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Process for Formulating an Infant Flour Based on Local Ingredients from Senegal, West Africa, Enriched with Baobab Oil (*Adansonia digitata* L.)

Edouard Mbarick Ndiaye[1]*, Alioune Sow[2], Kouakou N'guessan Stanislas Kobenan[3], Omar Toure[1], Seyni Ndiaye[1], Omar Ibn Khatab Cisse[4], Pape Guédel Faye[1], Hicham Harhar[5], Nicolas Cyrille Ayessou[1], Mady Cisse[1]

[1]Laboratory of Water Energy Environment and Industrial Processes (LE3PI), ESP, Center of Studies on Food Security and Functional Molecules (CESAM-RESCIF), Cheikh Anta Diop University of Dakar (UCAD), Dakar, Senegal
[2]Laboratoire of Biological, Agronomic, Food Sciences and Modeling of Complex Systems (LABAAM), UFR of Agronomic Sciences, Aquaculture and Food Technologies (S2ATA), Gaston Berger University of Saint-Louis, Saint-Louis, Senegal
[3]UMRI Agronomic Science and Processing, Félix Houphouët-Boigny Institut National Polytechnique of Yamoussoukro, Yamoussoukro, Côte d'Ivoire
[4]National School of Agriculture, University Iba Der Thiam of Thiès, Thiès, Senegal
[5]Laboratory of Materials, Nanotechnology and Environment, Faculty of Sciences-Rabat, Mohammed V University of Rabat, Rabat, Morocco
Email: *papaedou@gmail.com, aliouneabdsow@hotmail.fr, stanislasbelo83@gmail.com, omartoure@esp.sn, oumaribn.cisse@univ-thies.sn, papaguedel.faye@esp.sn, hichamoo79@yahoo.fr, nicolas.ayessou@ucad.edu.sn, tabyaouihamid@gmail.com, mady.cisse@ucad.edu.sn

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Abstract

Infant malnutrition remains a public health problem in rural Senegal. Locally-produced infant flours are of inferior quality and still do not comply with World Health Organization (WHO) recommendations. In this context, the aim of this study is to develop a new infant flour formula enriched with baobab oil, made from local cereals (millet and maize), local legumes (cowpea) and baobab fruit pulp. The matrix formulation method was used to generate the proportions of ingredients to be blended for the two (2) flours: one reference (F1) and the other enriched (F2). The results obtained show that F2 flour has a nutritional composition (protein 12.23 g·100g^{-1}; lipids 8.68 g·100g^{-1}; carbohydrates 68.60 g·100g^{-1}; energy values 398.47 kcal) in line with WHO standards, with calcium contents of 86.21 mg·100g^{-1}, potassium 961.98 mg·100g^{-1}, phosphorus 208.39 mg·100g^{-1}, iron 6.58 mg·100g^{-1} and zinc 3.27 mg·100g^{-1}. The addition of baobab pulp and oil not only increases the flour's energy value, but also enriches it with fatty acids, sterols, tocopherols and vitamin C. In short, this F2 flour could be recommended as a food supplement for infants and young children, helping to combat malnutrition.

Keywords

Baobab Oil and Pulp, Enrichment, Infant Flours, Nutritional Quality, Senegal

1. Introduction

According to the Food and Agriculture Organization of the United Nations (FAO), nearly 3.1 billion people worldwide suffer from malnutrition [1]. In West and Central Africa, acute food insecurity is reaching its highest level in a decade [2]. The COVID 19 pandemic, conflicts, socio-economic crises and recurrent extreme climatic events in the region continue to worsen hunger and malnutrition among children. As a result, 16.5 million children under the age of five (5) will face acute malnutrition in 2023, of whom 4.8 million will suffer from the severe debilitating form (SAM). This represents an 83% increase in global acute malnutrition (GAM) compared with the average for the period 2015-2022 [2]. In Senegal, malnutrition is a public health problem and, above all, a development issue. Acute malnutrition affects 8.2% of children under five. The prevalence of severe acute malnutrition in children under five is 2.1%, with regional disparities [3]. One third of deaths among children under five are directly or indirectly linked to poor nutrition [4].

