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Improvement of the Microbiological and Nutritional Quality of Infant Flours, Porridges, and Weaning Purees Consumed by Children Aged 6 to 24 Months at the Institute of Nutrition and Child Health of Guinea

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Abstract

This study, conducted from 15 January to 15 May 2025 in Conakry, assessed the microbiological and nutritional profiles of weaning flours, porridges, and purées made from local products consumed by children aged 6 to 24 months. Five infant flours were formulated from local ingredients. Their physicochemical and nutritional characteristics, as well as those of their porridges and purées, were analysed according to French standards. The physicochemical analysis showed a moisture content ranging from 6.23% to 13.59% and an ash content of 3.19% to 4.17%, indicating a good concentration of essential nutrients. The iodine content of the porridges and purées (7.19 to 25.1 ppm) was in line with recommended levels. Protein content ranged from 10.11% to 10.66%, lipids from 7.99% to 8.84%, carbohydrates from 64.45% to 71.56%, ash from 3.40% to 4.17%, and energy value from 371.44 to 406.37 kcal. The porridges and purées showed similar values, with a slight decrease in energy and nutrients. Microbiological analysis revealed levels of total aerobic mesophilic flora (22 to 120 CFU/g), yeasts and moulds (0 CFU/g), and total coliforms (1 to 70 CFU/g); *Staphylococcus aureus*, Salmonella, faecal coliforms, and faecal streptococci were absent, thus meeting health standards. Nevertheless, the presence of certain microorganisms indicates poor hygiene. The starch content (57.87% to 64.40%) provided a solid supply of complex carbohydrates to meet energy needs. The low cellulose content (0.01% to 0.72%) promoted digestibility. These results demonstrate the potential of local resources to improve infant nutrition. The promotion of industrial production and appropriate marketing of these products is necessary to strengthen food security and the health of Guinean children.

Keywords

Microbiological-Nutritional Quality, Infant Flours, Porridges, Purees, INSE Guinea

1. Introduction

For children aged 6 to 24 months, diets consist of a combination of commercially prepared foods and locally sourced preparations, with traditional porridges and purées being a key element of weaning. These latter play a central role in meeting the energy and nutritional needs of young children. However, their microbiological, physicochemical, and nutritional quality is a serious concern. The lack of systematic analyses and rigorous controls exposes children to various health risks, including gastrointestinal infections linked to microbial contamination, as well as nutritional imbalances that can affect growth and harmonious development [1].

Microbial contamination of these infant flours, porridges, and purees is often associated with the presence of pathogens such as total coliforms, yeasts, and molds, reflecting inappropriate hygiene practices during preparation, storage, or distribution. These microorganisms can cause recurrent diarrheal diseases, leading to high infant morbidity. Furthermore, the low nutritional density of many traditional formulations contributes to chronic deficiencies in essential micronutrients, particularly iron, vitamin A, and iodine, the deficiencies of which have irreversible consequences on physical, cognitive, and immune development [2].

Globally, malnutrition remains a major determinant of child mortality. According to estimates by the World Health Organization, approximately 45% of deaths in children under five are attributable to direct or indirect forms of malnutrition [1]. Furthermore, 42% of children in this age group suffer from iron deficiency, the leading cause of anemia, while vitamin A deficiency affects nearly 190 million preschool children, significantly increasing the risk of serious infections and mortality [2].

During the weaning period, it is necessary to gradually introduce new foods in liquid or semi-liquid form, such as porridges and purees, to supplement breast milk. These preparations are the most commonly used complementary foods for young children. However, their energy density and nutritional value are often insufficient to meet the physiological needs of growth. This weakness is mainly attributed to the high starch content of the raw materials used, including rice, maize, millet, sorghum, cassava, yam, and sweet potato. Complementary foods intended for this period must therefore have satisfactory nutritional, sanitary, and organoleptic qualities to ensure a proper dietary transition [3].

Malnutrition frequently develops between 6 months and 2 years of age, a critical period corresponding to the transition from an exclusively milk-based diet to a semi-liquid and then solid diet [4]. In Guinea, the results of the SMART Survey [5] indicate a national prevalence of **6.7%** global acute malnutrition among children aged 6 to 59 months, a situation considered concerning according to WHO standards. Furthermore, **25.5%** of children exhibit stunted growth and **14.6%** suffer from underweight, reflecting a persistent deterioration in nutritional status.

Linking local, regional, and global data is essential for a comprehensive understanding of children's nutritional and health status. This approach allows for the assessment of gaps between international trends and national realities, while also identifying the contextual determinants of malnutrition. Analyzing previous studies and interventions in Conakry and the interior regions is also a valuable resource for assessing past efforts and guiding future strategies to combat malnutrition [6].

Malnutrition in children aged 6 to 59 months often results from insufficient exclusive breastfeeding or inappropriate introduction of complementary foods [7]. This period represents a critical window of vulnerability, during which inadequate energy and nutritional intake fail to meet increasing metabolic needs. Inadequate quality and quantity of complementary feeding, combined with the high frequency of infections and limited access to healthcare, contribute to the emergence and persistence of various forms of malnutrition, both acute and chronic [8].

These findings underscore the urgent need to strengthen quality controls on locally produced infant flours, porridges, and purees, and to improve their nutritional profiles, particularly through fortification with essential micronutrients and the adoption of good hygiene and processing practices. Such an approach would help reduce health risks and promote healthy growth in children aged 6 to 24 months. Given the seriousness of this situation and the complexity of the factors involved, this study aims to analyze the relationship between the availability of local food resources and the microbiological, nutritional, and physicochemical quality of infant flours, porridges, and purees intended for weaning children aged 6 to 24 months, followed at the Institute of Nutrition and Child Health (INSE).

Objectives

General objective

Improve the nutritional quality of infant flours, their porridges and purees to cover the nutritional needs of children.

Specific Objectives

Formulating infant flours based on local agricultural resources.

Assessing the nutritional quality of infant flours, their porridges, and purees obtained.

Compare the nutritional value of infant flours, their porridges, and purees obtained according to the standards recommended by the WHO.

Identify and quantify the pathogenic microorganisms present in infant flours, porridges, and purees obtained and consumed by children aged 6 to 24 months.

Determine the levels of microbial contamination in the flours, porridges, and purees obtained and assess their compliance with sanitary standards.

2. Materials and Methods

2.1. Presentation of the Study Environments

See Figure 1.

