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RESEARCH ARTICLE

FORMULATION OF A WEANING FOOD BASED ON SESAME FLOUR AND CORN FLOUR FOR CHILDREN AGED 6 TO 18 MONTHS

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ABSTRACT

The objective of this study was to formulate mixed flours based on corn and sesame for children aged 6 to 18 months. Thus, 1630 g of corn flour and 524.93 g of sesame were purchased from the Matoto market. Thus, three formulations were manufactured: i) F10 (90% corn and 10% sesame), F20 (80% corn and 20% sesame), and F30 (70% corn and 30% sesame). The moisture, ash, protein, fat and carbohydrates contents were determined according to AOAC standards for single and mixed flours. The moisture, dry matter, ash, protein, lipids and carbohydrates contents in corn flour were 11.97, 88.03, 1.23%, 7.03%, 4.34% and 74.81%, respectively. As for sesame flour, they were 8.56%, 91.94%, 4.6%, 21.60%, 53.53% and 8.67% for moisture, dry matter, ash, protein, lipids and carbohydrates contents, respectively. Analysis of variance showed that these two types of flour are significantly different ($p < 0.05$). For example, the dry matter contents were 87.58 ± 0.21%, 87.58 ± 0.15% and 88.07 ± 0.23% in F10, F20 and F30, respectively. The protein content increased significantly with the levels of sesame flour incorporation. These values were 9.20 ± 0.05%, 9.97 ± 0.01% and 10.49 ± 0.01% in F10, F20 and F30 formulation, respectively.

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INTRODUCTION

Protein-energy malnutrition (PEM) and micronutrient deficiencies remain a public health problem in many developing countries (Kanan & Swar, 2016) affecting approximately 170 million children under five years of age with a prevalence of 23.2% suffering from PEM, 40% from vitamin A deficiency (Delpeuch *et al*., 2006) and 72.4% from iron deficiency (Diouf *et al*., 2015). The most affected are those aged 6–23 months, which is a critical window for children's physiological development, with suboptimal feeding practices inducing long-term developmental challenges in children (Ngaha Damndja *et al*., 2023)**.** Indeed, studies have shown that beyond 6 months, breast milk can no longer cover all of the child's nutritional needs, which requires the use of complementary foods (Wallace *et al*., 2020)**.** In developing countries in general and Guinea in particular, complementary foods mainly consist of porridge prepared with ready-to-use infant flours. Studies conducted in Africa and more specifically in Congo, 20.5% of children have growth retardation, and 4.2% of them have an abnormally low weight-for-height (Serge & , Pezennec Stephane, 1993). In West and Central Africa, seven out of 10 infants receive liquids and foods in addition to breast milk during their first six months of life, which contributes to malnutrition, illness and even child deaths (Anne Isabelle Leclercq Balde, 2019).

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Despite positive economic growth in these regions, the number of stunted children under five increased from 23 to 29 million between 2000 and 2018. In addition, the region is home to an estimated 4.9 million children suffering from severe acute malnutrition. This situation calls for governments, partners, businesses, communities and families to ensure that mothers receive the support they need to give their children the best start in life and this start can only be achieved by formulating flours composed of different cereals or legumes (Amoin *et al*., 2015). However, artisanal flours produced from cereals and tubers are generally low in proteins, vitamins, minerals and some essential amino acids (Muhimbula *et al*., 2011). In addition, porridges prepared from these artisanal flours have a lower energy density (Kouton *et al*., 2021). There are imported infant foods of good nutritional quality available on the market that could address the problem, but they are not affordable for the majority of the population due to their poor or non-income-generating status (Choudhury *et al*., 2019). To address this problem, the World Health Organization (WHO) recommends formulating complementary foods with higher nutritional value from locally available products to improve the technological knowledge of the local population and/or make them affordable to low-income households (James *et al*., 2018). The complementary food recommended by FAO/WHO, (1991)should provide 400 Kcal from 68% sugars (composed of 81% free sugars), 13% protein (with a minimum of 7% digestibility) and 7% lipids. This food should also contain 5% fiber, 7 mg iron and 350 µg vitamin A, all in 100 g of floursFAO/WHO, (1991). Since it is difficult to find a single food matrix containing all these nutrients, many researchers have developed mixtures of tuber and cereal flours as a source of energy (Awoyale *et al*., 2020) and legumes as a source of protein and fat(Kone *et al*., 2019). Fruits and vegetables are also added as a source of vitamins and minerals (Wallace *et al*., 2020). It is therefore necessary to introduce new foods in liquid or semi-liquid form into the diet of young children to supplement the intake of breast milk. However, good weaning practices still have a long way to go; especially since in Guinea, only 11% of children under 6 months are exclusively breastfed, 35% of deaths of Guinean children under one year old are attributable to inadequate breastfeeding practices and 45% of children aged 6 to 9 months do not yet receive the complementary foods essential for their adequate growth. This malnutrition leads to significant weight loss and significantly increases a high risk of infant mortality. Regarding corn flour, it has been shown that corn is not a significant source of protein, however, sesame seeds contain a high level of oil (44-58%) and protein (18-25%) and are an excellent source of vitamins, dietary fiber and microelements (Fe, Zn, Ca, Mg, Cu, Se, etc.).