The main causes of this malnutrition are an overall deficit in protein-energy intake and a deficiency in certain essential minerals such as calcium, iron and zinc [5]. In fact, in sub-Saharan Africa, the first supplementary foods are most often boiled cereals, roots or tubers, with or without sugar [5]. These predominantly plant-based diets provide insufficient quantities of certain key nutrients, notably iron, zinc, calcium and iodine, to cover the recommended nutrient requirements between 6 and 24 months of age [6] [7].

Faced with this shortcoming, the development of an infant flour formula based on local cereals, enriched with local ingredients, available at a good price and with a high energy density, would be a promising alternative to curb this scourge in Senegal.

The aim of this study was to develop an infant flour of the required nutritional quality based on locally available ingredients, for the benefit of low-income local populations.

2. Materials and Methods

2.1. Plant Material

The plant material used consisted of millet (*Penicillaire glaucum* L.), maize (*Zea mays*), cowpea (*Vigna unguiculata*) pulp and baobab (*Adansonia digitata* L.) oil. Millet, maize and cowpea were purchased at the Guédiawaye market (14˚46'34"

North and 17˚23'44" West) located in the Dakar region, Senegal. Baobab pulp and oil were obtained from fruit harvested at random in Sindian (12˚57'47" North; 16˚10'55" West) in the Ziguinchor region, Senegal.

2.2. Preparation of Plant Material

2.2.1. Flour Preparation

The different base flours were prepared separately according to standards (CAC, 2013) [8], taking into account the characteristics of each raw material used. Thus, 2 kg of maize and 1 kg of cowpea were weighed, then sorted and winnowed to separate impurities. The seeds were thoroughly washed separately with tap water, then drained before being oven-dried at 45˚C for 24 hours. The seeds were then ground using a locally-designed grain mill (ECM PENE and BROTHERS), equipped with a 7.5 hp electric motor, a 25 kg capacity hopper and running at a speed of 4800 rpm. The locally-built mill (ECM PENE and BROTHERS) comprises a grinding chamber in which a rotor rotates, supporting hammers that break up the seeds to produce flour. The flour obtained is cooled and then sieved using a stainless steel sieve (200 µm). Finally, the flours are packed in clean plastic boxes, protected from humidity, until they are ready for formulation.

With the millet, 2 kg are sorted to eliminate foreign bodies and bad seeds. The selected seeds are first hulled to remove the millet bran, using a locally-made millet huller with a production capacity of 250 $kg \cdot h^{-1}$ and equipped with a 7.5 hp electric motor. Next, the seeds, separated from the bran by winnowing, are carefully washed, then rinsed with water and drained before being oven-dried for 24 hours at 45˚C. Finally, after cooling, the dry millet seeds are ground in a cereal mill to obtain flour. This cooled flour is sieved through a 200 µm mesh sieve. Separately, the flours obtained are packaged in clean plastic boxes and kept away from humidity until formulation.

2.2.2. Preparation of Baobab Pulp

The baobab fruits were first shelled and the various components separated. Initially, the seeds, covered with the whitish pulp, were separated from the pulp by a dry process [9]. To do this, the pulp-coated seeds were first sun-dried and then pulped using a 316N stainless steel pulping machine fitted with a 150 µm sieve. This was followed by coarse sieving to separate the pulp from the seeds. The baobab pulp is ground in a mill and then sieved. The resulting baobab flour was oven-dried for 24 hours at 45˚C. After cooling, it is packaged in airtight plastic boxes for analysis and formulation.

2.3. Obtaining Baobab Oil

Baobab seed oil was obtained using the method described by Ndiaye *et al.* (2022) [10]. The seeds, separated from the pulp, were ground in a millet mill with a capacity of 300 to 350 $kg \cdot h^{-1}$ and an electric motor power estimated at 7.5 CV, fitted with sieves with 2 mm diameter holes and at a speed of 2800 rpm. The crushed material obtained was collected in a basin. The crushed material was then pressed using a KOMET DD85G press (IBG Monforts Ockotec GmbH, Germany). This press is fitted with a 10 mm die and rotated at a speed of 25 rpm. The outlet head was heated to 105˚C for 25 minutes at the start of extraction. The crude oil obtained was left to settle for two (2) days, then filtered through a plate filter fitted with special cloths and placed in plastic bottles until formulation. **Figure 1** shows the various ingredients used in infant flour formulation.

