Evaluation of nutritional value and sensory analysis of a composite flour for porridge and biscuits formulated by four-factor mixing plan.

Abstract

Objective: The aim of thisworkis to formulate a composite flour for porridges and biscuits based on plantain (*musa paradisiaca*), maize*(zeamays*), sesame (*sesamumindicum*) and N'sangui (*pellonullaleonensis*) in order to diversify the sources of nutrients in infant flours.

Design of the study: the plant and fishmaterialswerepurchased and processedbetween 15 September 2022 and February 2023, followed by analyses in twolaboratories at the site.

Methodology: A mixing plan wascarried out with the differentflours of eachmaterialusingwell-definedmethods. Biochemical analyses werecarried out on the composite flour formulations obtained. The porridge and biscuit preparationsweresubjected 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.

I. INTRODUCTION

Africaisrich in naturalresources. However, the populations of thisvast continent are generallyprey to food and nutritionalinsecurity. The situation iseven more worrying in sub-SaharanAfrica, where 12% of the population isacutelyfoodinsecure. This is due to the poor use of local foodresources, whosenutritionalvirtues have been documented**(FAO, 2021).** Malnutrition is at itsworst, and the mostvulnerable are childrenunder five, with more than 35% of deathseachyear**(UNICEF, 2010)**. Porridge is the foodmostoftenserved to childrenfrom the age of 6 months. Thesemaybetraditional porridges preparedwith local or importedflours**(IRD, 2020)**. Porridge, like biscuits, is made fromflour, milk and sugar, although biscuits are not boiled but baked at an averagetemperature of around 250°C

Porridges rich in protein-carbohydrate complexplaya key role in protectingweanersafterweaning. It can help eradicate malnutrition **(Ponka, 2016).** In the Congo, the vastmajority of porridge floursfound on the market are imported and sold at exorbitant prices. Facedwith budget constraints, not all households use thisflour. To solve thisproblem, almost the entire population resorts to porridges made fromfermentedmaize paste enrichedwithgroundnut paste **(Elenga et al., 2009)**. There are also not many infant flour production plants. Infant flourisproducedexclusivelyoutside the nutritional centre. The flourproducedisintended for adults as well as infants and youngchildren**(Elenga et** al**, 2017).**

The aim of thisstudyis to carry out a four-factor mixing plan, includingtwo basic factors, maizeflour and plantain banana, for carbohydrate intake and twocomplementaryfactors, sesame, avaluable source of lipids, and nsangui, whichcontains a significant proportion of proteins, in order to propose a composite flour of nutritionalqualitythatis acceptable for direct consumption as porridge and for the manufacture of biscuits.

II. MATERIALS AND METHODS

II.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.

II. 2.Material

II.2.1.Local food products used

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


Figure 1 :Banane plantainFigure 2: Sesame seeds


Figure 3 : Poisson NsangFigure 4 : Yellow Corn

II. 3. Methods

II. 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 **2012** for agricultural products .Maize flour by the method used by**SIKA** in **2019** ,Sesame flour by the modified method of **Ngono Eyenga** in **2018**and Nsangui flour by the method described by de **Gampoula**in **2020 .**

II.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 nsangui for protein intake. (Table I).

Table I: 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

II.3. 3. Evaluation of the nutritional value of different formulations

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

Ash content

Raw ash is the residue obtained after incineration at 550 ^{o}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 (mo);
- Weigh 5g of powder into the cup (m1);
- 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 (m2);

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

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

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).

$$\%N = \frac{V_{H2SO4} \times 0,07}{m} \times 100$$

With: %N: percentage of nitrogen, V_{H2SO4} : 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 .

Protein (%) = %N×6.25

Lipid dosage

Extraction was done with hexane in a Soxhlet extractor (UnidTecator, 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.

Determination of carbohydrate level:

The determination was carried out according to the formula:

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

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.

Energy value (Kcal) = [(% Carbohydrates × 4) + (% Protein × 4) + (% Fat × 9)]

II.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 the **Watts method(1992).**

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.

II.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.

III. RESULTS

III.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 Nsangui**(** *Pellonulaleonensis***)** are presented in Table II below.

Table II: Nutritional values of different flour formulations

Nutritional value per 100g	F1	F2	F3	F4	F5	F6	FAO/WHO Standards 2006	Recommended contributions UNICEF
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

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 rangedhe 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%.