The main fatty acids in sesame oil are oleic acid and linoleic acid (Harfi *et al*., 2019). In addition, Sene *et al*., (2018)reported that sesame has a high nutritional value (lipids: 45 to 55%, proteins: 19 to 25%, minerals, vitamins and antioxidants. Moreover, Gharby *et al*., (2017) reported that the oil contained in sesame is a source of unsaturated fatty acids (linoleic (46.9%), oleic acid (37.4%). The authors also reported that sesame seed oil was found to be rich in tocopherols with a predominance of c-tocopherol (90.5%) and phytosterol b-sitosterol which represented 59.9% of the total sterols. In their study, compositional analysis revealed that sesame seeds contained considerable amounts of proteins (22%) and high amounts of lipids (52%). Furthermore, Abou-Gharbia *et al*., (1997) noted that sesame has some potential of nutraceutical compounds such as phenolic compounds and tocopherols with antioxidant activity that have a significant effect on reducing blood pressure, lipid profile and vascular degeneration and impact on reducing chronic diseases. Despite these numerous beneficial effects on health, to our knowledge, no specific study has yet focused on the fortification of corn flour with sesame flour in the formulation of food supplements in Guinea intended for the feeding of children during the weaning period. Thus, the objective of this study is to develop a weaning food by fortifying corn flour with sesame flour to combat protein-energy malnutrition in children aged 6 to 18 months.

MATERIALS AND METHODS

Site and place of study: This work was carried out in the premises of the Institute of Nutrition and Child Health (INSE) in Donka, Conakry (Figure 1). This center is located within the Conakry University Hospital Center.

Preparation of corn and sesame flours: Maize and sesame flours were produced using the method described by Gernah *et al*., (2012) with a modification. As mentioned in Figure 2, maize (*Zea mays*) (2 kg) and sesame (*Sesamum indicum L.*) (3 kg) seed samples were purchased from Matoto market, Conakry, Guinea. These samples were carefully sorted to remove physical debris (pieces of stones, wood, etc.). Subsequently, winnowing was carried out to further remove impurities from the maize and sesame seeds that were not removed during sorting. They were then thoroughly washed with household water and then sun-dried to avoid contact with environmental debris. Subsequently, the seeds were soaked in tap water at room temperature using a ratio of 1:3 (w/v grains: water) in a bucket for 6 hours, followed by draining in a plastic basket and the grains were spread in a single layer on a moistened jute bag and allowed to dry in the sun. The dried seeds were ground in a mixer (Brook Crompton, 2000 series, England) to pass through a 0.2 mm sieve. The obtained corn and sesame flours were packed in plastic bags, stored at 4 °C and used for product formulation and analysis within 24 hours.

Preparation of mixed flours: The mixed flours (containing corn flour and sesame flour) were produced following the method of Ngaha Damndja *et al*., (2023) with a slight modification. Thus, three (03) batches of flour were produced on a pilot scale at the food technology workshop of Gamal Abdel Nasser University in Conakry. These batches are: i) a formulation F1 containing 90% corn and 10% sesame, ii) a formulation F2 composed of 80% corn and 20% sesame, and iii) a formulation F3 consisting of 70% corn and 30% sesame. These mixed flours were carefully preserved and sent to the laboratory for physicochemical and microbiological.

Physicochemical analyses of the flours produced: The physicochemical analyses of the flours produced focused on the determination of the moisture content, total ash and total carbohydrates.

Figure 1. Map of the Institute of Child Nutrition and Health of Donka-Conakry

Moisture Determination: The moisture content was determined using the method described by NF V 18 109. Thus, 5g of flour was weighed in a previously dried and weighed capsule, then introduced into the oven set at 105°C for 24 hours. After this drying time, the capsule was removed and placed in a desiccator for cooling, followed by weighing.

Total ash determination: The method of NF V 18-101 was adopted to determine the total ash in the samples of flour produced. To do this, 5 g of flour were weighed in a porcelain crucible previously dried and weighed, then placed in a muffle furnaceset at 650 ° C for 24 hours. Then, the crucible is placed in the desiccator to cool it, followed by weighing.

