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NUTRITIONAL AND SENSORY QUALITY OF INFANT COMPLEMENTARY FOODS ENRICHED WITH SESAME, *MORINGA OLEIFERA*, WHITE BEANS, AND FRESHWATER SHRIMPS (*CARIDINA* SP.)

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ABSTRACT

In many African countries, including Madagascar, the food consumed by children after 6 months of age does not meet their nutritional needs in terms of proteins, lipids, carbohydrates, minerals (calcium, iron, magnesium, copper and zinc) and vitamins. This can plunge children into malnutrition. The present study aims to produce complementary food flours for infant porridges based on widely available local products: yam, cassava and plantain flours for starch enriched with sesame paste, white bean flour, *Moringa oleifera* powder and freshwater shrimp powder for additional micro- and macronutrients. The proportions of the ingredients were balanced based on international standards to optimize nutritional and sensory qualities, resulting in five different flours (F1 to F5). The chemical, microbiological and organoleptic characteristics of these flours were determined according to standard methods. Proximal analysis reveals satisfactory levels of protein (10.02 - 12.05%), lipids (8.15 - 13.40%), and carbohydrates (61.1 - 70.55%), with energy value (390 kcal - 430. kcal/100 g) and most minerals; potassium (219 – 1187 mg / 100 g), calcium (1423 – 255 mg / 100 g), magnesium (189 - 239 mg / 100 g), iron (4.56 - 6.54 mg / 100 g) and copper (0.92 - 1.52 mg / 100 g) being within the recommended standards. The microbiological loads detected in these flours are lower than the microbiological criteria appropriate for infant flours, except the infant flour F2. Porridges prepared from the compound flours have dry matter contents close to the desired value 100 to 120 kcal/100 ml of porridge. They had appreciable sensory profiles for the panelist mothers. The flour composed of yam flour with sesame and white beans was the most appreciated by mothers; 56% rated it was "extremely pleasant," and 44% rated it as "very pleasant." The acceptability of F3 porridge compared to others is justified by its color, taste, and aroma. These composite flours could then be recommended for children under five, thus helping to combat child malnutrition.

Key words: Malnutrition, child, flour production, Proximal analysis, acceptability, Madagascar, Complementary feeding

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INTRODUCTION

In low-income countries, millions of people suffer from malnutrition due to nutrient deficiency [1]. Malnutrition represents a considerable challenge for human health, particularly in Africa [2]. The situation is particularly alarming in Madagascar, where undernutrition affects more than 50% of children under five [3,4]. The national prevalence of stunting in children under five is 50%, which is significantly higher than the average rate of 25% in developing countries [5]. Stunting has irreversible repercussions on a child's physical and cognitive development, thus affecting their learning capacity and productivity in adulthood [6]. Among preschool-aged children, the prevalence of subclinical vitamin A deficiency is 6% [7]. Furthermore, the first complementary foods given to infants and the diets of school-aged children consist mainly of rice dishes eaten with various side dishes, most often composed of plant foods [8]. The low diversity, intake, and nutrient bioavailability of young children's diets after weaning contribute significantly to the phenomenon of malnutrition [9]. These statistics illustrate the significant public health threat of malnutrition.

No significant decline in malnutrition has been observed for over a decade in Madagascar [7]. Causes of this situation include poverty, lack of time for parents or caregivers, lack of nutrition knowledge, and often inappropriate complementary feeding practices [10]. The National Nutrition Security Policy aims to eliminate hunger, ensure food security, promote agriculture, and improve nutrition [11]. Important initiatives include improving the economy, integrating health interventions, promoting sustainable agriculture and nutrition education, and improving access to nutrient-rich food supplements for weaning children [12].

In northeast Madagascar, including the SAVA region, high-quality food resources with great potential are available [13,14]. These products are accessible for low- and middle-income households. This study aligns with the national vision, with the overall objective of contributing to the prevention and reduction of malnutrition by leveraging the resources available in Madagascar. Specific objectives include:

- i. Producing nutrition supplements for weaning-aged infant complementary foods from locally sourced ingredients ;
- ii. Determining the proximal analysis of the supplements produced ;
- iii. Analyzing the sensory qualities and acceptability of the resulting infant supplements.