III. 2. Sensory profile of porridges and biscuits

III.2.1. For prepared porridges

The graphs below show the assessment range for colour, odour, appearance, mouthfeel and overallacceptability for each formulation at 95% (figure 5).

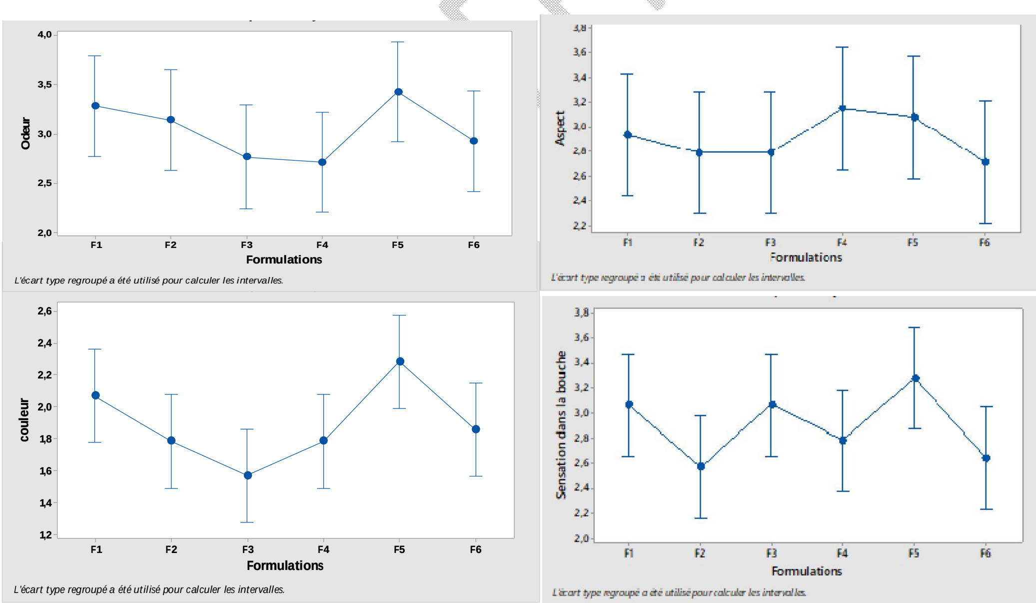

Figure 5: Graph of colour ranges for odour, appearance and mouthfeel as a function of formulation at 95% CI

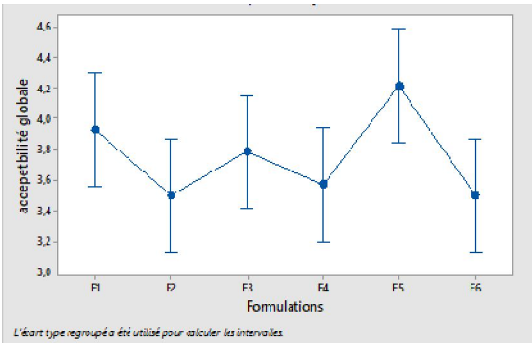

Figure 6: Graph of overallacceptabilityintervals as a function of formulation at 95% CI