Total carbohydrate determination: The standard method of Gauss Bonas Method was applied for the determination of total carbohydrates. Indeed, this technique consisted of putting 3g of flour and 50 ml of 5% hydrochloric acid in a conical flask. The solution thus obtained was heated in a water bath set at 90 °C for 2 hours then cooled while adding phenolphthalein drop by drop. The excess acid was neutralized by adding 40% sodium hydroxide until the pink color appeared. The excess sodium hydroxide was eliminated by adding 10% acetic acid drop by drop until the pink color disappeared. The hydrolyzate was defecated by adding 5ml of lead acetate then 0.5g of sodium sulfate was added while stirring vigorously. The solution obtained was filtered and the filtrate was transferred into a 250 ml graduated flask and filled with distilled water up to the gauge mark. The result was expressed by the following formula:

$$\%G = \frac{P \text{ x } 0{,}9}{Pe} \text{X } 100$$

%G: Total carbohydrate content
Pe: weight of the test sample;
P: weight of carbohydrates
0.9: Gauss Bonas conversion coefficient.

Determination of fat: The standard Soxhelet method was used to determine the fat content. For this method, the flask was dried in an oven at 103°C for 30 minutes, then cooled in a desiccator and weighed (P0). Then, a test sample (Pe) of 2.5g was placed in an extraction cartridge on which 2 to 3g of anhydrous sodium sulfate were added, then the cartridge was sealed using degreased cotton. Then add 360 to 400mL of petroleum ether to the extraction flask. Subsequently, the Soxhelet column was connected to a condenser. The extraction process, which lasts 6 hours on a hot plate, was started. After the end of the process, the ether was recovered and the flask containing the fat was kept in an oven overnight at 40°C to eliminate traces of solvent. Finally, the flask was cooled in the desiccator for 30 min followed by weighing (P1). The fat content was calculated according to the formula below:

$$\%F_g = \frac{P_1 - P_0}{P_e} \times 100$$

%F = Fat content;
Pe = Weight of the test sample;
Po = Weight of the empty evaporating flask;
P1 = Weight of the evaporating flask after drying the fat.
Determination of protein content

The ISO, (2005) was used for the determination of total nitrogen in the flours produced. The protein content was expressed as a percentage % of the sample mass after multiplying the total nitrogen by the conversion factor 6.25.

Microbiological analysis of the flours produced: In the flour samples produced, the count of the Total Aerobic Mesophilic Florawas carried out according to the ISO 4833: 2003 standard; that of the sulfite-reducing anaerobes was carried out according to the ISO 7937: 2004 standard. The faecal and total coliforms were counted according to the NS 03-142: 2013 standard. The yeasts and moulds were identified by the NF V 08-059: 2002 standard and the search for Salmonella was carried out according to the ISO 6579-1: 2017 standard. The results of the count were expressed by the following formulas:

$$N_g = \frac{\Sigma C}{V \times (n_1 + 0{,}1 n_2) \times d} \text{ and } N_g = \frac{\Sigma C}{V \times n \times d}$$

- *Ng: is the number of colony forming units per gram of the sample (CFU/g);*
- *Σc: sum of the colonies counted in all the plates retained from the two successive dilutions;*
- *n1: number of plates retained at the first dilution retained;*
- *n2: number of plates retained at the second dilution retained;*
- *V: is the volume of the inoculum applied to each plate (in ml);*
- *d: is the dilution n rate corresponding to the first dilution retained.*

Infants: The methodology described by Vieu, TahirouTraoré, Serge Trèche, (2001) was followed for the selection of children. Thus, all children eligible to participate in the study were recorded. Questions relating to the health of the children were asked to wet nurses (mothers of children). These children should not have any particular health problems. A total of 16 children, including 08 male infants and 08 female infants participated in the study. To be eligible, children had to be aged 6 to 18 months and who are used to consuming porridge. These children were categorized into two groups: i) moderate manlutris children, and ii) normal children.

Preparation and administration of porridge aux enfants: After the physicochemical and microbiological analysis of the manufactured flours, they were incorporated into each other to form mixed flours. These mixed flours were diluted in water and then mixed to obtain a uniform mixture; this mixture was diluted in boiling water in a saucepan brought to the fire for 20 minutes, stirring until a cooked porridge was obtained. Then, the porridge was cooled and given to the children according to Table 3. Thus, two ladles were given to the children at a frequency of 3 to 4 times for severely malnourished children and 2 to 3 times for normal children. It should be noted that during this administration, no child showed any sign of allergy.

Statistical data processing: Analysis of variance (ANOVA) was performed on XLSTAT software (2019) to compare the formulations. We considered a difference to be significant only when the p-value was greater than 5%.