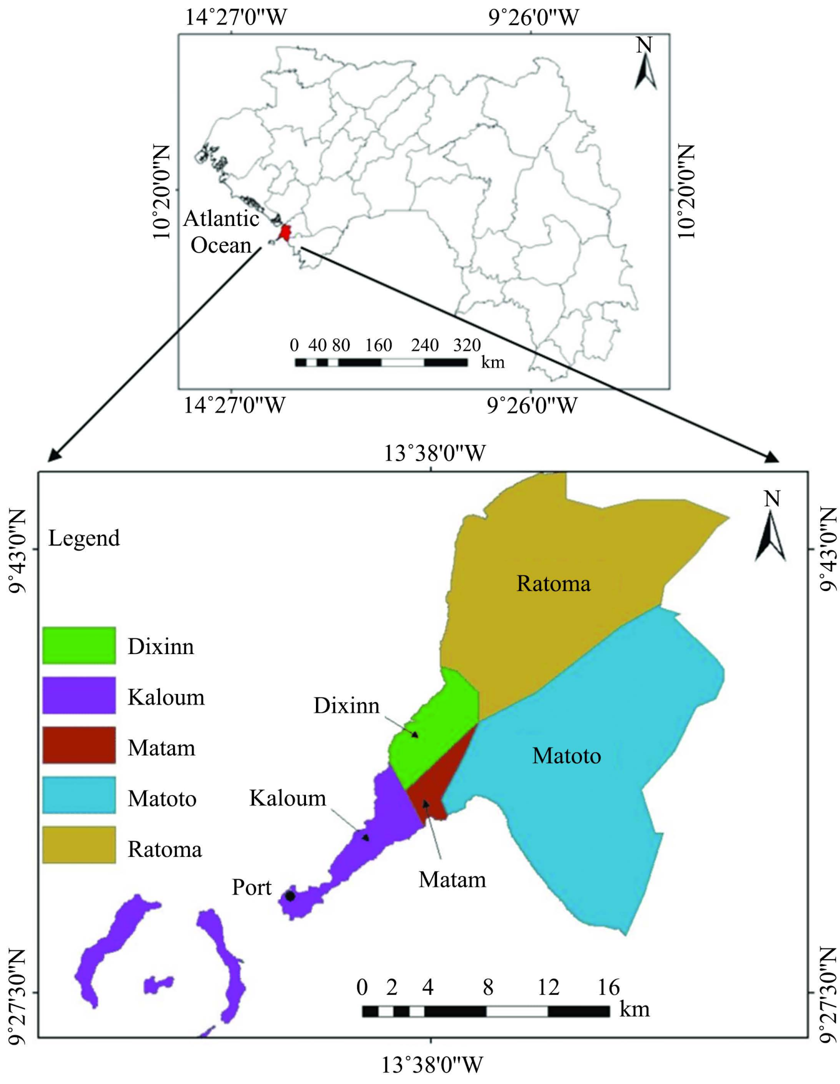


Figure 1. Geographical map of the city of Conakry [9].

2.2. Study Environment (City of Conakry)

The city of Conakry is the capital of the Republic of Guinea. It is located on the Atlantic Ocean. The Republic of Guinea is a West African country covering an area of 245,857 km^2. It is bordered by the Atlantic Ocean to the west and shares borders with six countries: Guinea-Bissau to the northwest, Senegal to the north, Mali to the north and northeast, the Ivory Coast to the east, and Liberia and Sierra Leone to the south.

Conakry is a peninsula of 308 km^2 with a length of 34 km and a width of 1 to 6 km. In 2015, the Conakry metropolitan area had more than 3 million inhabitants with a density of 81,151 inhabitants per km^2, making it the largest city in the country [9].

Located in southwestern Guinea, the Conakry conurbation extends across the coastal plain traversed by small rivers that water the Fouta-Djalon.

2.3. Study Framework (INSE, ONCQ)

The Guinean Institute of Nutrition and Child Health (INSE) and the National Office of Quality Control served as the frameworks for this study.

2.3.1. INSE (The Institute of Nutrition and Child Health)

The Institute of Nutrition and Child Health (INSE) was established by Ordinance No. 062/PRG/89 of October 16, 1989, with funding from the European Union. It is a public hospital and tertiary-level research institution located on the grounds of and opposite the maternity ward of the Donka University Hospital in the Dixinn district of the Dixinn municipality in Conakry. It is under the administrative supervision of the Ministry of Health and Hygiene and is attached to the National Directorate of Family Health and Nutrition.

INSE carries out several activities related to children's health. These activities are preventive, curative, and nutritional, but they also include scientific research and training.

2.3.2. ONCQ (National Office of Quality Control)

The National Office for Quality Control (ONCQ) is located in the commune of Matoto, specifically in the Khabitaya district.

It is a public scientific and technical institution with legal personality and financial and administrative autonomy. It is under the supervision of the Ministry of Commerce, and its mission is to monitor the application of regulations relating to the quality of consumer goods in the Republic of Guinea.

- He is notably responsible for developing and implementing quality control programs.
- To contribute to the establishment of a national system for monitoring food quality and safety.
- To carry out quality control of goods and products for import and export.
- To ensure compliance with hygienic quality and current commercial quality (products of plant origin, animal origin, fishery products, cosmetics, medicines, soap, paint, and any other product that can be controlled by the ONCQ delivered for domestic consumption and found in commerce), as well as to quantify the level of risk to consumption.
- To carry out expert assessments and analyses within the framework of the repression of fraud and falsification.

- To study the causes of deterioration in product quality and to indicate to economic operators the relevant corrective measures.

2.4. Materials and Methods

In the Guinean context, the dietary transition between 6 and 24 months relies primarily on porridges and purees made from local foods. Rice, plantain, and taro are widely available, culturally accepted, and economically accessible staple foods. Their use in infant flour formulations addresses the objective of utilizing local resources while improving the nutritional quality of weaning meals.

Fortifications (fish powder, egg yolk, peanut paste, carrot powder, sweet banana powder, sweet potato leaf powder, and vegetable oil) were selected for their high protein, lipid, fat-soluble vitamin, and mineral content, in order to more effectively meet the high nutritional needs of young children.

2.4.1. General Formulation Process

The flour formulations were developed using **NutVal 4.1 software** and **Microsoft Excel 2016 Solver**, enabling linear optimization to minimize cost while meeting WHO nutritional guidelines.

The proportions of each flour were determined based on:

- The nutritional composition of the ingredients,
- Energy and micronutritional objectives (Fe, Zn, Ca, Mg, iodine, vitamin A),
- Technological constraints (digestibility, local availability).

Constraints imposed in the solver:

- Total ingredients = 100%,
- Energy ≥ 400 kcal/100g,
- Minimum levels of protein, lipids, and micronutrients in accordance with the Codex Alimentarius,
- Minimizing the total cost.

The nutritional values of the formulated flours were calculated automatically using formulas inserted in Excel, allowing for the reproducibility of the method.

2.4.2. Preparation of Raw Materials

Rice: Sorting—Drying at 65˚C (2 h)—Cooling—Milling.

Sweet banana, plantain banana, carrot and taro:

Washing—Peeling—Cutting—Drying at 70˚C (2 h)—Grinding (30 to 50 s).