MATERIALS AND METHODS

Selection of Foodstuffs and Flour Production

In this study, the raw materials used were selected based on the following criteria: (i) the population's access and variability of them; (ii) the nutritional values of the ingredients that could meet children's needs; and (iii) the cost of these raw materials. Among the various products widely available in the northeastern part of Madagascar, we selected purple-fleshed yam tubers, cassava roots, plantain fruits, white bean seeds, white sesame seeds, freshwater shrimps (*Caridina* sp.) and *Moringa oleifera* leaves. The genus *Caridina* (Caridines) is common to fresh waters of almost all regions of Madagascar; with 18 species and 2 subspecies (locally called “Patsa fotsy” and “Patsa mena”; “Chevaquine rouge” in French and “red dried shrimp” in English). We chose these ingredients for their unique micro and macronutrient qualities: yams, cassava, and plantains are sources of carbohydrates, vegetables and pulses are rich in protein, minerals, and vitamins, and sesame is rich in unsaturated fats. Mixing them can improve the nutritional quality of complementary foods. They were purchased at the Antanambao market, in the town of Antalaha. Diagrams summarizing the different processing stages of the raw materials used are presented in Figure 1.

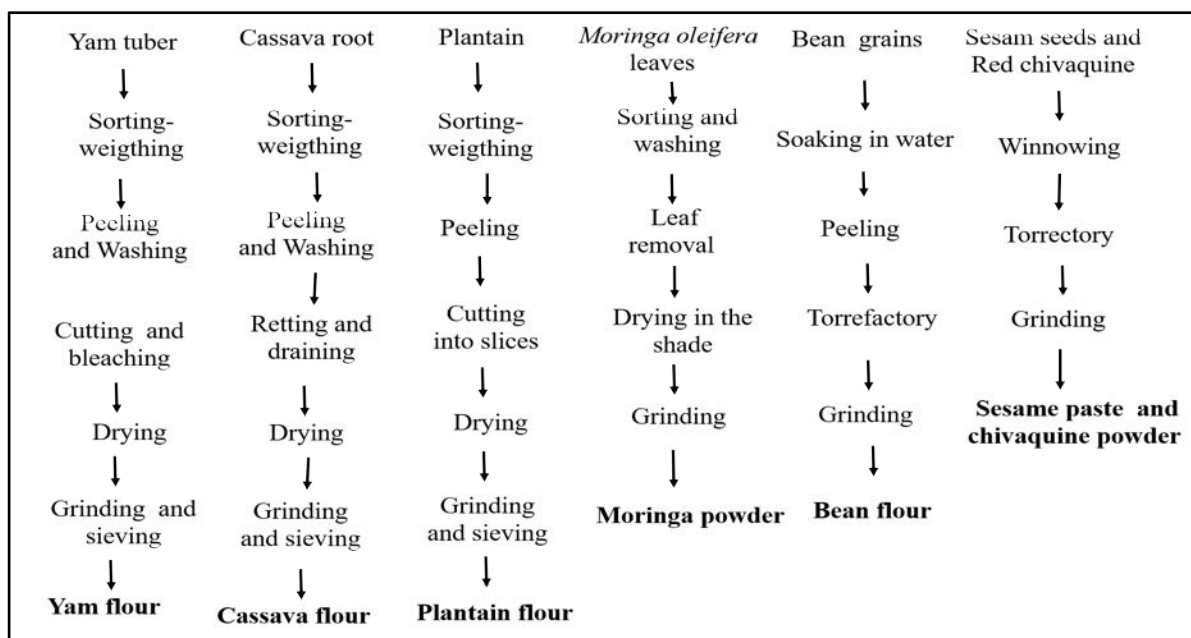


Figure 1: Production flow chart for flours and powders

The yam tubers were cut into slices approximately 2 cm long and 1 mm thick. The plantains were cut into flattened rounds approximately 1 mm thick. The cassava roots were soaked in water for 72 hours without being cut. The resulting yam slices,

plantain rounds, and cassava pulp were then sun-dried at room temperature for 10 days.

Proximal analysis of ingredients

The flours produced were analyzed at the laboratory of the National Center for Environmental Research (CNRE) in Tsimbazaza, Antananarivo, Madagascar.

- Dry matter and moisture content by oven drying at 105°C for 48 h [15];
- Crude protein content: by Kjeldahl method ($N \times 6.25$) [16] ;
- Crude fat content (CFC): by gravimetry based on hexane extraction using the properties of lipid insolubility in water and their solubility in organic solvents [15];
- Crude ash content (CA): by incineration in a furnace at 550°C for 6 hours [15];
- Total carbohydrate content : by difference method ;
- Metabolizable energy content : by calculation using Atwater's specific heat coefficients (SCC) from the energy principles.