Figure 1. Basic ingredients prepared. Millet flour (A), maize flour (B), baobab pulp flour baobab pulp flour (C), cowpea flour (D) baobab oil (E).

2.4. Flour Formulation

Microsoft Excel's linear programming solver was used to develop the flour formulation spreadsheet. It enables the cost of the feed to be minimized while striking a balance between the percentage, nutritional value and constraints of the ingredients used in the formulation [11]. Thus, this calculation system based on the matrix formulation method makes it possible, from a list of food ingredients, to find the solution leading to covering at least two nutrient requirements with at least two ingredients [12] [13]. The equation system is as follows:

$$\begin{cases} a_{11}X_1 + a_{12}X_2 + \cdots + a_{1n}X_n = b1 \\ a21X_1 + a22X_2 + \cdots + a2_nX_n = b2 \\ a_{n1}X_1 + a_{n2}X_2 + \cdots + a_{nn}X_n = bn \end{cases}$$

where a is the macro or micronutrient content; *X*, the proportions of ingredients used in the formulation and *b*, the requirements to be met.

This equation makes it possible to satisfy the nutritional needs of infants, taking into account the nutritional composition of the ingredients, the anti-nutritional factors and the proportion of ingredients in the flour.

2.5. Programming Constraints

The Microsoft Excel 2013 solver was used for programming. The basic objective is to formulate a flour that meets WHO requirements while minimizing the cost of the flour. To achieve this, a cell corresponding to the cost of the flour was created. This value must be minimum (min), hence the choice of the Min icon in the solver parameters. In addition, the sum of the percentages of the ingredients used must equal 100 (100%). However, the incorporation rate of the ingredients (cowpea and baobab pulp) must not exceed 10% (Table 1).

Table 1. Proportions by weight of ingredients ($g \cdot 100g^{-1}$) used in infant formula flours.

Formula	Ingredient	Proportion generated (g)
F1	baobab pulp	10
	Cowpea	10
	Corn	33
	Mil	47
F2	baobab pulp	10
	Cowpea	10
	Corn	33
	Mil	43
	Baobab oil	4

The various values for macronutrients (proteins, carbohydrates and lipids) expressed in grams per 100 g of flour, micronutrients (calcium, potassium, iron, phosphorus and zinc) in milligrams per 100 g of flour, and energy in kilocalories per 100 g of flour are calculated automatically using formulas developed in Excel software. This method makes it possible to formulate an infant flour (Figure 2) that is accessible to low-income households and complies with recommendations for macro- and micronutrient content [14].

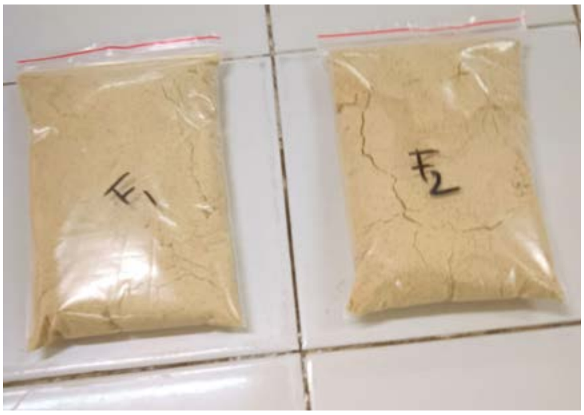

Figure 2. Flour made from local ingredients and enriched with baobab oil.

2.6. Flour Physicochemical Analysis

Moisture content, ash content, crude protein, crude fat, total carbohydrates, pH and titratable acidity were determined according to AOAC (1990) methods [15]. Lipid extraction was carried out with n-hexane using the soxhlet (Pierron 250 mL) according to the Ndiaye *et al.* method (2022).