RÉSULTATS ET DISCUSSION

Physicochemical composition of the flours produced: The results of the physicochemical analyses carried out on corn and sesame flours are presented in Figure 3. The results obtained show that the dry matter, ash, protein, fat and energy value contents are significantly higher in sesame flours compared to those of corn flour.The dry matter contents are significantly higher in corn flour (88.03 ± 0.60%) compared to sesame flour (91.94 ± 0.26%). The moisture content of corn flour (11.97%) is comparable to that found by Palacios-Fonseca *et al*., (2009) who obtained a variable moisture content depending on the storage time, ranging from 11.03 ± 0.06% on day 1 to 11.27 ± 0.06% on day 7 in commercial nixtamalized corn flours from three industrial plants in Mexico and traditional nixtamalized corn flour. In general, the moisture contents found are appreciable and allow the flours to be preserved for a long time, if they are placed in a dry place and protected from any humidification. Furthermore, the moisture content of maize flour is in the range (7.2-12.3%) found by Sika *et al*., (2019) in two types of maize flour (maize flour and safou flour). This high content indicates low moisture content. Furthermore, the variability in the composition of maize flour can be attributed to the different maize varieties as reported by Sandhu *et al*., (2007). These differences would be due to the drying methods applied, on the one hand, and the variety of sesame used. Regarding total ash content, it was significantly higher in sesame flour (4.46 ± 0.87%) compared to maize flour (1.23 ± 0.41%).

Table 1. Energy values of mixed flours

Formulations	Energy value Kcal	Standard flour Kcal
F10	417.85	400
F20	428.93	400
F30	434.6	400

Table 2. Results of microbiological analysis of simple and mixed flours

GermsSearched	Microbiologicalcriteria	Number of germsfound					Assessments
		FM	FS	I1	I2	I3	Satisfactory
FMAT	5.10^4 CFU/g	60	100	80	130	100	
CT	<10 CFU /g	00	00	00	00	00	
CF	Abs CFU /g	00	00	00	00	00	
LM	4.10^3 CFU /g	00	3	1	1	00	
ASR	Abs CFU /g	00	00	00	00	00	
SAL	Abs CFU /25g	00	00	00	00	00	

FMAT: Total Aerobic Mesophilic Flora; CT: Total Coliforms; CF: Fecal Coliforms; LM: Yeasts and Molds; ASR: Sulphite-Reducing Anaerobes; CFU: Colony Forming Unit; SAL: Salmonella; I: Insertion; FM: Corn flour; FS: Sesame flour.