Sweet potato leaves: Washed—Cut—Dried at 50˚C (1 h)—Ground (30 s).

Dried fish: the dried fish was purchased at the market, Tri-Mouture (30 s).

Dried onions: the dried onions were purchased at the market, Tri-Mouture (50 s).

Composition and Preparation of Rice Porridge Enriched with Fish Powder (Table 1)

Preparation technology

- Boil 1/4 cup of water in a pot.
- Mix sugar, rice flour, and fish powder with sweet banana powder in 1/4 of the water contained in a bowl.

Table 1. Proportion of ingredients in rice porridge enriched with improved fish powder.

No.	Ingredients	Weight (g)	%
1	Rice (Flour)	236	19
2	Sugar	50	4
3	Fish (powder)	553	44
4	Salted butter	365	29
5	Sweet Banana Powder	40	4
6	Totals	1244	100

- Return the mixture to the boiling water on the stove, stir it, and then let it boil for 20 minutes over low heat.
- Remove the porridge from the heat, then cool it and give the child the planned meal.

Composition and preparation of improved egg yolk-enriched rice porridge (**Table 2**)

Table 2. Proportions of ingredients in improved egg yolk-enriched rice porridge.

No.	Ingredients	Weight (g)	%
1	Rice (Flour)	215	10
2	Sugar	50	3
3	Egg (the yolk)	775	37
4	Vegetable oil	1005	48
5	Carrot Powder	40	2
6	Totals	2085	100

Preparation technology

- Boil 1/4 cup of water in a pot.
- Mix sugar and rice flour enriched with egg yolk, carrot powder in 1/4 of water in a bowl.
- Return the mixture to the boiling water on the stove, stir it, and then let it boil for 20 minutes over low heat.
- Remove the porridge from the heat, then cool it and give the child the planned meal.

Composition and preparation of rice porridge enriched with improved peanut paste (**Table 3**)

Preparation technology

- Boil 1/4 cup of water in a pot.
- Mix sugar with rice flour and peanut paste, sweet banana powder in 1/4 of the water contained in a bowl.
- Return the mixture to the boiling water on the stove, stir it, and then let it boil for 20 minutes over low heat.

Table 3. Proportion of ingredients in rice porridge enriched with improved peanut paste.

No.	Ingredients	Weight (g)	%
1	Rice (flour)	204	24
2	Sugar	50	6
3	Peanut butter	558	66
4	Sweet Banana Powder	40	4
5	Totals	842	100

- Remove the porridge from the heat, then cool it and give the child the planned meal.

Composition and preparation of improved taro puree (Table 4)

Table 4. Proportion of ingredients in the improved taro puree.

No.	Ingredients	Weight (g)	%
1	Taro Powder	1210	66
2	Fish powder	12	2
3	Peanut oil	181	10
4	Onion powder	30	2
5	Pumpkin Powder	240	13
6	Fresh tomato	120	6
7	Salt	4	1
8	Totals	1797	100

Preparation technology

- Boil 1/2 liter of water in a pot.
- Mix taro powder, fish powder, onion powder, and pumpkin powder in 1/4 cup of water in a bowl, then add fresh tomato.
- Return the mixture to the boiling water over the heat and stir it, add peanut oil and salt, then let it boil for 20 minutes over low heat.
- Remove the puree from the heat, then cool it and give the child the planned meal.

Composition and preparation of improved plantain banana puree (Table 5)

Table 5. Proportion of ingredients in plantain puree.

No.	Ingredients	Weight (g)	%
1	Plantain banana	882	32
2	Fish	1203	43
3	Palm oil	209	7
4	Onion	30	1
5	Pumpkin powder	240	9
6	Fresh tomato	120	4
7	Salt	4	1
8	Peanut butter	100	3
9	Totals	2788	100

Preparation technology

- Boil 1/2 liter of water in a pot.
- Mix plantain banana powder, fish powder, onion powder, and pumpkin powder in 1/4 of water in a bowl; add peanut paste and fresh tomato. Return the mixture to boiling water on the heat and stir it, add palm oil and salt, then let it boil for 20 minutes over low heat.
- Remove the puree from the heat, then cool it and give the child the planned meal.

2.4.3. Biological Materials Used: Infant Flours, Porridges, and Purees

1-FRPP = Rice Flour Enriched with Fish Powder

2-BRPP = Rice Porridge Enriched with Fish Powder

3-FRJO = Rice Flour Enriched with Egg Yolk

4-BRJO = Rice Porridge Enriched with Egg Yolk

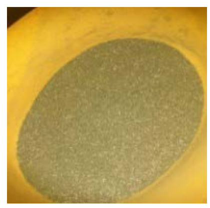
5-FRPA = Rice Flour Enriched with Peanut Paste

6-BRPA = Rice Porridge Enriched with Peanut Paste

7-FPT = Taro Puree Flour

8-PT = Taro Puree

9-FPBP Plantain Banana Puree



Flour/Sweet Potato Leaf Powder

10-PBP = Plantain Banana Puree

1) Laboratory Equipment and Apparatus

- Digestion device (Auto-Kjeldahl): Kjeltec^{TM} 8200, FOSS Analytical, Denmark
- Analytical balance: Sartorius Entris224i-1S, Sartorius, Germany
- Petri dishes: sterile polystyrene Ø90 mm, ref. 82.1473.001, Sarstedt
- Porcelain crucibles (50 mL), ref. 10.190.11, VWR International
- Kjeldahl catalyst – K_2SO_4 + $CuSO_4$, Merck KGaA, Germany
- Desiccator with ceramic plate, Fisher Scientific
- Drying oven (105˚C): Memmert UN110, Germany

- Soxhlet extractor: Büchi Extraction System B-811, Switzerland
- Muffle furnace (550˚C): Nabertherm LT 9/11/B180, Germany
- Laminar flow microbiological hood: Esco Airstream, Singapore
- Incubators (25˚C, 30˚C, 37˚C, 44˚C): Binder BD115, Germany
- Calibrated pH meter: Hanna Instruments HI5221 with pH buffers 4.01, 7.01, and 10.01
- Micropipettes: Eppendorf Research® plus (0.5 - 1000 µL), Germany
- UV-Visible Spectrophotometer: Shimadzu UV-1800/7600, Japan
- Test tubes: Pyrex 16 × 150 mm, ref. 9826, Corning Inc.

