

Formulation of Enriched Infant Flours Based on Orange-Fleshed *Ipomoea batatas* for Children Complementary Feeding in Burkina Faso

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Abstract The quality of infant flours is important during the complementary feeding to meet with children nutritional needs. This study aimed to produce infant flours, sources of vitamin A, from orange-fleshed sweet potatoes to improve children feeding and contribute to reduce child malnutrition. Excel was used for the theoretical formulation of compound flours according to West Africa and Burkina Faso food composition tables. The proportions of ingredients were set in the spreadsheet to ensure that the final composition of the formulations complied with nutritional recommendations. Three infant flours were produced by combining local ingredients, and physicochemical analyses were performed according to standard methods. The results of proximate compositions have shown that for 100 g of dry matter of flour formulated, the moisture varied from 5,98 - 6,28 g, ash 2,77 - 3,71 g, fibers 12,57 - 13,58 g, vitamin A 273,63 - 325,73 µg Retinol Equivalent, protein content 13,20 - 14,78 g, lipids 14,19 - 18,34 g, carbohydrates 52,08 - 54,72 g, and an energy value of 412,12 - 426,23 Kcal. Functional properties of flours demonstrated that water absorption capacity ranged from 193,30 - 257,24 %, solubility index 61,78 - 86,42 % and oil absorption capacity 89,72 - 109,01 %. The porridges prepared from these flours formulated at 25 % of dry matter had satisfactory consistencies with energy densities ranging from 101,45 - 106,55 kcal / 100 ml. Globally, the results show that the formulated flours have satisfactory nutritional quality that can contribute to fighting against malnutrition in children aged 6 to 23 months, during the complementary feeding.

Keywords: orange-fleshed sweet potato, vitamin A, nutritional quality, infant porridge consistency, malnutrition

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1. Introduction

Malnutrition constitutes a major public health problem affecting many children around the world. It is due to an imbalance between nutritional needs and nutrient intake into the body. According to the WHO [1] report, 6.6 % of children under 5 years old worldwide suffered from acute malnutrition, 23.2 % from chronic malnutrition, 15.2 % from underweight, and 5.5 % from obesity. In addition to these forms, there is also malnutrition linked to micronutrient deficiencies, and the most common are iron, vitamin A, and iodine deficiencies [2]. In Africa, malnutrition severely affects thousands of children, with a prevalence of 5.4 % for wasting and 31.7 % for stunting

[3]. In Burkina Faso, the nutritional status of children under the age of 5 is precarious. According to UNICEF [4], Burkina Faso ranks fifteenth among the countries most affected by malnutrition, with prevalence rates of 9.9 % from emaciation, 19 % from stunting and 13.2 % from underweight [5]. According to the nutritional survey report SMART 2025, malnutrition is more pronounced during the complementary feeding age (6 to 23 months), with prevalence rates of 14.4 % for acute malnutrition and 32.1 % for chronic malnutrition among children aged 6 to 11 months and 12 to 23 months, respectively [5]. During this period, new foods are introduced into the infant's diet, with a change in the texture from semi-liquid to solid according to the infant's psychomotor abilities, while continuing breastfeeding [6]. At this stage of infant feeding, the diet should be well-balanced and varied, rich

in nutrients. For UNICEF [7], it is important to ensure this dietary transition with foods that are suitable for them both technologically and nutritionally. However, IRD and UNICEF [8] reported in a study conducted in six Sahelian countries that certain populations have difficulty to access certain food groups that are essential to ensure adequate intake of essential nutrients. Traditionally, cereal-based porridges are used in developing countries as complementary foods for infant nutrition. However, the quality of the flours used to prepare these porridges is crucial. Infant industrial flours are presented in the market place, which are not accessible for the most vulnerable population [9]. Also, Bayala-yaï *et al.* [10] have reported in their study that the local infant flours have 60 %, 80 %, and 88 % respectively for protein, lipid, and energy values below the authorized limits according to Burkina Standard NBF 01-198 [11]. IRD and UNICEF [8] have reported that mostly, local infant flours are made from cereals. To enhance nutritional quality of infant flours, tubers as staple food sources can be used for new formulation of infant flours. Particularly, orange-fleshed sweet potatoes (OFSP) reported as a good source of β -carotene content (9,490 $\mu\text{g}/100\text{ g}$) which the body can convert into vitamin A [12], would make it possible to offer children other types of flour with good nutritional quality. A food formulation based on orange-fleshed sweet potatoes (OFSP) could help to combat nutritional deficiencies, specifically those related to vitamin A deficiency, which is a public health problem in Burkina Faso among children [13]. The objective of this study is to formulate infant flours based on orange-fleshed sweet potatoes (OFSP) as the main ingredient in order to contribute to improve complementary feeding while increasing vitamin A intake in children aged 6 to 23 months.