2.6.1. Carbohydrate Content

Carbohydrate content was determined according to the following formula:

$$\%\text{carbohydrate} = 100 - (\%\text{moisture} + \%\text{protein} = \%\text{fat} + \%\text{ash})$$

2.6.2. Energy Value

Energy values were calculated using Atwater's specific coefficients for proteins, lipids and carbohydrates.

$$\text{energy value}(\text{kcal}) = \left[(\%\text{carbohydrates} \times 4) + (\%\text{proteins} \times 4) + (\%\text{lipids} \times 9)\right]$$

2.6.3. pH Value

The pH was determined using the potentiometric method. For this, 10 g of flour were mixed with 100 mL of distilled water. The resulting mixture was macerated for 30 min, then filtered. With the filtrate obtained, a volume of 10 mL was taken and the pH measured using a pH meter (HI2210-Hanna Instruments).

2.6.4. Titratable Acidity

Titratable acidity was determined following the method described by Pamba *et al.*, (2018) [16]. A volume of 50 mL of distilled water was added to 5 g of flour. The mixture was homogenized using a magnetic stirrer for 10 min and then filtered. Consequently, a 10 mL volume of the filtrate noted V_0 was titrated with a sodium hydroxide (NaOH) solution of normality, $N_1 = 0.1$ N in the presence of phenophthalein. The volume of NaOH solution poured at equivalence is noted V_1. The total acidity, expressed in milliequivalents per 100 grams of product, is given by the following relationship:

$$\text{TA}\left(\frac{meq}{100g}\right) = \frac{N_1 \cdot V_1 \cdot 10^5}{mV_0}$$

where TA, corresponds to titratable acidity and m, the mass of the test sample in grams.

2.6.5. Mineral Content

The mineral and trace element contents of the samples were determined using a NITON XL3T X-ray fluorescence spectrometer [17]. When the sample under analysis is bombarded with X-rays, the elements present enter an excited state and re-emit radiation during relaxation (transition from the excited state to the ground state) in the form of, among other things, X-rays. This is the phenomenon of X-ray fluorescence. The spectrum of X-rays emitted by the material is characteristic of the sample's composition. By analyzing the spectrum emitted and calibrating the instrument, the elemental composition of the sample can be deduced.

2.7. Determination of Flour Functional Properties

2.7.1. Water Absorption Capacity and Solubility Index

Water absorption capacity and solubility index were determined according to the method described by Soro *et al.* (2013) [5] and Gampoula *et al.*, (2020) [7]. For this, 1 g (M_0) of flour was mixed with 10 mL of distilled water. The mixture was stirred on a shaker for 30 minutes, then placed in a water bath at 37˚C for 30 minutes and centrifuged at 4000 rpm for 20 minutes. The resulting sediment M_2 was then weighed and oven-dried at 105˚C for 24 hours to constant weight M_1 in grams. The water absorption capacity (WAC) was calculated according to the following equation:

$$\text{WAC}(\%) = \frac{M_2 - M_1}{M_1} \times 100$$

The percentage solubility index (SI) was determined according to the following relationship:

$$\text{SI}(\%) = \frac{M_0 - M_1}{M_1} \times 100$$

2.7.2. Oil Absorption Capacity

The oil absorption capacity (OAC) of the flours produced was determined using the method described by Soro *et al.*, (2013) and Gampoula *et al.*, (2020). A volume of 10 mL of baobab oil was mixed with 1 g (M_0) of infant flour. The mixture was homogenized on a shaker and centrifuged at 4000 rpm for 15 minutes. The M_1 sediment was weighed and the OAC oil absorption capacity, expressed as a percentage, is given by the following relationship:

$$\text{OAC}(\%) = \frac{M_1 - M_0}{M_0} \times 100$$

2.7.3. Rapport Hydrophile-Lipophile

The ratio of water absorption capacity to oil adsorption capacity is used to assess the comparative affinity of the flours analyzed for water and oil [18].

2.8. Statistical Analysis of Results

One-factor analyses of variance and Fischer's LSD test at the 5% significance level were used to compare means. The results obtained represent the average of three analyses, and STATISTICA software (version 16.2.04) was used.

3. Results and Discussion

3.1. Biochemical Composition of Flours

The physico-chemical characteristics of the base flours used in infant formula are given in Table 2.