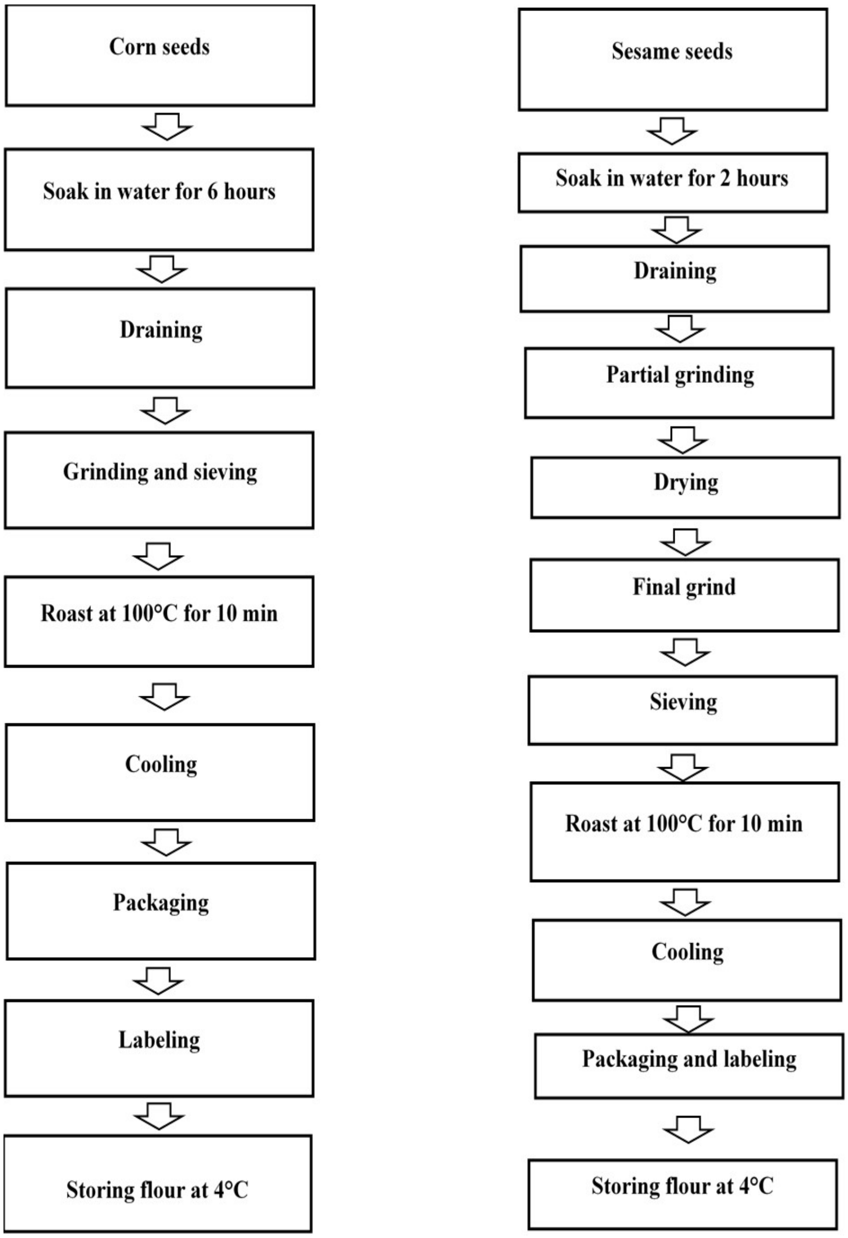


Figure 2: Technological diagram of the production of corn and sesame flours

The ash content found in maize flour is slightly higher than the value found by Sika *et al*., (2019) which is 1.19%. This difference could be attributed to the maize variety used as reported by Sandhu *et al*., (2007) who reported that the ash content of maize varieties ranged from 0.19% to 1.66%. On the other hand, Singh *et al*., (2003) found 0.21% ash content in maize flour.

The total ash content found in sesame flour is lower than that reported by Phillips *et al*., (2005) which is 5.30%. These differences are thought to be due to the milling processes applied, the nature of the soil, the raw materials used and the analysis methods. Furthermore, a similar content of 1.20% was obtained in sesame (Oluwamukomi, 2015). The chemical composition of seeds can be affected not only by genotype but also by agro-climatic conditions (Zebib *et al*., 2015). As mentioned in Figure 1, the carbohydrate contents found in corn flour is 74.81 ± 0.03% and it is significantly higher than that found in sesame flour 8.67%. The carbohydrate contents of corn flour are lower than those found bySandhu *et al*., (2007) who obtained a carbohydrate content of 87.9 to 92.5% in 9 corn varieties. The authors indicated that the carbohydrate content is highly variable depending on the variety. These results show that corn flour is an important source of carbohydrates; which gives it its energetic character compared to sesame flour which in turn, is three times richer in nitrogenous compound (proteins), especially amino acids(Baghery *et al*., 2023). It is also rich in anti-oxidant(Baghery *et al*., 2023). Thus, a combination of these two products could be beneficial for the management of protein-energy malnutrition.The protein contents found in corn and sesame flour as shown in Figure 1, are 7.03 ± 0.02% and 21.60 ± 012% respectively. Analysis of variance showed that there is a significant difference between these values. The protein content of corn flour is lower than that found bySika *et al*., (2019) which is 10.15%. On the other hand,Sandhu *et al*., (2007) found a protein content ranging from 5.18% to 7.82% in nine (9) corn varieties; which is lower than our results. One explanation for this variation would be that different varieties do not have the same protein levels (Sandhu *et al*., (2007). For sesame flour, it appears that the protein content in whole sesame seeds is at an average value of 23.27%. These differences would generally be due to genetic and/or environmental factors or to the analysis method applied.