2. Materials and Methods

2.1. Biological Material

Orange-fleshed sweet potatoes (OFSP), soybeans, peanuts, millet, baobab pulp, powdered milk and sugar were used for the formulations. All raw materials were collected from the market in Ouagadougou and transported to the Laboratoire de Microbiologie et de Biotechnologie Microbienne (LAMBM) of University Joseph KI-ZERBO for analysis and formulation process.

2.2. Raw Materials Processing

Fresh OFSP were thoroughly cleaned and peeled, and the slices obtained were soaked in water for a few minutes to prevent enzymatic browning. The drained slices were dehydrated in an air dryer at 65 °C for 20 hours. The resulting flakes were then ground using a blender in combination with other ingredients in appropriate proportions for each formulation.

Soybeans, peanuts, and millet were processed separately according to the standard Codex Alimentarius CAC/GL 8-1991 requirement [14]. The grains were first sorted manually and washed three times with tap water to remove impurities. After solar drying, the grains were

roasted separately over low heat in a pot while stirring constantly with a wooden spatula for 15 to 20 minutes, followed by cooling. The soybeans were exceptionally soaked in water followed by gentle pounding before drying to remove the skins. As for the peanuts, the skins were removed after roasting. The peanuts and soybeans were then winnowed to remove any remaining skins. After these individual operations, soybeans, peanuts and millet were ready to be weighed and ground for the formulations.

Baobab pulp, sugar, and milk were supplied directly in powder form.

2.3. Infant Flour Formulation Strategy

Composite flour formulations were developed and optimized using the Linear Programming of the Excel solver 2010 version, based for West Africa [12] and Burkina Faso [15] food composition tables, and the results of the study on OFSP flour by Koua *et al.* [16]. The formulas were programmed into the spreadsheet on the basis of 100 g of dry matter for children aged 6–23 years [17]. Infant flours were prepared by mixing various ingredients according to the recommendations for infant flours in the Codex Alimentarius CAC/GL 8-1991 [14] and Burkina Standard NBF 01-198 [18]. Three infant flours were formulated (Figure 1, Figure 2, and Figure 3), with the following compositions per 100 g of total flour (mixture):

- Formulation F1: OFSP (42 g), soybeans (28 g), peanuts (14 g), baobab pulp (8 g), sugar (8 g);
- Formulation F2: OFSP (40 g), milk (22 g), peanuts (22 g), baobab pulp (8 g), sugar (8 g);
- Formulation F3: OFSP (37 g), millet (20 g), soybeans (19 g), peanuts (17.5 g), sugar (6.5 g).