The water content of the base flours analyzed ranged from 5.64% (cowpea flour) to 7.78% (baobab pulp flour). A significant difference at the 5% threshold was noted between cowpea flour and the others. The low moisture content of these flours can be explained by the fact that they come from grains that have already been dried. In addition, after sieving, the flours were steamed to control their water content and thus ensure their stability. Indeed, water favors the proliferation of microorganisms capable of hydrolyzing the starch present in the flours with the help of their amylases, thus facilitating the acidification of the flours [19].

Table 2. Biochemical composition of the base flours analyzed.

Parameters	Flours			
	baobab pulp	Cowpea	Corn	Mil
Humidity %	7.68^a	5.64^b	7.57^a	7.78^a
Protein %	3.79^a	24.12^b	7.59^c	16.12^d
Fats %	0.35^a	1.86^b	6.07^c	5.73^c
Carbohydrates %	81.31^a	66.98^b	73.32^c	67.98^d
Ash %	2.87^a	1.31^b	1.45^c	1.05^d
Phosphorus (mg·100g^{-1})	80.00^a	387^b	202^c	221^d
Calcium (mg·100g^{-1})	358.6^a	134.2^b	37.49^c	57.11^d
Potassium (mg·100g^{-1})	2822.23^a	1678.78^b	601.33^c	961.49^d
Iron (mg·100g^{-1})	8.55^a	4.18^b	7.94^c	6.24^d
Zinc (mg·100g^{-1})	0.60^a	5.35^b	2.73^c	4.14^d
Energy value (Kcal·100g^{-1})	343.45^a	381.45^b	378.24^b	387.94^c

These values represent the averages of three measurements. Values with different letters on the same line are significantly different.

Protein content varied significantly ($P < 0.05$) from 3.79^a to 24.12^b. Millet (16.12^d %) and cowpea flours had the highest contents. The high protein content of cowpea justifies its addition to infant flour formulations. Proteins play a role in the body's defense system and cover the nitrogen expenditure required for tissue renewal and the synthesis of certain compounds, such as hormones and enzymes, involved in the proper functioning of the body [19].

The lipid content of the basic ingredients is relatively low, ranging from 0.35 to 6.07%. Millet and corn flours have the highest lipid content. However, these values are below the minimum value indicated by the WHO (WOH, 2002) for infant flours (7 - 8 mg·100g^{-1}) [14]. To make up for this deficit, 4% baobab oil, composed of more than 60% instaurates, will be incorporated into the infant flour to be optimized.

Total carbohydrate content is relatively high for all base flours, with a significant difference ($P < 0.05$). It is respectively equal to 81.31^a; 66.98^b; 73.32^c and 67.98^d % for baobab, cowpea, maize and millet pulp flours. These results show that our various base flours are rich in sugar and, consequently, could have a high energy density.

Baobab pulp has the highest ash content (2.87^a g·100g^{-1}), while millet flour has the lowest (1.05^d). For maize and cowpea, the ash content is 1.45^c and 1.31^b g·100g^{-1} respectively. These different ash contents of the flours analyzed show a significant difference at the 5% threshold. The high ash content of baobab pulp could be explained by its high mineral content.

Millet flour (387.94^c Kcal·100g^{-1}), cowpea flour (381.45^b Kcal·100g^{-1}) and maize flour (378.24^b Kcal·100g^{-1}) have the highest energy values, with a significant difference ($P < 0.05$). Baobab pulp flour had the lowest energy value at 343.45^a Kcal·100g^{-1}. According to the FAO/WHO, infants and toddlers (6 to 24 months) need to consume high-energy foods to cover their energy requirements, and therefore recommend that weaning foods be energy-rich.

The micronutrient composition of the different base flours analyzed is significant and significantly different ($P < 0.05$). Baobab pulp flour is richer in potassium (2822.23^a mg·100g^{-1}), calcium (358.6^a mg·100g^{-1}) and iron. Cowpea and millet flour are richer in phosphorus (387^b; 221^d mg·100g^{-1}) and zinc (5.35^b; 4.14^d mg·100g^{-1}). Some of these nutrients are involved in membrane transport and enzyme activation, and play a role in muscle contraction. Others are involved in skeletal formation, but also in numerous metabolic functions such as enzymatic and hormonal activities, nerve stimuli and oxygen transport [19] [20].