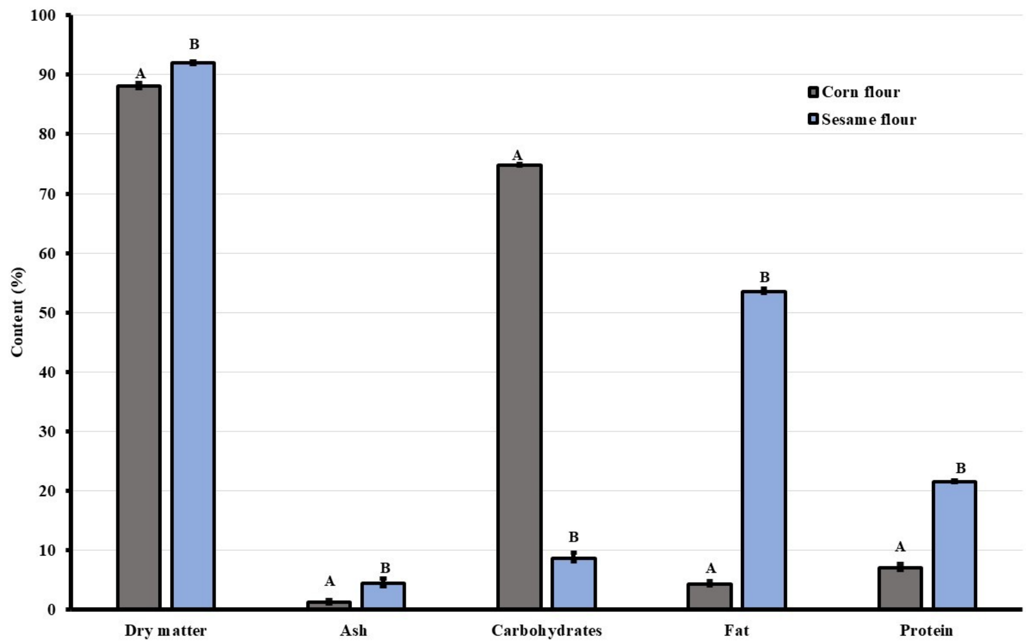
4.52% in different corn varieties. These studies concluded that the fat content in corn is highly variable. This variability in lipid content can only be attributed to varietal factors, environmental factors, the interaction of the two factors, the date of seed harvest or the method of analysis. In sesame flour, the fat content found (53.53 ± 0.08%) is within the range of 43.4% to 58.8% for 42 sesame strains(Bahkali *et al*., 1998). This difference could be attributed to varietal factors, and some processing techniques, such as soaking time. Furthermore, the authors found that soaking time caused a variation in fat levels in sesame flour, since the fat levels increased from 55.26% in flour from soaking day 1 to 37.40% in flour from soaking day 16.Furthermore, a fat content of 59.97 ± 0.07%, 57.22 ± 0.07%, 57.32 ± 0.16% and 59.90 ± 0.11% was obtained in raw, 10-minute toasted, 20-minute toasted and 30-minute toasted seed flour, respectively (Lawal *et al*., 2021). These results suggest that the flour production technology promotes a variation in fat levels.

Results of the physicochemical analyses of the mixed flours produced: The results of physicochemical parameter analyses are shown in Figure 4a and 4b. The dry matter contents were 87.58 ± 0.21%, 87.58 ± 0.15% and 88.07 ± 0.23% in F10, F20 and F30, respectively. The incorporation of sesame flour into corn flour ranging from 10 to 20% did not result in a significant variation in terms of dry matter.These results are lower than those reported by Vieu, Tahirou Traoré, Serge Trèche, (2001) who found a dry matter content of between 10.3±0.8 % to 25.5 ±1.4 % in different porridges.

Table 3. Results of preparation and administration of porridges

Children's Code	Quantity Administered	Frequency	State of Consumption	Reactionafter Consumption
Moderatelymalnourished				
A	2 ladles	4 to 5 times	Completely consumed	ND
B	2 ladles	4 to 5 times	Completely consumed	ND
C	2 ladles	4 to 5 times	Completely consumed	ND
Normal children				
D	2 ladles	2 or 3 times	Completely consumed	ND
E	2 ladles	2 or 3 times	Completely consumed	ND

ND:Unidentified

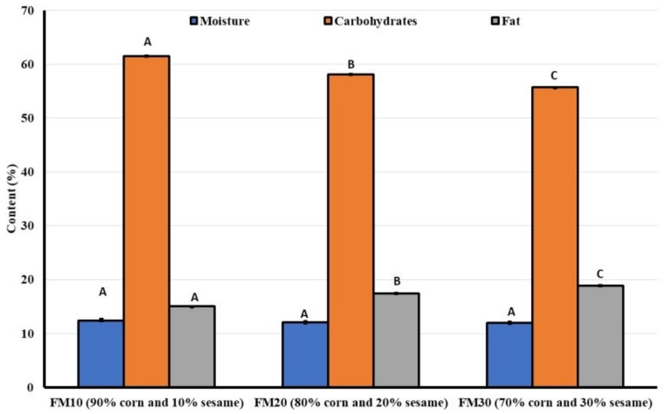


The capital letters mentioned in the figure represent the significant differences between sesame flour and corn flour