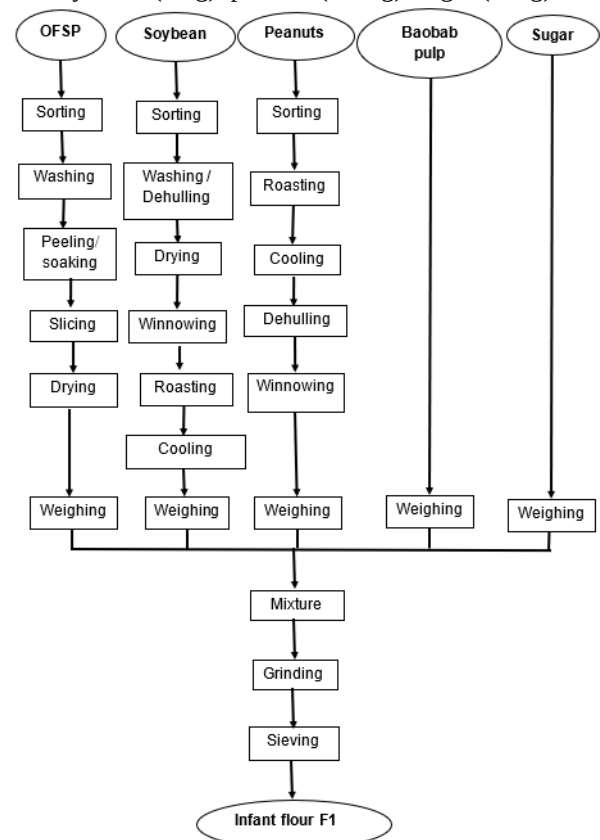


Figure 1. Infant flour F1 production diagram

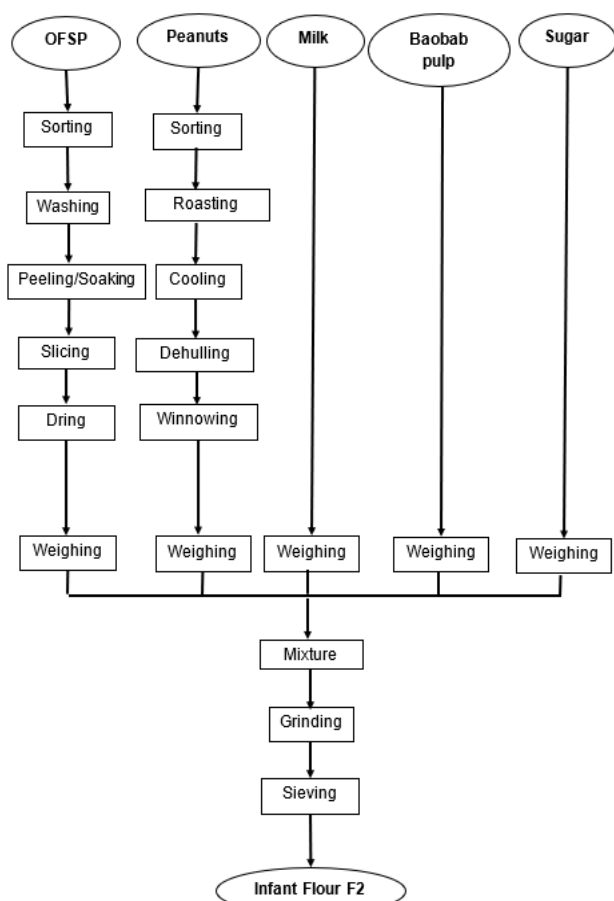


Figure 2. Infant flour F2 production diagram

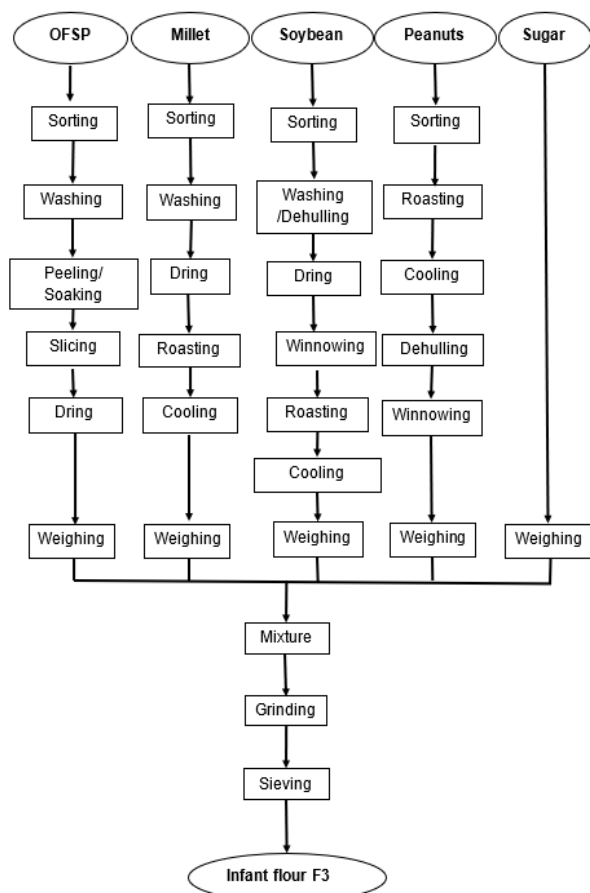


Figure 3. Infant flour F3 production diagram

2.4. Determination of Physicochemical and Nutritional Parameters of Flours

Moisture: content was estimated by desiccation with the drying oven at 105 °C during 24 h according to AOAC method No 925.10 [19].

Ashes: The ash content was estimated by incineration with the furnace at 550 °C during 5 h according to AOAC method No 923-03 [19].

Proteins: The total proteins content of the various samples were determined by the KJEDAHN method based on the determination of total nitrogen content according to AOAC method No 979.09 [19].

Lipid: Lipid content is determined according the extraction method by the soxhlet according to AOAC No 960.39 with hexane as the solvent [19].

Crude fibers: Crude fibers content was determined according to method described by Sluiter et al. [20] and Ayeni et al. [21] based on the determination of insoluble lignin (IL) and soluble lignin (SL) content of the samples. For this, 3 ml of sulfuric acid (72 %) were added to 0.3 g of flour and kept at room temperature for 2 hours. Then, 84 ml of distilled water were added and the mixture was autoclaved at 121 °C for 1 hour and filtered. The insoluble lignin is determined by drying and incinerating the residues at 575 °C, and the soluble lignin fraction by measuring the Absorbance at 320 nm.

$$IL (\%) = \frac{a - b}{c} * 100 \quad (1)$$

$$SL (\%) = \frac{A}{110} * \frac{\text{Dilution}}{m} * 100 \quad (2)$$