3.2. Characteristics of Formulated Infant Formulas

3.2.1. Macronutrient Composition of Formulated Flours

The matrix method was used to generate two (2) infant flours (F1 and F2) with the nutritional composition shown in **Table 3**, compared with WHO standards.

Table 3. Nutritional composition of formulated infant flours.

Constituents	Farines		WHO standards
	F1	F2	
Humidity %	5.34^a	4.47^b	<12
Protein %	12.88^a	12.23^b	6 - 13
Fats %	4.91^a	8.68^b	7 - 8
Carbohydrates %	71.32^a	68.60^b	60 - 70
Ash %	2.47^a	2.86^b	2
Phosphorus (mg·100g^{-1})	217.23^a	208.39^b	150 - 200
Calcium (mg·100g^{-1})	88.49^a	86.21^b	100 - 400
Potassium (mg·100g^{-1})	1000.44^a	961.98^b	400 - 800
Iron (mg·100g^{-1})	6.83^a	6.58^b	5.8 - 14
Zinc (mg·100g^{-1})	3.44^a	3.27^b	2.8 - 8.3
Energy value (Kcal·100g^{-1})	377.99^a	398.47^b	400 - 440
Price per kg	0.76 €	1.29 €	-

These values represent the averages of three measurements. Values with different letters on the same line are significantly different.

The macronutrient, ash and moisture contents of F1 and F2 flours were significantly different ($P < 0.05$). F1 flour, made from millet, cowpea, maize and baobab pulp, contains 12.88% protein, 4.91% lipids and 71.32% carbohydrates for a value of 377.99 Kcal per 100 g dry flour, while F2 flour, enriched with baobab oil, contains 12.23% protein, 8.68% lipids and 68.60% carbohydrates for an energy value of 398.47%. Ash content is 2.47% for F1 flour and 2.86% for F2 flour. Moisture levels for F1 and F2 flours are low, at 5.34% and 4.47% respectively. Analysis of macronutrient composition showed that protein and carbohydrate contents were in line for F1 and F2 flours. However, only F2 flour complied with WHO lipid standards [14]. The low lipid content of F1 flour (4.91%) can be explained by its composition. Indeed, the basic ingredients (millet, maize, cowpea and bouy) making up F1 flour all have low lipid content. The addition of 4% baobab oil to F1 flour resulted in a more balanced F2 flour that meets WHO requirements. In addition to meeting lipid requirements, baobab oil also provides other health benefits for children. According to Ndiaye *et al.*, (2022), baobab oil is rich in unsaturated fatty acids, sterols and especially tocopherols, which are natural antioxidants. These macronutrient results are comparable to those obtained by Gbogouri *et al.*, (2019) and Loba *et al.*, (2019). The former authors had found protein, lipid, carbohydrate, ash and energy contents equal to 12.23%; 9.75%; 68.54%; 2.76% and 410 Kcal respectively for an infant flour composed of millet, germinated maize, beans and sugar. They had also enriched their F1S flour, composed of (52% millet, 10% germinated maize, 16% soya, 6% sugar) with 4% fish oil. The nutritional composition of their F1S flour, enriched with fish oil, was close to that of the F2 flour, and consisted respectively of 13.29% protein; 9.86% lipids; 68.17% fat; 2.45% ash, with an energy value of 414.6 Kcal per 100 grams. Finally, the F2 flour (1.29€) thus obtained, while satisfying the nutritional needs of infants and young children, is 3.5 times less expensive than the infant flours (4.58€) sold in pharmacies and supermarkets. This will enable low-income households to save 3.29€ on each purchase.