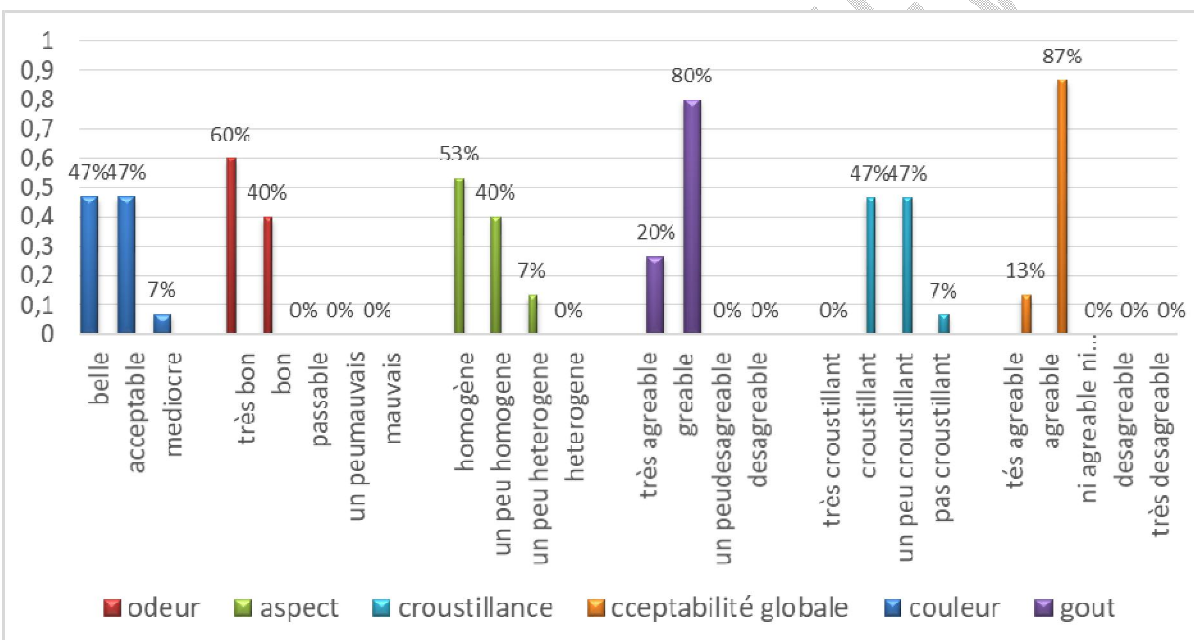

Figure 7: graph of tasters' appreciation rate by descriptor

III.3. Discussion

III.3.1. Nutritional value

As far as nutritional value isconcerned, the value of carbohydrates varies from one formulation to another and thisisexplained by the proportion of maizeflour and plantains, the main sources of starch in each formulation. Theseresults of 50 to 65% for incorporations between 30 and 50% are close to thosefound by **Pambou-Tobi (2015)** for plantain and to the results of **Sika (2016**) for maize. For ash and protein, the variation isproportional to the incorporation of Nsanguis in each formulation, the higher the nsangui content, the higher the ash and protein content. Theseresultsconfirm the high levels of ash and proteinfound by

Gampoula (2020). The variation in lipid content isproportional to the amount of sesame in each formulation. The greater the quantity of sesame in a formulation, the higher the lipid content. There istherefore more lipid in sesamethan in the otherproductsused, and this high levelcoincideswith the resultsfound by **NZIKOU (2009).**

III.3.2. Sensory profile of porridges and biscuits

For prepared porridges

Colour

The colour of a foodis the first thingthat 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 (figure 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, F5 = 2.286 is the formulation most appreciated by the tasters.

Odour

The odourassessment range for each formulation (figure 5) below shows the same pattern with a few modifications. The results of this graph do not show a significantdifferencebetween the samples, as shown by $p>0.05$. In this case, no formulation issignificantlydifferentfrom the others. Compared to the average, F5=3.286 is the formulation mostappreciated by the tasters.

Appearance

A product'sappearanceplays an important role in consumers' perception of itsquality. In addition to the functionsit must fulfil, a product must have an impeccable appearance. Figure 5 above shows the range of ratings for the appearance of each formulation. This graph does not show a significantdifferencebetween the formulations, as shown by $p>0.05$. In this case, no formulation issignificantlydifferentfrom the others. Compared to the average, F4=3.143 is the formulation mostappreciated by the tasters.

Sensation in the mouth

Mouthfeel or taste is a set of sensations associatedwitheachfood. However, the taste buds can be more or less sensitive depending on the individual. This part of the process isverydecisive, if not fundamental, in determining the acceptance of a food. Figure 5 above shows the range of mouthfeel ratings for each formulation. This graph does not show a significantdifferencebetween the formulations, as shown by $p>0.05$. In this case, no formulation issignificantlydifferentfrom the others. Compared to the average, F5 = 3.286 is the formulation mostappreciated by the tasters. Overall, all the formulations showed a pleasantmouthfeeldespite the differencefrom the average.

Overallacceptability

Figure 6 above shows the range of overallacceptability for each formulation. The results of this graph show a significantdifferencebetween the samples as shown by p=0.05. In this case, at least one formulation isdifferentfrom the others. Compared to the average, F5=4.318 is the formulation mostappreciated by the tasters.

For biscuits made with the F5 formulation

Figure 7 below 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.

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 nsangui 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.

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