$$\text{Crude fibers } (\%) = IL + SL \quad (3)$$

In the formulas:

IL= insoluble lignin

SL= soluble lignin

a=residue on the filter (g)

b= weight of ash of residue (g)

c= masse of the sample (g)

A: Absorbance

m: mass of the sample (g)

Vitamin A: vitamin A content was obtained from the β-carotene content determination, using Nagata & Yamashita [22] method with some modification. A mixture of 100 mg of flour and 10 ml of 80 % ethanol, shaken vigorously, was centrifuged at 4500 rpm for 10 min. The Absorbance of the supernatant was determined at 453, 645, and 663 nm. The β-carotene content was calculated using formula (4):

$$\beta\text{-carotene (mg/100 ml)} = 0.216 \times A_{663} - 1.22 \times A_{645} + 0.452 \times A_{453} \quad (4)$$

Vitamin A content was calculated using formula (5) [23]

$$\text{Vit A } (\mu\text{g RE / 100g}) = \frac{\beta\text{-Carotène}}{12} \quad (5)$$

In the formulas:

A₆₆₃ = Absorbance à 663 nm

A₅₀₅ = Absorbance à 505 nm

A₄₅₃ = Absorbance à 453 nm

RE= retinol equivalent

Carbohydrates: Total carbohydrates content relative to dry matter (DM) was determined by differential calculation [24], according to the formula (6):

$$\text{Carbohydrates (\% DM)} = 100 - (\text{Protein (\% DM)} + \text{Lipids (\% DM)} + \text{Ash (\% DM)} + \text{Fiber (\% DM)}) \quad (6)$$

Energy value: The energy value (EV) was calculated using the conversion coefficients established by Atwater & Benedict [25]:

$$\text{EV (kcal/100 g)} = (\% \text{Carbohydrate} \times 4\text{kcal}) + (\% \text{Protein} \times 4\text{kcal}) + (\% \text{Lipid} \times 9\text{kcal}) \quad (7)$$

