13% as "a little heterogeneous". For the taste, 80% of tasters appreciated it as "pleasant" and 20% as "very pleasant". The taste is therefore judged as "pleasant". 47% of tasters appreciated it as "crunchy" and 47% as "very crunchy". The biscuits are therefore judged as "crunchy". Finally, the overall acceptability is 87% pleasant and 13% very pleasant. These taster appreciation rates show that the formulated biscuits were found to be "pleasant" overall, with an "acceptable" color, a "homogeneous" appearance, a "pleasant" and "crunchy" taste.

## **4. CONCLUSION**

This study aims to formulate composite flour for porridge and biscuit based on local products in order to diversify the sources of nutrients in infant flours. Four factors characterized by different local products such as plantain, corn, sesame and nsangu made it possible to examine six formulations. Overall, all the formulations are close to the standards in force and the sensory profile produced on the biscuits prepared from the most popular formulation (F5) of the porridge was highly appreciated by the tasters. In a short time, it will be necessary to study the microbiological flora, determine the functional properties and the composition in mineral salts of the different formulations.

## **DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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