2.4.4. Reagents Used

- Boric acid (ACS reagent grade): ref. 100165, Merck
- Sulfuric acid 98%: Ref. 100731, Merck
- Sodium chloride 0.85%: isotonic solution, ref. 1.06404, Merck
- Sodium hydroxide (NaOH): tablets, ref. 106,462, Merck
- Solvents (hexane ≥ 95%, ref. 104872; petroleum ether 40˚C - 60˚C, ref. 109018), Merck

2.4.5. Culture Media Were Used

- Agar PCA: Ref. CM0325, Oxoid/Thermo Fisher
- Agar VRBD: ref. CM0107, Oxoid
- TBX: ref. CM0945, Oxoid
- Salmonella-Shigella (SS): ref. CM0099, Oxoid
- Baird-Parker agar: ref. CM0275, Oxoid
- Agar Sabouraud: Ref. 105437, Merck

2.5. Methods

2.5.1. Study Design

This was an evaluative study that consisted of determining and comparing the microbiological, physicochemical, nutritional, and micronutrient characteristics of local infant flours and their porridges and purees with the relevant standards.

2.5.2. Study Framework and Population

The study was conducted in the city of Conakry during the period from January 15, 2025, to May 15, 2025. The biological material concerned consisted exclusively of locally produced infant flours from their porridges and purees consumed by children aged 6 to 24 months at the Institute of Nutrition and Child Health of Guinea.

2.5.3. Study Variables

Our variables were the analysis of the physico-chemical parameters of infant flours and their porridges and purees: the determination of water content, crude protein, fat, total ash, and total carbohydrates, and the measurement of pH according to the methods described by the AOAC (1990; 1995) [10] and the FAO (1998) [11], and the microbiological analysis Total aerobic mesophilic flora

(TAMF), Total coliforms, Fecal coliforms, Yeasts and Molds, Anaerobes Sulfite - reducing agents, *Salmonella* spp., *Staphylococcus aureus*, *Fecal Streptococci*, according to standards (AFNOR 2004-ISO 2006_2022).

2.5.4. Physicochemical and Nutritional Analyses

- **pH determination:** pH was determined according to the AOAC potentiometric method (2005) [10] using the electrode of a pH meter. Five grams of infant flour or porridge were weighed and added to 10 ml of distilled water in a beaker; then the tip of the HANNA pH meter electrode was immersed in the solution, and the pH value was instantly displayed on the screen.
- **Moisture determination:** The method described by the AOAC (1995) was adopted. Weighed slurry samples were dried in an air oven (Memmert, UFE-600) at 105˚C until a constant weight was reached. The moisture percentage was calculated as the difference between the fresh weight and the dry weight.
- **Determination of total ash content:** The ash content was determined using the drying method described by the AOAC (1995), where the weighed sample was heated to 750˚C for 5 hours to ensure adequate incineration. The percentage ash content was calculated.
- **Determination of crude protein:** Nitrogen and crude protein were determined using the Micro Kjeldahl method (AOAC, 1995). The sample was digested with sulfuric acid and a mixed catalyst (96% $CuSO_4$ + 3.5% Na_2SO_4, 0.5% selenium oxide) in a digestion apparatus (Kjeltec System HT 2, Fosstecator, Hoganäs, Sweden). The distillate, trapped in a boric acid solution, was titrated with 0.1 M HCl using a mixture of methyl blue and methyl red as indicators to obtain total nitrogen. The crude protein content was calculated using a correction factor of 6.25.
- **Lipid determination:** Infant flour was extracted using petroleum ether in a Soxhlet extraction unit (Soxtec system, Hoganäs, Sweden), according to the method described by the AOAC (1995).
- **Determination of total carbohydrates:** The total carbohydrate content was calculated by difference. For this reason, the other constituents of the feed, namely lipids, proteins, and ash, were measured separately, added together, and subtracted from the total weight of the feed. The total carbohydrate content was determined according to the FAO formula (1998). [11]

2.5.5. Micronutrients

1) Iodine

The iodine content of the gruels and purees was determined using the iodometric titration method, in accordance with the WHO/UNICEF/ICCIDD 2007 guidelines [12].

2) Iron

The iron content was measured by atomic absorption spectroscopy (AAS) according to the AOAC 2000 standard [13].

3) Zinc

Zinc was determined using AAS as described in AOAC 2000 [13].

4) Vitamin has

The vitamin A content was analyzed by high-performance liquid chromatography (HPLC) in accordance with AOAC 2000 [13].

5) Calcium

Calcium was determined by titration with EDTA according to AOAC 2000 [13].

6) Magnesium

Magnesium was measured using AAS in accordance with AOAC 2000 [13].

7) Starch

The starch content was analyzed enzymatically using AOAC 2000 [13].

8) Cellulose

The cellulose content was determined by the Weende method according to AOAC 2000 [13].

2.6. Microbiological Analyses

Samples of formulated, boiled, and pureed flours were analyzed to detect the presence of microorganisms that could impact children's health. These analyses were performed at the ONCQ laboratory using standard culture media and in accordance with international standards.

2.6.1. Total Aerophilic Mesophilic Flora (TAMF)

Used to assess the overall microbial load and general microbiological quality of slurries, the analysis was carried out by deep plating on plate count agar (PCA) and incubation at 30˚C for 72 hours, in accordance with ISO 4833-1:2022 [14].

2.6.2. Total Coliforms

These are indicators of environmental contamination and possible hygiene deficiencies during the preparation of the slurry. The method used was VRBD spreading and incubation at 37˚C for 24 hours, also according to ISO 4832:2006 [15].

2.6.3. Fecal Coliforms

The detection of fecal coliforms allows for the assessment of fecal contamination and adherence to hygiene practices. The method used is inoculation onto red-violet bile dextrose (VRBD) agar and incubation at 44˚C for 24 hours, in accordance with ISO 4832:2006 [15].

2.6.4. Yeasts and Molds

Their presence can affect the quality of the slurry and pose health risks due to the potential production of mycotoxins. The method used consisted of spreading the mixture onto potato dextrose agar (PDA) and incubating it at 25˚C for 5 days, in accordance with ISO 21527-1:2008 [16].

2.6.5. Sulfite-Reducing Anaerobes

Enumeration of Sulfite-Reducing Anaerobes (AFNOR ISO 7937, 2004) [17].

2.6.6. *Salmonella* Spp.

The detection of Salmonella is essential because it causes serious foodborne illnesses. The method used included pre-enrichment in buffered peptone water (BPW), isolation on Salmonella-Shigella (SS) agar at 37˚C for 24 to 48 hours, and biochemical confirmation in accordance with ISO 6579-1:2017/Amd 1:2020 [18].

2.6.7. Staphylococcus Golden

This pathogen can produce toxins responsible for food poisoning. The analysis consisted of plating on Baird-Parker (BP) agar, incubation at 37˚C for 24 to 48 hours, and confirmation by coagulase test, in accordance with ISO 6888-1:2021 [19].

2.6.8. Fecal Streptococci

The enumeration of fecal streptococci was carried out in accordance with the AFNOR ISO 7937 standard, 2005 [20].

2.7. Data Collection and Processing Methods

Our data were collected using laboratory analysis forms, then entered into Excel 2016, and subsequently analyzed with SPSS version 26.0. Descriptive statistics (mean, standard deviation, frequency, and percentage) were calculated. Comparisons between groups were performed using Student's t-test or ANOVA for continuous variables and the chi-square test for categorical variables. Statistical significance was set at $p < 0.05$.