2.5. Functional Parameters of Flours

Water absorption capacity (WAC) and solubility index (SI) were determined using the method described by Anderson *et al.* [26] and Phillips *et al.* [27]. The mixture of 1 g of flour and 10 ml of distilled water was shaken with a stirrer for 30 minutes. The mixture was kept in a water bath at 37 °C for 30 minutes and centrifuged at 5000 rpm for 15 minutes. The sediment obtained was weighed and then dried at 105 °C until a constant weight was reached. WAC and SI were determined using formulas (8) and (9):

$$\text{WAC (\%)} = \frac{\text{M}_2 - \text{M}_1}{\text{M}_1} \times 100 \quad (8)$$

$$\text{SI (\%)} = \frac{\text{M}_0 - \text{M}_1}{\text{M}_1} \times 100 \quad (9)$$

M₀ = mass of flour (g)

M₁ = mass of dried sediment (g)

M₂ = mass of resulting sediment (g)

The oil absorption capacity (OAC) was determined using Sosulski [28] method. 1 g of flour was added to 10 ml of oil. The mixture was shaken for 30 minutes with a stirrer and centrifuged at 4500 rpm for 10 minutes. The sediment obtained was weighed. The OAC was calculated using the formula (10).

$$\text{OAC (\%)} = \frac{\text{M}_1 - \text{M}_0}{\text{M}_0} \times 100 \quad (10)$$

M₀ = mass of flour (g)

M₁ = mass of resulting sediment (g)

2.6. Gel Consistency Measurement and Energy Density of Porridge Made from Formulated Flours

The method described by Vieu and Traoré [29], based on determining the flow rate of the porridge through a Bostwick consistometer, was used to determine the porridge consistency. For this purpose, porridge with 25 % and 30 % dry matter were prepared. 100 ml of porridge was placed in the first compartment of the device. When the porridge reached 45.0 ± 0.5°C, the trigger was activated to release the porridge into the second compartment. The distance travelled by the front of the porridge in 30 sec was then measured. The energy density (ED) of porridge was calculated using formula (11) according [25].

$$\text{ED} = (9 \times \text{lipids (\%)} + 4 \times \text{proteins (\%)} + 4 \times \text{carbohydrates (\%)} \times \text{DM (\%)} \quad (11)$$

2.7. Statistical Analysis

All data collected were recorded in triplicate and expressed as mean values and standard deviations. The data collected on the parameters were subjected to analysis of variance (ANOVA) according to Fisher's test with a probability threshold of 5 %. For this purpose, XLSTAT 2016.02.27444 software was used to perform these various statistical analyses.

3. Results

3.1. Physicochemical and Nutritional Characteristics of Infant Flours

The results of the physicochemical and nutritional parameters of the formulated flours are presented in Table 1. Moisture varied from 5.98 to 6.69 %, ash from 2.78 to 3.72 %, fiber from 12.60 to 13.60 %, vitamin A from 259.47 to 330.57 µg RE, protein from 13.2 to 14.79 %, lipids from 14.20 to 18.34 %, carbohydrates from 52.09 to 54.73 %, and energy value from 403.61 to 428.37 Kcal. Statistical analyses showed that there was a significant difference ($p < 0.05$) for each of the parameters studied, with the exception of protein and fiber content.

Table 1. Physicochemical and nutritional parameters of flours per 100 g of dry matter

Samples	Moisture (%)	Ash (%)	Fiber (%)	Vit A (µgRE)	Protein (%)	Fat (%)	Carbohydrate (%)	EV (kcal)
F1	5,98 ^c ± 0,07	3,71 ^a ± 0,07	12,57 ^a ± 0,16	330,56 ^a ± 1,8	14,78 ^a ± 0,86	14,19 ^c ± 0,71	54,72 ^a ± 0,3	403,612 ^c ± 0,9
F2	6,68 ^a ± 0,07	3,57 ^a ± 0,09	12,79 ^a ± 0,91	259,47 ^c ± 2,7	13,20 ^a ± 0,57	18,34 ^a ± 0,33	52,08 ^b ± 1,31	428,36 ^a ± 2,16
F3	6,28 ^b ± 0,13	2,77 ^b ± 0,11	13,58 ^a ± 0,37	284,42 ^b ± 1,4	14,57 ^a ± 0,62	15,51 ^b ± 0,45	53,53 ^{ab} ± 0,51	412,12 ^b ± 1,08

In a column, values that have a letter in common do not show a significant difference according to the LSD test at a probability level of 5 %. F1: mixture of OFSP, soybeans, peanuts, baobab pulp, sugar; F2: mixture of OFSP, powdered milk, peanuts, baobab pulp, sugar; F3: mixture of OFSP, millet, soybeans, peanuts, sugar; EV: energy value; Vit A: vitamin A.