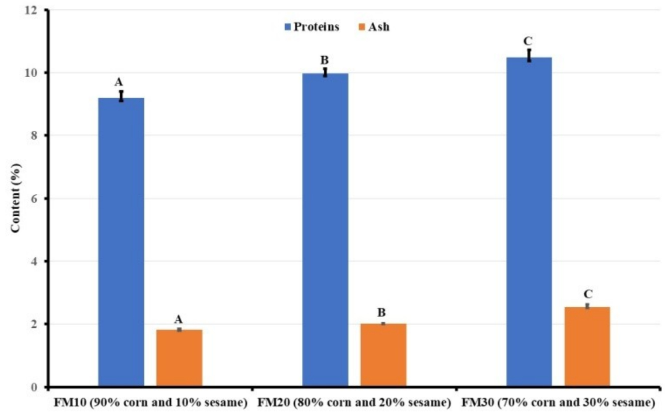
Figure 3. Physicochemical parameters of manufactured corn and sesame flours

The fat content obtained in corn and sesame flour is shown in Figure 3. The fat value is significantly higher in sesame flour (53.53 ± 0.08%) compared to corn flour (4.34 ± 0.031). Note that the value obtained in corn flour is higher than that found bySandhu *et al*., (2007) who obtained a fat value ranging from 1.65% to 2.42% in nine corn varieties. On the other hand, our results are similar to the work ofChaudhary *et al*., (2013), who found a content ranging from 4.29 to

This difference could be attributed to the ingredients used in the porridges. The protein content increased significantly with the levels of sesame flour incorporation. These values were 9.20 ± 0.05%, 9.97 ± 0.01% and 10.49 ± 0.01% in F10, F20 and F30 formulation, respectively (Figure 4b). This increase in protein contents depending on the insertion rates could be due to the incorporation of sesame flour into corn flour. This would mean that fortifying corn flour with sesame flour is a necessity, as it increases the protein content. This trend is similar to the work of Soro *et al*., (2013)who found that protein content increased with the rate of soy incorporated. The authors found that protein content ranged from 6.56 ± 0.01 g / 100 g in unfermented yam flour, and 7.38 ± 0.27 01 g / 100 g in fermented yam flour to 21.88 ± 1.09 g / 100 g with 40% soy incorporation. In this study, yam and soybean fermentation induced an increase in the protein content of yam and soybean flours (Soro *et al*., 2013). In addition, the protein contents of formulated feeds can have a positive impact on tissue repair and muscle building. They are therefore extremely important during growth and pregnancy (Soro *et al*., 2013). In addition, in another similar study, Kone *et al*., (2019) reported that the protein content increased with the levels of incorporation of cashew flour into attieke flour. The lipid contents of the mixed flours are 15.01%, 17.41% and 18.88% respectively (Figure 4a).



The capital letters mentioned in the figure represent the significant differences between sesame flour and corn flour



The capital letters mentioned in the figure represent the significant differences between sesame flour and corn flour

Figure 4. Results of the physicochemical parameters ((a) moisture, carbohydrates and fat; and (b) protein and ash) carried out on mixed flours

This rate increases significantly with the increase in the rate of incorporation of sesame flour into corn flour. These results corroborate those of Fathelrahman *et al*., (2015) who showed that increasing the incorporation rate of defatted sesame flour in wheat flour led to an increase in the lipid level in the composite flours (Sika *et al*., 2019). The carbohydrate contents found in mixed flours are respectively 61.49%, 58.09% and 55.68%, this decrease in the carbohydrate rate would be due to the low content of the carbohydrate fortifier (Figure 4a**)**. The carbohydrate content varies from 61.49 to 55.68%. This content decreases significantly with the increase in the rate of incorporation of Sesame Flour into Corn Flour. Such a decrease was also observed by Shiriki *et al*., (2015) in corn, soybean and peanut flour enriched with Moringa oleifera. However, these contents are lower than that recommended by the (FAO / WHO) which is 68%. Thus, these flours could be a source of dietary energy for infants thanks to the amount of sugar readily available for basic metabolic activities that allow growth and development. Ash contents in the mixed flours were 1.82 ± 0.015%, 2.02 ± 0.004% and 2.55 ± 0.005% in formulations F10, F20 and F30, respectively. Analysis of variance applied to these data showed that ash values increased with the levels of incorporation of sesame flour. This increase could be due to the additional contribution of minerals by sesame flour since sesame has been reported to be an important source of minerals (Kajihausa *et al*., 2014). Moreover, these ash levels are higher than the range (0.73-2.20%) reported by Kone *et al*., (2019)on corn flours fortified with sweet potato leaf extracts.