2.7.1. Descriptive Statistics

The mean, standard deviation, and proportions were calculated for all variables of interest.

2.7.2. Interpretation According to WHO, FAO and Codex Alimentarius Standards

The results were interpreted on the basis of WHO, FAO and Codex Alimentarius standards relating to nutrient intake, microbiological safety and iodine deficiency [12]-[14].

2.8. Study Limitations

The main limitations included the use of dietary data reported by the CREN, potential seasonal variations in food availability, and constraints in laboratory analyses due to resource limitations.

2.9. Study Constraints

The constraints encountered were that we were unable to dry the various ingredients using local methods, we had to use an oven, there were transport difficulties for collecting samples, and occasional power outages affected the laboratory equipment.

3. Results and Discussion

In this study, 5 infant flours, their porridges, and purees, composed of different ingredients, were formulated.

3.1. Physicochemical Parameters of the 3 Infant Flours and Their Porridges Analyzed

The pH values of the fortified rice porridges ranged from 4.45 to 5.72, with an average of 5.31, indicating slight acidity. These values fall within the range recommended by the **Codex Alimentarius**, **FAO**, and WHO (4.5 - 6.8) for infant cereal products. They are lower than those reported by AE Sika *et al.* (2019), who observed pH levels between 6.23 and 6.29 [21]. The measured pH, being slightly acidic, is a favorable factor for product stability and limiting microbial growth. (**Table 6**)

Table 6. Representation of the descriptive pH analysis of the enriched rice porridge samples.

	N	Minimum	Maximum	Average	Standard deviation
pH	6	5.68	5.72	5.69	0.02
		4.98	4.99	4.98	0.01
		5.21	5.30	5.25	0.04
		5.50	5.55	5.52	0.02
		4.45	5.45	5.10	0.56
		4.45	5.72	5.31	0.34
Valid N (list)	6				

Good quality infant flour is a key factor in ingredient selection for various porridges. Dry matter content is an indicator of good quality porridge. The results for the physical parameters (dry matter, moisture, and total ash content) of the samples are presented in **Table 7**.

Table 7. Representation of the means and standard deviations of dry matter, moisture, and ash content.

Samples	Dry matter (%)	Humidity (%)	Ash (%)
FRPP	92.82 ± 0.01**	7.17 ± 0.01**	3.44 ± 0.61
FRJO	92.08 ± 1.29***	7.91 ± 1.29***	3.42 ± 0.03**
FRPA	93.77 ± 1.67**	6.23 ± 1.67**	3.05 ± 0.48**
BRPP	86.95 ± 0.01*	13.04 ± 0.01*	4.17 ± 0.85*
BRJO	87.29 ± 0.01	12.70 ± 0.01	3.19 ± 0. 54***
BRPA	86.52 ± 0.20*	13.47 ± 0.20***	3.40 ± 0.02*

Legend: FRPP = Rice Flour Enriched with Fish Powder; **FRJO** = Rice Flour Enriched with Egg Yolk; **FRPA** = Rice Flour Enriched with Peanut Paste; **BRPP = Rice Porridge** Enriched with Fish Powder; **BRJO** = Rice Porridge Enriched with Egg Yolk; **BRPA** = Rice Porridge Enriched with Peanut Paste. Values with the same number of exponents in the row are not significantly different from each other.

After performing the non-parametric Kruskal-Wallis test, we found that the P value is 0.001, and we conclude that the comparison of the means of the dry matter content and the moisture content from one sample to another was not significantly different.

All the flours generally had a high dry matter content (92%). The porridges—Rice porridge enriched with Fish Powder; Rice porridge enriched with Egg Yolk; Rice porridge enriched with Peanut Paste—had, respectively: 86.95% ± 0.01%; 87.29% ± 0.01%; 86.52% ± 0.20% dry matter content.

In terms of ash content, rice flour enriched with fish powder and rice porridge enriched with fish powder had remarkable values of 3.44% ± 0.61% and 4.17% ± 0.85%, respectively. In terms of moisture content, the highest value was that of rice porridge enriched with peanut paste at 13.47% ± 0.20%, and the lowest value was that of rice flour enriched with peanut paste at 6.23% ± 1.67%.

Our results are comparable to those of Chabi *et al.* in 2019, who found 91.07% ± 0.26% and 91.65% ± 0.42% dry matter content in the two infant flours, FT25 and FT35, formulated in Benin [4].

In terms of ash content, they are higher than those of Chabi *et al.* (2019), who found values between 2.23% ± 0.16% and 2.58% ± 0.15% in the two infant flours [4].

3.2. Nutritional Parameters of the 3 Infant Flours and Their Porridges Analyzed

Values with the same number of exponents are not significantly different at the 5% threshold. (**Table 8**)

Table 8. Representation of the means and standard deviations of the lipid, protein, and carbohydrate content.

Samples	Lipids (%)	Protein (%)	Carbohydrates (%)
FRPP	8.84 ± 0.09**	10.66 ± 0.05**	69.86 ± 0.53***
FRJO	8.67 ± 0.26***	10.52 ± 0.05**	71.56 ± 1.41**
FRPA	8.58 ± 0.48**	10.56 ± 0.05**	71.56 ± 1.41**
BRPP	8.06 ± 0.06*	10.41 ± 0.15*	64.30 ± 0.98*
BRJO	7.99 ± 0.01*	10.19 ± 0.01*	65.91 ± 0.55***
BRPA	8.00 ± 0.01*	10.45 ± 0.01*	64.65 ± 0.19***

Legend: FRPP = Rice Flour Enriched with Fish Powder; **FRJO** = Rice Flour Enriched with Egg Yolk; **FRPA** = Rice Flour Enriched with Peanut Paste; **BRPP =** Rice Porridge Enriched with Fish Powder; **BRJO** = Rice Porridge Enriched with Egg Yolk; **BRPA** = Rice Porridge Enriched with Peanut Paste.

Our results are lower than those of Chabi *et al.* in 2019, who found 14.98% ± 0.01% and 20.96% ± 0.01% protein levels in the two infant flours, FT25 and FT35, formulated in Benin [4].

In terms of lipid content, they are higher than those reported by Chabi *et al.* (2019), who found values between 5.46% ± 0.01% and 7.31% ± 0.01% in the two infant flours [4]. The carbohydrate levels found vary between 64.30% ± 0.98% and 71.56% ± 1.41% fall within the range of 60% - 75% recommended by the Codex Alimentarius, WHO, and FAO (2020). (**Table 9**)

Table 9. Representation of the descriptive analysis of the energy value of samples of infant flours and their porridges.