Table 2. Functional properties of formulated flours

Sample	Water absorption capacity (%)	Solubility index (%)	Oil absorption capacity (%)
F1	261,60 ^a ± 3,58	64,44 ^b ± 1,56	91,08 ^b ± 1,95
F2	230,20 ^b ± 2,77	78,42 ^a ± 0,9	105,18 ^a ± 0,1
F3	197,34 ^c ± 2,86	46,28 ^c ± 0,42	89,72 ^b ± 1,36

In a column, values that have a letter in common do not show a significant difference according to the LSD test at a probability level of 5%.

Table 3. Energy density (ED) and porridge consistency at 25 % and 30 % dry matter concentration

Porridge	Porridge at 25 %		Porridge at 30 %	
	Consistency (mm /30 s)	Energy densities (Kcal)	Consistency (mm /30 s)	Energy densities (Kcal)
BF1	115 ^b ± 2	101,45 ^b ± 0,98	70 ^b ± 2	121,75 ^b ± 1,18
BF2	125 ^a ± 2	106,55 ^a ± 1,06	123 ^a ± 2	127,87 ^a ± 1,28
BF3	105 ^c ± 3	103,03 ^b ± 0,26	58 ^c ± 2	123,63 ^b ± 0,32

In a column, values that have a letter in common do not show a significant difference according to the LSD test at a probability level of 5 %. BF1: flour F1 porridge; BF2: flour F2 porridge; BF3: flour F3 porridge.

3.2. Functional Properties of Flours

The results obtained for the functional parameters of the flours are shown in Table 2. The water absorption capacity (WAC), solubility index (SI), and oil absorption capacity (OAC) ranged from 197.35 to 261.6 %, 46.28 to 78.42 %, and 89.73 to 105.18 %, respectively. Statistical analyses showed that there was a significant difference ($p < 0.05$) for each of the parameters studied.

3.3. Porridge Consistency and Energy Density

Table 3 shows the consistency and porridges energy density at 25 % and 30 % of flour. The Bostwick flow rates of the 25 % porridges corresponding to the consistency ranged from 105 to 125 mm/30 s with energy densities between 101.45 and 106.55 kcal. For the porridge at 30 %, the flow rates ranged from 58 to 123 mm/30 s with energy densities between 121.75 and 127.87 kcal. Statistical analyses showed that there was a significant difference ($p < 0.05$) for these parameters.

4. Discussion

4.1. Physicochemical and Nutritional Characteristics of Formulated Flours

The water content of the formulated flours (Table 1) is similar to that reported by Laryea *et al.* [30] for infant flours based on OFSP, millet, and soybean, which was 6.47 %. These results also comply with Burkinabe Standard NBF 01-198 [18], which recommends less than 8 % of water content in infant flours. Significant difference ($p < 0.05$) obtained, which can be explained by the nature of the ingredients in each formulation and their macronutrient composition, such as lipids. The moisture levels obtained are low, which implies a lower risk of microbial spoilage of the formulated flours. However, it is therefore necessary to use appropriate packaging that will allow the water content of the flours to be properly preserved during storage.

The ash values obtained in this study were higher than those reported by Oguizu *et al.* [31], who found 2.31 to 2.43 % of ash content from OFSP and soybean flours. The high total ash content of the formulated flours could be explained by the addition of ingredients such as fruit pulp

and unhusked cereals, which are good sources of minerals. The ash obtained complies with the recommendation of 3 % [32]. Ash content is proportional to the mineral salt concentration in flours. Ash values obtained in this study show that all three formulations are rich in mineral salts. Mineral salts perform various functions in the body, such as regulating water balance, contributing to bone formation, strengthening the immune system, and playing a role in energy metabolism.