Modeling of composite flours

To formulate infant flours, different blends were made, taking into account the values from proximal analysis of the ingredients. The experiment was based on blends between starchy plant flours (yam flour, cassava and plantain) as the main sources of carbohydrates (energy source) and sources of proteins, lipids, minerals and vitamins, including sesame (source of lipids), shrimp (source of B12 vitamin and animal protein), white beans and *Moringa oleifera* (source of proteins and minerals). The formulations were programmed in Excel spreadsheet based on 100 g of dry matter [17], using the nutritional values of the West African food composition table [18]. The quantities of the necessary ingredients were combined with reference to the recommendations of the Codex Alimentarius Commission [19]. This approach admits to finding a resolution allowing to cover at least the needs in two nutrients with at least two types of foods, from a list of food ingredients [20,21]. Equations relating the protein, lipid and carbohydrate contents of the products used and the total energy intake recommended for these three products, as a function of the unknowns (m_1 , m_2 and m_3) were carried out. The system of equations used is as follows:

$$a_1m_1 + b_1 m_2 + c_1m_3 = d_1 \quad (1)$$

$$a_2 m_1 + b_2 m_2 + c_2m_3 = d_2 \quad (2)$$

$$a_3 m_1 + b_3 m_2 + c_3m_3 = d_3 \quad (3)$$

Where:

m_1 , m_2 , and m_3 are the masses, in grams, of product 1, product 2, and product 3.

d1, d2, and d3 are the total energy intake from proteins, lipids, and carbohydrates in these three products.

Nutritional and Microbiological Analysis of the Infant Flour

The infant flours obtained were analyzed using various methods. Nutrient determinations were performed using AOAC methods [15].

About microbiological analysis, total mesophilic aerobic flora (TMAF) was counted according to ISO 4833 Thermotolerant coliforms (TC) were counted according to NF V08-060. *Salmonella sp* were tested according to ISO 6579. *Sulfite-reducing anaerobes* (SR) were counted according to ISO 7937. *Escherichia coli* (E. coli) was tested according to ISO 16649-2. *Bacillus aureus* (BA) and *Staphylococcus coagulase* (S.Coa) were tested according to ISO 6888-2.

Porridge Preparation and Energy Density Determination

The Infant complementary foods were prepared from combinations of the five blended flours. For each infant flour, 50g was dissolved in 150ml of water and then cooked in 200 ml of water in a saucepan. The mixture was heated for 10 minutes with manual stirring, adding a pinch of iodized salt to form a porridge. At the end of cooking, 12.5g of commercial sugar and 12.5g of powdered milk were added to the porridge. For each porridge, 5 g of sample was introduced in an incubator at 70°C during for 5 days and reweighed once a day until constant masses representing the dry matter content were obtained. The energy density was calculated by multiplying the dry matter content by the carbohydrate energy coefficient, which is equal to 4 kcal.

Sensory Evaluation of Porridges Prepared from Mixed Flours

A trained panel of nine randomly selected mothers was convened to conduct a series of tests on the prepared porridges. The assessment of each porridge was based on appearance (color), taste (flavor), odor (aroma), oral texture, and overall acceptability of the porridges, using a nine-point hedonic scale [22]. The ranking ranges consistently descending from 9 to 1. A number 9 corresponds to a highly unpleasant product; a number 8 is assigned to a very unpleasant product. A number 7 corresponds to an unpleasant product, a number 6 to a fairly unpleasant product. A number 5 is assigned to a product that is neither pleasant nor unpleasant (indifferent), a number 4 corresponds to a fairly pleasant product. A number 3 corresponds to a pleasant product, a number 2 is assigned to a very pleasant product, and a number 1 to highly pleasant product. These 9 scales were reduced in five scale during visualization of data after grouped two by two for clarify the results. So, the scales 1&2 corresponding a highly pleasant level, 3 & 4 a pleasant, 5: indifferent, 6 & 7: unpleasant and 8 & 9: Highly unpleasant. The instant flour

“FARILAC” (“Farine de blé Lactée”), which is based of wheat and milk and produced in Madagascar was also used for comparison in this study in hedonic tests.

Statistical Analysis

The nutritional and sensory data from each experiment were analyzed using RStudio version 4.2.0 software. The parametric test (ANOVA) was used to compare the means of the data from proximal analysis. The Tukey SD post-test was applied to determine whether the different sets of values were significantly different from each other, provided that the ANOVA test was significant at least at the $p < 0.05$ threshold. The hedonic scale obtained from each porridge was analyzed from the average scores assigned for each scale during the hedonic test and Kruskal-Wallis’ test was used to compare all average marks. The appreciation levels were visualized by Likert scale plot.