Energy Value	Minimum	Maximum	Moyenne	Ecart Type
FRPP	401.19	402.25	401.68	0.53
FRJO	398.59	414.42	406.37	7.91
FRPA	401.38	414.50	405.77	7.56
BRPP	368.16	374.98	371.44	3.41
BRJO	374.28	378.57	376.40	2.14
BRPA	371.95	373.40	372.52	0.77

Legend: FRPP = Rice Flour Enriched with Fish Powder; **FRJO** = Rice Flour Enriched with Egg Yolk; **FRPA** = Rice Flour Enriched with Peanut Paste; **BRPP =** Rice Porridge Enriched with Fish Powder; **BRJO** = Rice Porridge Enriched with Egg Yolk; **BRPA** = Rice Porridge Enriched with Peanut Paste.

The energy values of our infant flours range from 401.68 to 406.37 kcal. Rice flour enriched with egg yolk had the highest value, and rice flour enriched with fish powder had the lowest. Our results are comparable to those of A. E. Sika *et al.* (2019) [21], who found 397.27 kcal ± 0.90%/100g and 400.86 kcal ± 0.49%/100g for the three infant flours FC1, FC2, and FC3 formulated in Côte d'Ivoire. According to the WHO, an increase in the energy value of porridges could be due to a high dry matter content in the flours. The energy values of our porridges range from 371.44 to 376.40 kcal, close to the results found by Sylla *et al.* (2025) of 369.47 to 393.13 kcal in their analyzed samples of local porridges given to young children in the Fria prefecture of the Republic of Guinea [6]. Our results are higher than those of Touré *et al.* [22], who found energy values ranging from 168.24 to 288 kcal in these samples of unimproved porridges at INSE. (**Table 10**)

Table 10. Results of mineral and vitamin A analysis of flour samples and their porridges.

Samples	Fe (mg/100g)	Zn (mg/100g)	Ca (mg/100g)	Mg (mg/100g)	Iodine (ppm)	Vitamin A (µg RE/100g)
FRPP	7.8	3.3	374.5	7.43	10.35	311.65
FRJO	9.4	2.1	362.5	6.95	10.27	325.51
FRPA	5.5	2.4	241.5	7.39	10,19	307.95
BRPP	5.4	2.5	158.7	4.43	9.44	305.15
BRJO	7.2	1.7	271.4	3.26	8.38	315.25
BRPA	2.3	2.1	241.1	3.38	7.19	303.07

Legend: FRPP = Rice Flour Enriched with Fish Powder; **FRJO** = Rice Flour Enriched with Egg Yolk; **FRPA** = Rice Flour Enriched with Peanut Paste; **BRPP =** Rice Porridge Enriched with Fish Powder; **BRJO** = Rice Porridge Enriched with Egg Yolk; **BRPA** = Rice Porridge Enriched with Peanut Paste; **Fe** = Iron; **Zn** = Zinc; **Ca** = Calcium; **Mg** = Magnesium; I = Iodine; **Vit A** = Vitamin A.

The mineral concentrations in the flour and porridge samples show significant variability depending on the element analyzed. Calcium has the highest levels (158.7 to 374.5 mg/100g), followed by iron (2.3 to 9.4 mg/100g) and zinc (1.7 to 3.3 mg/100g). Magnesium concentrations remain low (3.26 to 7.43 mg/100g), while iodine concentrations range from 7.19 to 10.35 ppm. These values, although modest, indicate a significant contribution to total mineral intake, particularly calcium and iron, elements essential for the growth and development of young children. However, the relatively low levels of zinc and iodine suggest the need for dietary enrichment or diversification to optimize mineral status. Furthermore, the concentrations of vitamin A (303.07 to 325.51 µg RE/100g) and iodine (7.19 to 10.35 ppm) meet the essential nutritional requirements for maintaining vision and strengthening immunity. Overall, these results demonstrate that the analyzed porridges have a balanced micronutritional profile, adapted to the physiological needs of growing children. Our results are consistent with those found by Sylla *et al.* in their analysis of local porridges given to young children in the Fria prefecture of the Republic of Guinea [6].

3.3. Microbiological Parameters of the 3 Infant Flours and Their Porridges Analyzed

The results presented in Table 11 show that the analyzed formulated flour samples and their porridges contained relatively low concentrations of total aerobic mesophilic flora and total coliforms, ranging from 1 to 120 CFU/g. The highest values were observed in samples 1, 2, and 3, which could reflect differences in hygiene conditions during preparation or storage. However, these concentrations remain

Table 11. Results of the microbiological analysis samples of infant flours and their porridges.

Samples	FMAT	CT	CF	LM	STA	ASR	SAL	SF
FRPP	77	27	00	00	00	00	00	00
FRJO	120	70	00	00	00	00	00	00
FRPA	31	01	00	00	00	00	00	00
BRPP	29	00	00	00	00	00	00	00
BRJO	20	00	00	00	00	00	00	00
BRPA	22	00	00	00	00	00	00	00
Critères	$\leq 10^6$	$\leq 10^3$	**Absence/ 25g**	$\leq 10^2$	**Absence/ 25g**	**Absence/ 25g**	**Absence/ 25g**	**Absence/ 25g**

Legend: FRPP = Rice Flour Enriched with Fish Powder; **FRJO** = Rice Flour Enriched with Egg Yolk; **FRPA** = Rice Flour Enriched with Peanut Paste; **BRPP = Rice Porridge** Enriched with Fish Powder; **BRJO** = Rice Porridge Enriched with Egg Yolk; **BRPA** = Rice Porridge Enriched with Peanut Paste. **FMAT** = Total Aerobic Mesophilic Flora; **CT** = Total Coliforms; **CF** = Faecal Coliforms; **LM =** Yeasts & Molds; **STA** = *Staphylococcus aureus*; **ASR** = Sulfite-reducing anaerobes; **SAL** = Salmonella; **SF** = Fecal streptococci.

below the maximum tolerated threshold of 10^3 CFU/g, in accordance with microbiological food safety standards. No contaminating organisms were found for LM, *Staphylococcus aureus*, ASR, SAL, or fecal streptococci. Although these levels remain well below the regulatory limit of 100 CFU/g, contamination risks may occur, particularly with prolonged storage at room temperature. Furthermore, the detection of spoilage microorganisms such as total aerobic mesophilic flora and total coliforms, combined with the absence of indicator bacteria of fecal contamination, suggests that good hygiene practices were not applied uniformly during preparation. These results also highlight the need to improve storage conditions. Overall, this microbiological profile underscores the importance of strengthening hygiene and control measures throughout the production chain to ensure the safety of flours and porridges intended for infant feeding. However, total aerobic mesophilic flora and total coliforms were identified, but at numbers far below the microbiological criteria respectively reported by FAO 2015: 3.5×10^4; 2.75×10^4 CFU/g FMAT and 1×10^4 CFU/g CT and (AE Sika *et al.*, 2019). In the Ivory Coast 2.09×10^2; 2.54×10^2 CFU/g FMAT_FC1 and FC2.