The fiber content (Table 1) is similar to that reported by Amagloh *et al.* [33], who obtained 8.18 to 10.57 %. However, it exceeds the recommendation of less than 5 g / 100 g set by the Codex Alimentarius CAC/GL 8-1991 [14]. This could be explained by the use of certain ingredients with high fiber content, such as soybeans, monkey bread and unhusked millet. Statistical analysis did not reveal any significant differences. Fiber has the attribute of facilitating intestinal transit, helps prevent certain diseases such as cancer and slows down food digestion while promoting satiety [34]. In order to optimize this content, other technologies such as germination, dehulling or fermentation of cereals and legumes grains before the formulation of flours, which significantly reduce the fiber content, could be applied.

Statistical analysis of the vitamin A contents in the formulated flours (Table 1) shows a significant difference ($p < 0.05$). This could be explained by the difference in OFSP flour incorporation rates and also the different beta-carotene contributions of the other ingredients. The results obtained (Table 1) are similar to those reported by Eke-Ejiofor *et al.* [35], who found 92.33 to 371.66 µg RE/100 g in OFSP-based compound flours. However, they are below the nutrient reference value (NRV) of 400 µg RE for children [14]. Nevertheless, they would meet 68.41 to 81.43 % of an infant's vitamin A requirements. It is recommended that the vitamin A content of a daily complementary food ration should be greater than 50 % of the NRV [14]. The vitamin A content of infant flours formulated complies with this recommendation. These flours could therefore contribute to improving the vitamin A status of children. Vitamin A strengthens their immune system, reduces the incidence of diarrhea and measles, and prevents blindness and hearing loss [36].

The protein contents obtained (Table 1) are in line with the recommendations of Codex Alimentarius CAC/GL 8-1991 [14], which recommends protein contents between 6 and 15 %, and those of Burkinabe Standard NBF 01-198

[18], which is at least 12.7 % for infant flours. The results for formulas F1 and F3 are superior to those for formula F2. This could be explained by the difference in the incorporation rates of protein sources (soybeans and milk) and peanuts, which have a significant protein content. Soybeans, contained in formulas F1 and F3, are one of the best sources of vegetable protein (31.3 % protein) [12]. Soybeans are rich in proteins and therefore may be a good complement to enrich infant food flours, in a context of developing countries where proteins from animal sources are expensive [37]. They are involved in the synthesis and functioning of muscles and organs, in the production of enzymes and hormones, and in supporting the natural immunity of living organisms [38].

The lipid contents (Table 1) are higher than those obtained by Adetola *et al.* [39], who reported 13.15 % and 13.32 % for formulations composed of OFSP, soybeans, and carrots. However, the results are in compliance with Codex Alimentarius CAC/GL 8-1991 [32], which recommends a lipid intake of at least 20 % of total energy intake for complementary feed. However, they are above the content recommended by Burkinabe Standard NBF 01-198 [18], which is 12.45 % for infant flours. This could be explained by the addition of peanuts to our formulations, which are an important source of lipids (44.8 g/100 g) [15]. Statistical analyses showed that there was a significant difference ($p < 0.05$) between the formulations. Thus, F2 had the highest lipid content because the peanut incorporation rate is relatively higher. Lipids are essential in infant nutrition, providing a significant portion of the body's energy and participating in vital physiological processes, including growth, development, and brain function [40]. Lipids presence increases the intestinal absorption of vitamin A, which is a fat-soluble vitamin found in formulated flours [41].