RESULTS AND DISCUSSION

Proximal analysis of the Flours

According to the proximal analysis results, the nutritional compositions of the seven flours produced are summarized in Table 1. Analysis of Table 2 shows that purple yam flour (PYF), cassava flour (CAF), and plantain flour (PF) are sources of carbohydrates (78.49 to 87.36%), while freshwater shrimps’ powder (FSP) and powder of *Moringa oleifera* (PMo) and beans flour (BF) are rich in protein (18.64 to 58.53%). These results are comparable to those of Munguti *et al.* [23], which reported 56.1% protein for *Caridina nilotica* and corroborate the results of Fadjiné [24], which reported a respective composition of 30.3%, 30.98%, and 31.64% for *Moringa oleifera* leaves from South Africa, Namibia, and Bangladesh. As for White sesame paste (WSP), it had the most impressive fat content ($57.22 \pm 0.46\%$). Significant differences were observed for all nutrient contents ($p < 0.05$) among all the samples

Proportion and Nutritional Quality of the Modeled Flours

The weight proportions of ingredients used in the formulation of the five infant flours and their nutritional quality are presented in Table 2 and Table 3. Analysis of Table 3 reveals that the moisture content of the flour’s ranges from 7.52% to 9.03%. These values are higher than those of cassava + soy flour (5 g/100 g) and atieké + soy flour (5 g/100 g) produced by Zannou *et al.* [25] in Côte d'Ivoire. This dissimilarity may be explained by the difference in the methods used and/or the drying time of the products. However, these levels are well below the standard of 12%, which is recommended for better flour preservation [26]. This is significant because flour moisture plays an important role in the shelf life and the taste of the finished product. A low flour moisture content increases its shelf life [1].

The nutrient content of the resulting composite flours varies: 10.02 to 12.05% protein, 8.15 to 13.40% fat, 61.1 to 70.55% carbohydrates and energy value 393 to 430 kcal/100 g of flour. These results are comparable to the starch-based flour enriched with vitamins and iron, developed for weaning infants in Congo called VITAFORT (74.05 g of carbohydrates, 10.5 g of protein, 5.8 g of fat, energy value 380 kcal/100 g [27]) and the milk-wheat based flour in Madagascar called FARILAC (78.5 g of carbohydrates and 13 g of protein) [28]. Based on the Recommended Daily Allowance (RDA) for children aged 6 to 23 months, shown in Table 3, most of the infant flours tested have protein content and energy densities that meet the recommended standard (11 to 21% and 400 kcal/100 g respectively). Protein is of paramount importance during the first months of life [30], as it plays an important role in tissue repair and muscle building [29,21]. Therefore, the flours in this study are viable options for complementary foods to address protein-energy imbalances in children.

Concerning the mineral profiles detailed in Table 3, F2 and F3 flours are richer in potassium (1180 and 1187 mg/100 g respectively) and phosphorus (615 and 584 mg/100 g respectively). Phosphorus is necessary for energy production and utilization, bone and tooth preservation, and potassium is involved in regulating cell osmotic pressure and counteracting heart rhythm disturbances [31].

F4, F2, and F1 flours are notable for their high calcium content. Calcium plays a fundamental role in skeletal growth, bone mineralization, cell permeability, neuromuscular excitability, cardiac function, and blood coagulation [32], especially essential in young, growing children [32]. Key mineral elements were varied with magnesium ranging from 189 to 239 mg/100g, Iron (4.56 to 6.54 mg/100g), copper (0.92 to 1.52 mg/100g) and zinc (0.63 to 1.5 mg/100g). These covered the minimum mineral amounts of the recommended daily intake for children aged 6 to 23 months, which are 19 mg (Mg); 4 mg (Fe); 0.04 mg (Cu) and 0.8 mg (Zn) [32].

According to FAO/WHO [33], the minimum compliance values are respectively 48.7 mg (Mg); 8.5 mg (Fe); 0.1 mg (Cu) and 3.7 mg (Zn) per 100g of dry matter. The flours designed in this study, especially F1 to F5, flours can meet the recommended standards with twice-daily intake.

Microbiological Load of Modeled Infant Flours

Table 4 shows that all study flours comply with Codex Alimentarius Standard 741981 yielding a satisfactory microbiological quality [35], regarding total mesophyll aerobic flora (*Staphylococcus coagulase*, *Bacillus aureus*, *Escherichia coli*, *ASR*, and *Salmonella ssp*, in CFU/g). Indeed, the microbiological qualities of the flours are satisfactory. However, flour F2 (infant flour containing 64.75% purple yam + 22.93% sesame puree and 12.32% *Moringa oleifera* leaf powder) appears to be more heavily

loaded with total coliforms, with 2.102 CFU/g, value higher than the reference value (1.102 CFU/g) recommended for infant flours. This indicates that only F2 infant flour has a load that does not comply with the reference value.