3.4. Physicochemical Parameters of the 2 Infant Flours and Their Analyzed Purees

The pH values of taro and plantain purees ranged from 4.45 to 5.72, with an average of 5.10, indicating slight acidity. These values fall within the range recommended by the **Codex Alimentarius**, **FAO**, and WHO (4.5 - 6.8), but remain lower than those reported by Sylla *et al.* (2025), who observed pH values between 6.22 and 6.46. The measured range (5.10 - 5.69) reflects a slightly acidic to near-neutral environment, favorable to product stability and limiting microbial growth. (**Table 12**)

Table 12. Representation of the descriptive pH analysis of Taro puree and Plantain Banana puree samples.

	N	Minimum	Maximum	Average	Standard deviation
pH	4	4.45	5.45	5.10	0.56
		4.46	5.47	5.10	0.01
		5.10	5.55	5.10	0.56
		5.68	5.72	5.69	0.20
Valid N (list)	4				

The quality of infant flour used in the preparation of purees depends closely on the choice of ingredients. Among the determining criteria, dry matter content is a key indicator of the overall quality of the purees. The results for the physical parameters dry matter, moisture, and total ash content obtained for the different samples are presented in **Table 13**.

Table 13. Representation of the means and standard deviations of dry matter, moisture, and ash content.

Samples	Dry matter (%)	Humidity (%)	Ash (%)
FPT	86.52 ± 0.20**	13.47 ± 0.01**	3.40 ± 0.23**
FPBP	92.08 ± 1.29***	13.59 ± 0.01***	3.40 ± 0.21**
PT	93.77 ± 1.67**	10.02 ± 3.25**	3.44 ± 0.40**
PBP	92.08 ± 1.29*	7.91 ± 1.29*	4.42 ± 0.22**

Legend: FPT = Taro Puree Flour; **FPBP** = Plantain Banana Puree Flour; **PT** = Taro Purée; **PBP** = Plantain Banana Puree.

Values with the same number of exponents in the row are not significantly different from each other.

The results presented in Table 13 indicate that the flours used in local purees are characterized by a relatively stable moisture content, ranging from 13.47% to 13.59%, ensuring good consistency while preserving nutrients. The dry matter content, varying from 86.52% to 93.77%, reflects a high concentration of nutrients, typical of cereal-based preparations. The ash content, ranging from 3.40% to 3.44%, indicates a mineral richness consistent with expected values for this type of food. Our results are higher than those of Ndiaye *et al.* in 2025, who found ash contents of 2.47% ± 0.26% and 2.86% ± 0.42% for the two infant flours F1 and F2 formulated in Senegal.

3.5. Nutritional Parameters of the 2 Infant Flours and Their Analyzed Purees

Values with the same number of exponents are not significantly different at the 5% threshold. (Table 14)

Table 14. Representation of the means and standard deviations of lipid, protein, and carbohydrate content.

Samples	Lipids (%)	Protein (%)	Carbohydrates (%)
FPT	800 ± 0.01**	10.45 ± 0.07**	64.65 ± 0.10**
FPBP	7.99 ± 0.05**	10.54 ± 0.07**	64.45 ± 0.03**
PT	8.40 ± 0.44***	10.47 ± 0.18**	67.86 ± 3.06*
PBP	8.67 ± 0.26*	10.52 ± 0.05**	71.56 ± 1.41***

Legend: FPT = Taro Puree Flour; **FPBP** = Plantain Banana Puree Flour; **PT** = Taro Puree; **PBP** = Plantain Banana Puree.

The fat content, ranging from 7.99% to 8.67%, contributes to a significant energy intake, while carbohydrates, the primary energy source, represent between 64.45% and 71.56%. The protein content, between 10.45% and 10.54%, supports growth and muscle development. Starch, present at levels within acceptable limits

(57.76% to 59.39%), ensures an adequate intake of complex carbohydrates. The low fiber content (0.26% to 0.59%) promotes good digestibility while providing a moderate amount of fiber beneficial to intestinal transit.

Our results are lower than those of Ndiaye *et al.* in 2025, who found 12.88% ± 0.01% and 12.23% ± 0.01% protein levels in the two infant flours, F1 and F2, formulated in Senegal [8].

In terms of lipid content, these results are higher than those reported by Ndiaye *et al.*, 2025 in Senegal, who found values between 4.91% ± 0.01% and 8.68% ± 0.01% in the two infant flours [8]. Carbohydrate levels ranged from 64.45% ± 0.98% to 71.56% ± 1.41%, falling within the range of 60% - 75% recommended by the Codex Alimentarius, WHO, and FAO (2020). (**Table 15**)

Table 15. Representation of the descriptive analysis of the energy value of samples of infant flours and their purees.

Energy Value	Minimum	Maximum	Average	Standard deviation
FPT	374.28	378.57	372.52	0.77
FPBP	371.95	373.40	371.97	0.07
PT	371.89	372.04	389.01	7.56
PBP	374.05	375.66	406.37	7.91

Key: FPT = Taro Puree Flour; **FPBP** = Plantain Banana Puree Flour; **PT** = Taro Puree; **PBP** = Plantain Banana Puree.

The energy values of infant flours range from 371.97 to 372.52 kcal/100g. Plantain banana puree flour has the highest value, while taro flour has the lowest. These values, influenced by dry matter content, remain lower than those reported by Ndiaye *et al.* (2025) in Senegal (377.99 - 398 kcal/100g) [8].

The purees have values between 389.01 and 406.37 kcal/100g, close to those observed by Sylla *et al.* (2025) in Guinea (369.47 - 393.13 kcal/100g) [8].

Despite this proximity, the average value (<400 kcal/100g) remains slightly below the recommended threshold, suggesting the need for fortification to fully meet the energy needs of children aged 6 to 24 months.

Analysis of the data in **Table 16** reveals that the iron content, ranging from 6.2 to 8.7 mg/100g, falls within the recommended range of 5 to 10 mg/100g, indicating a sufficient intake to contribute to the prevention of anemia in children. Zinc concentrations, ranging from 2.9 to 4.5 mg/100g, are above the minimum required threshold (≥3 mg/100g) and play a crucial role in strengthening the immune system and supporting growth. Furthermore, the calcium (254.7 to 379.1 mg/100g) and magnesium (6.55 to 10.55 mg/100g) levels are within the reference ranges, ensuring an effective contribution to bone mineralization and the proper functioning of cellular metabolism. Moreover, the concentrations of vitamin A (310.25 to 321.95 µg RE/100g) and iodine (15.15 to 2.1 ppm) meet the essential nutritional requirements for visual health and immune response. Overall, these results confirm that the studied purees have a balanced micronutrient profile, meeting the physiological needs of children during their growth and developmental phases.