The carbohydrate contents obtained (Table 1) are close to those reported by Agbemaflle *et al.* [42], who obtained 57.09 to 73.16 % for OFSP-based formulations, but lower than those obtained by Dessta and Terefe [40], who found 66.94 to 76.11 % for formulations based on corn, OFSP, sweet lupin and moringa. Statistical analyses indicate a significant difference between the samples ($p < 0.05$). This difference may be due to variations in the quantities of carbohydrate source ingredients introduced into the formulations. The energy values of the flours (Table 1) are similar to those reported by Agbemaflle *et al.* [42], who found 379.15 to 459.82 kcal. They also comply with the Codex Alimentarius CAC/GL 8-1991 [14] recommendation of at least 400 kcal/100 g of flour. The energy requirements of children aged 6 to 23 months range from 576 to 890 Kcal, of which 33 to 71 % must be provided by complementary foods. For a 30 g serving of infant flour providing 400 kcal, 58.5 to 63.1 % of energy requirements are covered by infant flours [43]. The results obtained in this study show that 59.06 to 67.63 % of energy requirements of children will be covered with a daily ration of at least 30 g of formulated flours.

4.2. Functional Characteristics of the Formulated Flours

Statistical analysis of the technological parameters presented in Table 2 indicate a significant difference ($p <$

0.05). This could be explained by the nature and composition of the ingredients used in the formulations. Each ingredient has its own functional properties, which therefore influence those of the mixture. The high WAC of formulation F1 could be explained by its higher content proteins and carbohydrates. Sreerama *et al.* [44] reported that carbohydrates (starch) promote water retention in flours. As for solubility index (SI), the results (Table 2) corroborate those reported by Gampoula *et al.* [45], who found 25 to 100 %. Formulation F2 had the highest SI value. This may be due to the milk contained in this flour, which dissolves completely and instantly in water without lumps. This parameter allows us to assess the flour's ability to disperse in water and provide a homogeneous solution [46], and digestibility. High flour solubility is generally associated with better digestibility and could be explained by the digestive enzymes can easily access soluble components. As for OAC (Table 2), it is a parameter that improves mouthfeel while maintaining the flavor of food products [47]. Oil absorption capacity is important for the nutrient and energy density of food products, particularly for infants and young children [48]. It is thought to be linked to the presence of proteins. Awuchi *et al.* [49] reported that the oil absorption rate is very high in foods with a high protein content. However, in this study, formulation F2 had the highest OAC but not the highest protein value. This could be explained by the nature and protein structure of the main protein sources in the formulations, which are animal proteins (milk powder for F2) and plant proteins (soybean for formulations F1 and F3). Authors have reported that the oil-binding capacity of proteins in feed depends on intrinsic factors such as protein conformation, amino acid composition, and surface polarity or hydrophobicity [50].

4.3. Porridge Consistency and Energy Density

Porridge consistency is a very important factor in infant nutrition. It has a direct impact on the energy density of the porridge and therefore on the infant's energy intake [51]. When porridge is too thin, it will have a low energy density. If it is very thick, it will be difficult for the infant to consume, leading to a tendency to dilute it, thereby reducing its energy density. The consistency and energy density evaluations of porridges with 25 % and 30 % dry matter (Table 3) of the three infant formulations made it possible to compare their ability to meet the requirements of the Burkinabe Standard NBF 01-198 [18], which recommends an energy density of at least 100 kcal / 100 g with a consistency between 90 and 150 mm/30 sec. Based on these recommendations, only the BF1 and BF3 porridges at 30 % dry matter did not comply (good energy density but too thick consistency). The incorporation of enzymes into these porridges could be one alternative for improving consistency while maintaining adequate energy density.

5. Conclusion

This study involved formulating three infant flours for weaning-age children based on Orange-fleshed sweet potatoes (OFSP). The formulated flours have good

mineral content and low moisture levels, which should improve shelf life. Their protein and lipid content, and energy values comply with the standard. The vitamin A content of these different flours is quite good and could contribute to improving vitamin A intake in infant nutrition. The functional properties studied show that porridges made from these flours are digestible and have a good consistency. In summary, infant flours formulated from local ingredients have high nutritional qualities, and could contribute to fight against infant malnutrition and vitamin A deficiency during the complementary feeding.

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Conflict of Interest Statement

The authors do not have any conflict of interest.

Abbreviations

ED: energy density; EV: energy value; IL: Insoluble lignin; OFSP: orange-fleshed sweet potatoes, RE: retinol equivalent; SI: solubility index; SL: soluble lignin; OAC: oil absorption capacity, WAC: water absorption capacity.

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