Dry Matter Content and Energy Densities of the Porridges

The five porridges tested had dry matter contents ranging from 17.58 ± 0.22 to 21.23 ± 1.43 g/100 ml and energy densities ranging from 70.311 ± 0.884 to 84.931 ± 5.730 kcal/100 ml (Figure 2). Statistically, no significant difference was observed between the means of energy density and dry matter content of the porridges ($X^2 = 4.00$, Df = 4, $p = 0.40$). These energy densities are slightly lower than the recommended standard, with a dry matter content of 24 g/100 g of porridge and 100 to 120 kcal/100 ml of energy. However, they differ from those of traditional porridges, which are generally low in energy density (50-60 kcal/100 ml of porridge) [34,35]. This disparity can be explained by the lack of technological treatment such as the addition of α -amylase source which can increase the fluidity of the porridge due to the action of hydrolyzing large starch molecules into smaller molecules (maltodextrins) which have a low water retention capacity.

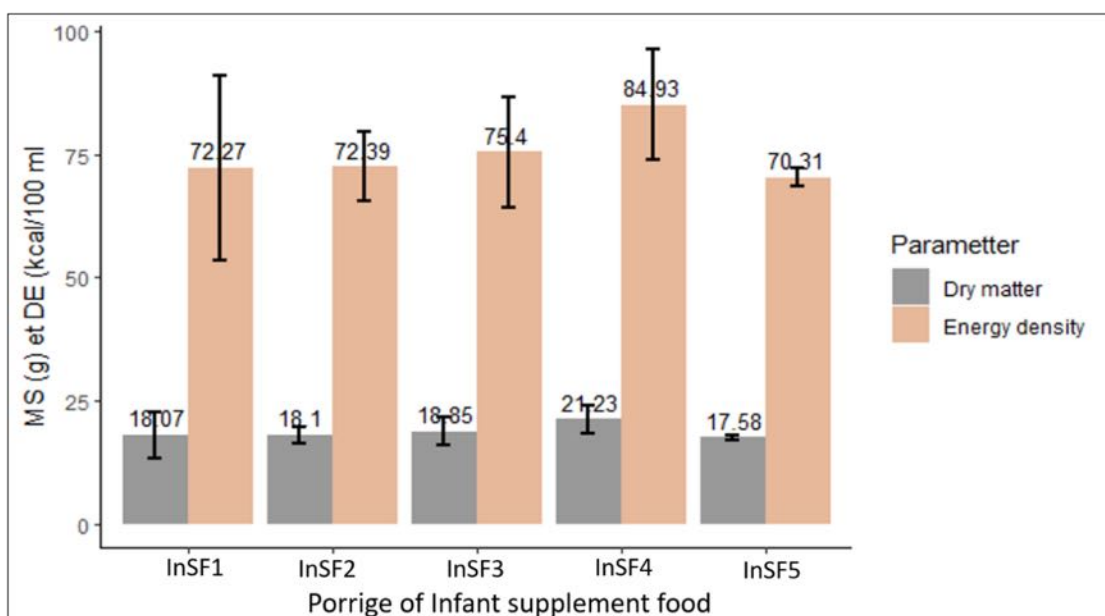


Figure 2: Dry matter content and energy density per 100 ml of porridge

Sensory profiles of porridges from five flours produced

The evaluated sensory parameters such as color, taste, smell or aroma, and overall acceptability of all the infant foods obtained are significantly different ($X^2 = 13.10$, Df = 5, p -value = 0.05, table 5). On the other hand, no significant difference is observed in the oral texture and consistency (p -value = 0.45 and 0.19 respectively, table 5) of this porridge. The proportional size of acceptance show in Figure 3 illustrates the acceptability indices of the infant complementary foods formulated.

In terms of taste, InSF4, InSF1, and InSF3 infant complementary foods were liked by mothers, from pleasant to strongly pleasant. This indicates that the sensation of good taste in such a product makes it more acceptable [10].

The smell or aroma of infant complementary foods produced was appreciated by mothers with a rating of 56 to 100%. However, they found the *Moringa* odor quite strong and unpleasant for the InSF2 formulation.

About an oral texture, the panelists felt that the five foods were enjoyable and met their expectations with a rating of 78 to 100%, with comparable levels of palatability to previous studies [36].