However, the moisture contents of the mixed flours are respectively 12.42%, 12.03% and 11.93%, which correspond to dry matter rates of 87.58%, 87.97% and 88.07%. Compared to the assessment limit of mixed infant flours 13-15% reported by Coraf/W., 2012, the results are appreciable. Ultimately, the results obtained deduced that sesame flour is rich in fat, proteins and ash compared to corn flour which is poor in these elements, hence the advantage of its use. The fat, protein and ash contents increase in mixed flours, on the other hand, those of carbohydrates decrease. This increase in nutrient contents would be due to the addition of sesame flour and the decrease in carbohydrates would be due to the low content of the fortifier (sesame flour) in carbohydrates. Therefore, fortification increases the nutrient values in mixed flours so these mixed flours can be used as a complementary food for children during weaning period. As mentioned in Table 1, the energy values of the mixed flours are respectively 417.85 kcal, 428.93 kcal and 434.6 kcal. It should be noted that the energy values of the mixed flours increase according to the insertion rates and this increase would be due to the incorporation of sesame flour into that of corn. These energy values found are slightly higher than those of the 400 kcal infant flours reported by Cyrille Bruce, (2017); although they are in the range of (421.26-484.81 kcal) reported by Patricia, R. N., 2016. These differences would be explained by the richness of the raw materials in macronutrients and the different insertion rates applied during the fortification of these flours.In a similar study, Fanou Fogny *et al*., (2018) found an energy intake of 409.15 kcal in an infant porridge intended for the care of children aged 6 to 23 months. These results are slightly lower than those obtained in our formulations. This difference could be attributed to the nature of the raw materials and ingredients used in these recipes. The results of the microbiological analyses are mentioned in Table 2. No germs of total, faecal coliforms, Sulfite-Reducing Anaerobes and Salmonella were found in both simple and fortified flours, this could be explained by the respect of good hygiene practices applied during the manufacture of flours and the quality of raw materials. However, germs of FMAT and Yeasts and Moulds were identified but at numbers well below the microbiological criteria respectively 5.104 CFU/g and 4.103 CFU/g. The fungal and bacteriological loads detected are lower than the microbiological criteria applicable to infant flours (Codex Stan 74-1981). These low loads could be explained by the humidity rate found in the different flours and the good manufacturing and hygiene practices applied during the production of these flours. The different flours obtained in this study are therefore of satisfactory microbiological quality.

Preparation and administration of porridges: After the physicochemical and microbiological analyses of the flours produced, porridges were prepared and given to the children. As indicated in Table 3, the administration of the porridges was done taking into account the nutritional status of the children. For this, the children were subdivided into two (moderately malnourished children and normal children). For each category of children, two ladles were served to each child with a frequency of 4 to 5 times for moderately malnourished children and 2 to 3 times for normal children. The qualities of porridge served were completely consumed by the children; which shows the acceptability of the porridges by the children. In addition, no signs of allergy, vomiting, diarrhea, itching were observed in the children who consumed them. This could be explained by the respect of the hygiene rules applied during the preparation of the porridges, the insertion rates during the preparation as well as the nature of the food.

CONCLUSION

This work aims to fortify corn flour with sesame flour in the care of children aged 6 to 18 months. Corn and sesame flours were produced from corn and sesame seeds that were purchased at the Matoto market in Conakry. These flours were analyzed microbiologically. The germs counted complied with the established microbiological criteria. Mixed flours were manufactured on the basis of 10, 20 and 30% incorporation. These flours were analyzed to determine the dry matter, ash, protein, lipid and carbohydrate content. These three recipes were significantly different. In addition, microbiological analyses on total aerobic mesophilic flora, total and fecal coliforms, sulfite-reducing anaerobes, staphylococci complied with the criteria; which confirmed that mixed flours do not contain pathogenic microorganisms. The physicochemical parameters show that the incorporation of sesame flour into corn flour improved the nutritional characteristics; since these parameters evolved according to the levels of incorporation of sesame flour. The energy value also evolved with the levels of incorporation of sesame flour. Mixed flour has a higher energy value than that of simple corn flour despite the decrease in the total carbohydrate content in mixed flour. In addition, this study showed the interest of associating sesame flour with corn flour for the care of children during the weaning period. The scientific findings of this research constitute an opportunity for nutritionists. However, additional studies are necessary to optimize the nutritional values of the flours produced by including other specific analyses such as structural, chromatographic and mineral element determination analyses.

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Data availability: I don't have any research data outside the submitted manuscript file.

Author contributions

Mamadou Lamanarana Souaré: Methodology, Writing - review and editing, Resource; Moriken Sangaré: Conceptualization, Investigation, Validation of the Methodology, Resources, Data curation, Visualization, Writing - original draft, Writing - review and editing; Mariam Mohamed Traoré: Analysis, manufacturing and laboratory analyses of flours, Writing - review and editing; Nèma Théa: Revision, data processing, Validation; Mahamadou Elhadj Gouga: Validation and data processing; Lonseny Traoré: Conceptualization, Investigation, Validation of the Methodology.

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