Table 16. Results of mineral and vitamin A analysis of flour samples and their purees.

Samples	Fe (mg/100g)	Zn (mg/100g)	Ca (mg/100g)	Mg (mg/100g)	Iodine (ppm)	Vitamin A (μg RE/100g)
FPT	8.7	4.5	379.1	10.43	20.55	315.85
FPBP	8.9	3.2	365.5	10.55	25.1	321.95
PT	7.5	3.4	305.5	8.25	15.15	310.25
PBP	6.2	2.9	254.7	6.55	17.05	317.53

Legend: FPT = Taro Puree Flour; **FPBP** = Plantain Banana Puree Flour; **PT** = Taro Purée; **PBP** = Plantain Banana Puree; **Fe** = Fer; **Zn** = Zinc; **Ca** = Calcium; **Mg** = Magnesium; **I** = Iodine; **Vit A** = Vitamin A.

3.6. Microbiological Parameters of the 2 Infant Flours and Their Purees Analyzed

The results in Table 17 show that the formulated flours and their purees have low microbial levels, with concentrations of total aerobic mesophilic flora (TAMF) and coliforms total (CF) values ranging from 1 to 36 CFU/g. The highest values were observed in samples 8 and 9 for FMAT, and 7 and 10 for CF, likely reflecting variations in hygiene during preparation and storage.

Table 17. Microbiological analysis results for samples of infant flours made from taro puree and plantain banana puree.

Samples	FMAT	CT	CF	LM	STA	ASR	SAL	SF
FPT	06	08	00	00	00	00	00	00
FPBP	36	00	00	00	00	00	00	00
PT	60	08	00	00	00	00	00	00
PBP	19	23	00	00	00	00	00	00
Critères	**$\leq 10^6$**	**$\leq 10^3$**	**Absence/ 25g**	**$\leq 10^2$**	**Absence/ 25g**	**Absence/ 25g**	**Absence/ 25g**	**Absence/ 25g**

Legend: FPT = Taro Puree Flour; **FPBP** = Plantain Banana Puree Flour; **PT** = Taro Puree; **PBP** = Plantain Banana Puree; **FMAT** = Total Mesophilic Aerobic Flora; **CT** = Total Coliforms; **CF** = Faecal Coliforms; **LM =** Yeasts & Molds; **STA** = *Staphylococcus aureus*; **ASR** = Sulfite-reducing anaerobes; **SAL** = Salmonella; **SF** = Fecal streptococci.

All microbial loads remained below the regulatory threshold of 10^3 CFU/g, in accordance with microbiological safety standards. No pathogenic organisms—yeasts and molds, *Staphylococcus aureus*, sulfite-reducing anaerobes, Salmonella spp., or fecal streptococci—were detected.

Although the observed loads remained well below the limit of 100 CFU/g, a risk of secondary contamination persists, particularly during prolonged storage at room temperature. The presence of mesophilic flora and coliforms, combined with the absence of indicator organisms of fecal contamination, suggests partial adherence to good hygiene practices during preparation.

Overall, these results highlight the good microbiological quality of the flours and porridges, while emphasizing the need to strengthen hygiene and storage conditions to prevent recontamination. The values obtained remain significantly lower than the FAO (2015) criteria—3.5×10^4 CFU/g for FMAT and 2.75×10^4 CFU/g for CF—and close to those reported by Sylla *et al.* (2025) in Guinea (1 to 22 CFU/g) in local porridges intended for young children in Fria [6].

4. Conclusions

This study on local flours, porridges, and purees consumed by children aged 6 to 24 months at the Institute of Nutrition and Child Health in Guinea highlights important results concerning their microbiological, physicochemical, and nutritional quality.

From a microbiological standpoint, the total aerobic mesophilic flora and total coliform counts (1 to 120 CFU/g) remained well below regulatory thresholds (10^3 CFU/g and 100 CFU/g). These results demonstrate the overall satisfactory sanitary quality of the products, while highlighting the need to improve hygiene practices during preparation and handling to further reduce the risk of contamination.

From a nutritional standpoint, the analyzed flours had a high energy value (401.68 ± 0.53 to 406.37 ± 7.91 kcal/100g), exceeding the recommendations of the Codex Alimentarius, FAO, and WHO, confirming their potential as high-nutritional-density complementary foods. However, a significant decrease in energy density was observed after cooking and dilution of the porridges (371.44 ± 3.41 to 376.40 ± 2.14 kcal/100g), bringing them below the recommended value of 400 kcal/100g. This energy decrease poses a major challenge for meeting children's nutritional needs.

The levels of iron (2.3 - 8.7 mg/100g), zinc (1.7 - 4.5 mg/100g), calcium (158.7 - 379.1 mg/100g), and vitamin A (303.07 - 321.95 µg RE/100g) remained adequate, demonstrating that these foods can contribute usefully to the prevention of nutritional deficiencies. Regarding iodine, the use of iodized salt resulted in levels within the reference ranges; however, given potential heat loss, it is recommended to add iodized salt *after* cooking.

Overall, the results confirm the good nutritional value, relative safety, and suitability of fortified local flours and their derivatives, while also indicating the need to improve certain household practices to optimize their energy and health benefits. These data are particularly useful for national infant and young child feeding programs, notably for promoting fortified local flours, reducing dependence on imported flours, and developing policies for the industrialization of small-scale production.

The decrease in energy density observed after cooking directly supports the following practical recommendations:

- **Reduce the dilution of the slurries** in order to maintain optimal energy density;
- **Always add energy-rich ingredients**, such as small amounts of vegetable oils or peanut paste, just before consumption;

- **Control the cooking time** to limit losses and avoid excessive dilution due to prolonged cooking.

In summary, the results demonstrate that locally sourced fortified flours represent a viable and culturally acceptable option for improving the nutritional status of children aged 6 to 24 months in Guinea. Particular attention to preparation practices could significantly enhance their impact on nutritional security.

Recommendations

Based on the results obtained, several measures are proposed to sustainably improve the **microbiological and nutritional quality** of flours, porridges, and purees intended for children, as well as to strengthen the overall nutritional status of young children in Guinea.

To the health authorities

- Promote local production of fortified infant flours.
- Strengthen community training on the preparation of high-energy-density porridges.
- Encourage the use of iodized salt added after cooking.

To healthcare professionals

- Train the mothers to reduce the dilution and slightly extend the cooking time as needed.
- Promote a diversified diet rich in micronutrients.

To mothers and childcare providers

- Prepare the porridges by limiting the amount of water to maintain the energy density.
- Always add a source of fat (oil, peanut paste).
- Gradually introduce foods rich in iodine and micronutrients.

To the general population

- Promote and support local flour production sectors.
- Adopt strict hygiene practices to reduce microbiological risks.

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Conflicts of Interest

The authors of this article certify that they have no conflicts of interest to declare in relation to the publication of this article.

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