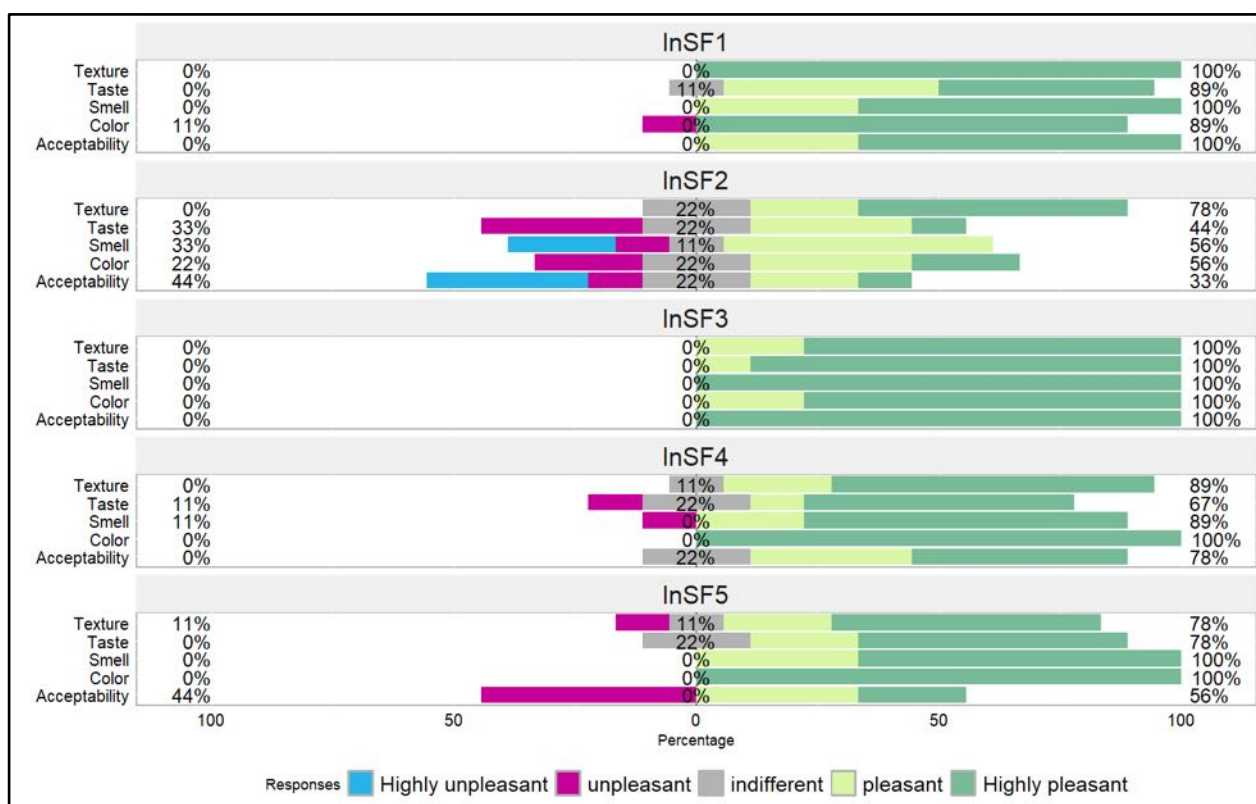


Figure 3: Likert scale result of infant complementary foods produced

The sensory quality of complementary foods plays an important role in food acceptability by consumers. According to Figure 4, the hedonic test results revealed that the complementary foods made from manufactured composite flours have good acceptability. InSF 3 has the best result with all the five sensory attributes rated on the agree and strongly agree scale. InSF5 had a 44% and 11% disagreement on acceptability and oral texture respectively. While InSF2 was the least acceptable in the sensory attributes with 33% and 44% receiving a strong disagreement in terms of its smell and acceptability respectively. A further 22% and 33% respectively disagreed with taste and color of InSF2. These results are similar to those reported by Muhimbula *et al* [38] in a study evaluating the sensory qualities of cereal and legume-based complementary foods in Tanzania. These authors state that complementary foods containing cowpea and common beans were significantly more acceptable by the panelists. This high appreciation may be due to the sodium, calcium, magnesium, and potassium content of the flours, which are known to enhance the taste of food by stimulating sensory receptors. According to them, the presence of legume samples, rich in minerals, led to a significant improvement in the taste of the foods [38]. The results also suggest that inclusion of sesame, bean and freshwater shrimp powders in the F3 and F1 formulations improves sensory perception of the panelists. Two composite flours, F4 and F5, had the lowest acceptability of porridges, likely due to the perceived unpleasant odors from fermented cassava flour in those composites [39,40] Similarly, the very pronounced aroma of moringa, the bitter taste, and the strong green color of the F2 composite flour. The bitter taste of moringa is associated with the high levels of magnesium and calcium, elements known to be linked to food bitterness.