3.2.2. Micronutrient Composition of Formulated Flours

The mineral composition of F1 and F2 flours is shown in **Table 3**. The mineral contents of the flours were significantly different at the 5% threshold. Phosphorus, calcium, potassium, iron and zinc contents were higher in F1 flour than in F2 flour. These were 217.23; 88.49; 1000.44; 6.83 and 3.44 $mg \cdot 100^{-1}$ dry flour respectively. However, F1 and F2 flours had micronutrient compositions comparable to WHO standards [14]. These mineral results are superior to those obtained by ponka *et al.*, (2016). Indeed, the authors had found for an F1 flour, made up of corn (77.34%); soy (6.45%); peanuts (12.9%); sugar (3.31%), calcium, potassium, phosphorus, iron and zinc contents equal to 2.65; 267.99; 182.00; 2.16 and 2.27 $mg \cdot 100^{-1}$ gram respectively. According to Gbogouri *et al.*, (2019), certain nutrients, such as iron, are supplied exclusively by supplementary feeding at 6 months.

In this study, the addition of baobab oil was intended to make up for the lipid deficiency of F1 flour and thus contribute to improving the energy value. The addition of the cowpea legume to the formulation was primarily intended to boost the flour's protein value. Baobab pulp improved the flour's taste, while providing minerals and vitamin C. According to Cissé *et al.*, (2009), baobab pulp contains up to 6 times more vitamin C than orange juice. Baobab pulp is recognized for its antidiarrheal properties [21]. However, the addition of baobab pulp to infant flours needs to be carefully monitored to avoid pre-menopausal constipation in children.

The F2 flour thus obtained, after enrichment of the F1 flour made from local ingredients, has a nutritional composition in line with the values required by the World Health Organization. According to FAO/WHO 2002, 100 grams of infant flour intended to supplement breast milk should provide between 6% and 13% protein, 7% to 8% lipids, 60% to 70% carbohydrates and 400 to 440 Kcal. Mineral intakes vary from 100 to 400 mg calcium, 400 to 800 mg potassium, 150 to 200 mg phosphorus, 5.8 to 14 mg iron and 2.8 to 8.3 mg zinc [7] [22] [23]. These results illustrate the nutritional quality of F2 flour.

3.3. Functional Properties of the Flours Developed

The functional properties of the F1 and F2 infant flours formulated are presented in **Table 4**.

Table 4. Functional properties of F1 and F2 flours.

Flours formulated	Functional properties of formulated flours					
	WAC (%)	SI (%)	OAC (%)	pH	H/L	TA ($mEq \cdot 100^{-1}$)
F1	289.45^a ± 2.33	37.86^a ± 0.5	126^a ± 1	5.07^a ± 0.01	2.30^a ± 0.002	1.45^a ± 0.05
F2	278.53^a ± 2.71	27.05^b ± 2.05	78.5^b ± 1.5	4.96^a ± 0.005	3.55^b ± 0.09	1.35^a ± 0.05

WAC: water absorption capacity, SI: solubility index, OAC: oil absorption capacity, H/L: hydrophilic/lipophilic ratio, TA: titratable acidity.

The titratable acidity of F1 flour not enriched with baobab oil was 1.45^a, compared with 1.35^a $mEq \cdot 100^{-1}$ for F2 flour. The pH values of F1 and F2 flours were 5.07^a and 4.96^a respectively. The solubility index was higher for F1 flour (37.86^a %) than for F2 flour (27.05^b). Water absorption capacity (WAC) was 278.53^a versus 289.45^a $mEq \cdot 100^{-1}$ for oil-enriched F2 flour. Oil absorption capacity was higher for F1 flour (126^a) than for enriched flour (78.5^b). Analysis of variance at the 5% level revealed a significant difference in water absorption capacity, solubility index and hydrophilic/lipophilic ratio. This difference could be explained by the addition of oil.

4. Conclusions

In Africa, particularly in Senegal, supplementary feeding of children aged 6 to 24 months is a major public health problem. Lack of income and lack of awareness among the local population are the main causes of the problem.

This study led to the development of an infant flour, F2, made from locally available ingredients and accessible to all, which meets WHO recommendations at an affordable price (1.29€). F2 flour, obtained by enriching F1 flour (millet, maize, cowpea and baobab pulp) with baobab oil, is of the required nutritional quality and contains good levels of proteins, lipids, carbohydrates and minerals. Consumption of this F2 flour would cover the needs of infants and young children.

An *in vitro* study of the efficacy of the enriched flour thus obtained could be envisaged on animals to assess the quality of the flour on children as well as its potential side effects.

Conflicts of Interest

The authors declare no competing interests.

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