CONCLUSION AND RECOMMENDATIONS FOR DEVELOPMENT

This study allowed us to gather information on the nutritional potential of seven food resources widely available in northeast Madagascar, but underutilized. Combining three of these seven recommended ingredients resulted in the formulation of five complementary food powders with good nutritional quality and high energy density. These qualities stem from the fact that yam, cassava, and plantain flours are rich in carbohydrates. Moringa, bean, and crayfish powders provide essential protein, certain minerals, and vitamins in these infant flours. Sesame seeds also contribute essential fatty acids, protein, and minerals.

The composite flour F2, which included moringa, yam, and sesame, failed to meet microbiological standards due to its total coliform count exceeding the reference value. This can be avoided by reducing the conditions conducive to bacterial survival, such as conserving at lower temperatures rather than ambient or warm temperatures, maintaining a neutral pH, low humidity, and maintaining hygienic equipment and workspaces. The porridges made from these infant flours have

slightly lower energy densities than the recommended standard, but these were deemed acceptable by the panelists. In the future, further studies are needed, such as using amylase sources to increase energy density and adding other ingredients to improve the palatability of the porridges. Our results are applicable to the design of complementary foods for improving nutrition of children under two years old.

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Conflict of interest

We have no conflicts of interest to disclose.

Table 1: Proximal analysis and macronutrient content per 100 g of flour

	Moisture	Crudes Ash	Proteins	Fat	Carbohydrates	Total sugar	Energy value
PYF	10.84 ^d ± 0.15	3.17 ^e ± 0.11	7.27 ^d ± 0.06	0.21 ^c ± 0.03	78.49 ^b ± 0.13	12.65 ^a ± 0.18	338.50
CAF	10.43 ^d ± 0.04	0.46 ^f ± 0.00	1.31 ^f ± 0.20	0.43 ^c ± 0.02	87.36 ^a ± 0.27	9.60 ^a ± 0.02	341.81
PF	9.31 ^e ± 0.03	2.87 ^e ± 0.10	3.78 ^e ± 0.03	0.35 ^c ± 0.13	82.88 ^b ± 0.19	4.06 ^c ± 0.02	317.44
PMo	11.37 ^c ± 0.13	9.04 ^b ± 0.01	29.91 ^b ± 0.13	6.18 ^b ± 0.50	43.48 ^d ± 0.58	6.12 ^b ± 0.45	280.01
FSP	12.96 ^b ± 0.05	16.02 ^a ± 0.1	58.53 ^a ± 1.68	5.05 ^b ± 0.11	5.43 ^f ± 1.12	0.23 ^d ± 00	286.59
BF	13.77 ^a ± 0.04	4.32 ^d ± 0.00	18.64 ^c ± 0.00	3.44 ^b ± 0.13	59.54 ^c ± 0.23	6.5 ^b ± 0.22	336.85
WSP	3.75 ^f ± 0.07	5.91 ^c ± 0.01	21.42 ^c ± 0.02	57.22 ^a ± 0.46	11.69 ^e ± 0.52	9.7 ^a ± 0.81	600.98

Results are presented as mean ± standard deviation; means with different superscript letters within the same column are significantly different at $P < 0.05$. **PYF**: Purple Yam Flour; **CAF**: Cassava Flour; **PF**: Plantain Flour; **PMo**: Powder of Moringa oleifera; **FSP**: Freshwater Shrimps Powder; **BF**: Beans Flour; **WSP**: White Sesame Paste; **PMo**: Powder of Moringa oleifera

Table 2: Proportions of raw materials used in each Infant Supplementary food (InSF) formula

Infant Food	Mixture	Proportion in (g) per 100 g of flours
InSF1	PF x WSP x FSP	72.00 g + 22.79 g + 5.21 g
InSF2	PYF x WSP x LPMo	64.75 g + 22.93 g + 12.32 g
InSF3	PYF x WSP x BF	60.84 g + 23.07 g + 15.19 g
InSF4	CAF x WSP x FSP	68.14 g + 23.68 g + 8.18 g
InSF5	CAF x WSP x BF	44.81 g + 22.70 g + 32.49 g

Table 3: Proximal Analysis per 100 g of infants Flours obtained

	InSF1	InSF2	InSF3	InSF4	InSF5	Nutritional goal (RDA)
Macronutrients content per 100 g						
Dry matter (g)	91.81	91.07	92.48	90.97	91.99	
Organics matter (g)	88.02	86.55	88.48	87.76	88.92	
Moisture (g)	8.19	8.93	7.52	9.03	8.01	<12
Crudes Ash (g)	3.79	4.52	4	3.21	3.07	2
Protein(g)	10.83	12.05	11.04	11.35	10.02	11 - 21
Fat (g)	8.15	13,4	10.93	13.35	8.35	7 - 8
Carbohydrates (g)	69.04	61.1	66.51	66.26	70.55	60 - 70
Acidity	6.1	6.1	4.9	6.1	6.1	
Energy value (kcal/100 g)	392.8	413.05	408.57	430.59	397.43	400
Micronutrients content per 100 g						
Potassium (mg/100g)	219.79	1180.35	1187	382.08	709.91	> 129*
Calcium (mg/100g)	205.49	219.19	142.93	254.86	159.69	> 125*
Phosphorius(mg/100g)	180.1	614.51	583.81	250.82	233.48	281.2**
Magnesium (mg/100g)	201.79	188.71	200.65	202.43	239.49	> 19*
Sodium (mg/100g)	28.33	20.35	17.24	51.42	10.24	> 74*
Iron(mg/100g)	6.02	5.1	4.56	6.54	5.12	> 4.0*
Zinc (mg/100g)	0.63	1.21	1.5	0.83	1.5	> 0.8*
Copper (mg/100g)	1.38	0.92	0.95	1.52	1	> 0.04*

Values marked in bold are in accordance with the recommendations according to RDA and WHO

RDA: Recommended Daily Allowance, (*): Normr OMS; (**): (CAC. 2013). InSF: infant Supplementary food

Table 4: Microbiological characteristics of the flours produced

Colonies tested	InSF1	InSF2	InSF3	InSF4	InSF5	Reference value
AMFT à 30° C	3.10 ¹	1.1. 10 ²	10 ²	9. 10 ²	7.10 ²	3.10 ⁵ UFC/g
<i>Coliformes totaux</i>	<1	2.10 ²	<1	6.10 ¹	<1	1.0.10 ² UFC/g
<i>Staphylococcus coagulase +</i>	<1	<1	<1	<1	<1	<1 UFC/g
<i>Echerchia coli</i>	<1	<1	<1	<1	<1	1.0.10 ³ UFC/g
<i>Bacillus cereus</i>	<1	<1	<1	<1	<1	1.0.10 ³ UFC/g
ASR à 46° C	<1	<1	<1	<1	<1	1.0.10 ² UFC/g
<i>Salmonella Sp</i>	Absent	Absent	Absent	Absent	Absent	Absence/25g
Decision	C	NC	C	C	C	

C: Compliant, **NC:** Not Compliant, **InSF:** Infant Supplementary food

AMFT: Aerobic Mesophill Flora Total; **ASR:** Aerobic Sulfite-Reducing

Table 5: Average mark of sensory perception of the porridges

	Farilac	InSF1	InSF2	InSF3	InSF4	InSF5	p-value
Color	1.33 (± 0.50)	1.67 (± 1.00)	4.78 (± 0.44)	2.11 (± 0.33)	1.44 (± 0.73)	2.11 (± 0.78)	0.001
Smell	1.11 (± 0.33)	2 (± 0.50)	4.11 (± 0.33)	1.44 (± 0.53)	2.22 (± 0.67)	1.78 (± 0.67)	0.001
Taste	1 (± 0.00)	1 (± 0.00)	3.56 (± 1.13)	1 (± 0.00)	2.89 (± 1.76)	1.44 (± 0.88)	0.001
Oral texture	1.44 (± 0.53)	1.56 (± 0.73)	2 (± 0.87)	1.56 (± 0.53)	1.78 (± 0.83)	1.33 (± 0.71)	0.45
Consistency	1.44 (± 0.53)	1.67 (± 0.71)	2.22 (± 0.67)	1.67 (± 0.50)	1.89 (± 0.60)	1.67 (± 0.71)	0.19
Global Acceptability	1.33 (± 0.50)	2.33 (± 1.32)	2.66 (± 1.12)	1.44 (± 0.53)	2.33 (± 1.30)	2.66 (± 1.12)	0.05
Range	1	2	3	1	2	3	

InSF: Infant Supplementary food

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