Original Research Article

Characterization, microbiological and nutritional quality of complementary foods for children (6 to 24 months) produced in the city of Man (Côte d'Ivoire)

ABSTRACT: This study aims to determine the microbiological and nutritional quality of complementary foods for children produced in the city of Man (instant flour and porridge). To do this, a structured survey of mothers of children (6-24 months) and vendors, coupled with microbiological and nutritional analyzes was carried out. The main germs (Total Aerobic Mesophilic Flora, yeasts and molds, total coliforms, *Escherichia coli*, *Staphylococcus* sp. and *Salmonella* sp.) and the macronutrients, physicochemical and micronutrient parameters (carbohydrate and lipid content, humidity and ash content, P, K, Ca, Fe, Zn and Cu were determined in the samples analyzed. The results of the survey attest that the majority of mothers (61.1%) give a complementary food before the age of introduction (6 months), with regard to the saleswomen (100%) are unaware of the proportion of the components and their nutritional contribution as well as 54.8% of them have an unsanitary work place and environment. For the microbiological analysis, a total of 50 samples were analyzed and these testify to a potential contamination of spoilage and pathogenic germs The contamination rate of Anagobaka porridge is very worrying unlike other porridges and flours, especially with the presence of *salmonella*, the high rate of Escherichia coli and *Staphylococcus aureus* respectively ($3.91\times10^3 \pm 0.09$ and $5.34\times10^4 \pm 0.10$ CFU/mL). Concerning the nutritional analysis, there is a content of carbohydrates, lipids, zinc and copper raised to the standards in the 6 types of samples analyzed. Overall flour (FM5B) based on seven mixtures of raw materials shows the best nutrient rates and contents. All these results have shed light on the existence of a potential health risk and possible nutritional deficiencies in infants and young children who consume locally produced complementary foods.

KEYWORDS: Microbiological quality, Complementary food, Physico-chemical characteristics, Germs, Man (Côte d'Ivoire).

1 INTRODUCTION

Malnutrition remains a public health problem throughout the world. Nearly 112 million children under five worldwide are underweight and 178 million are stunted [1]. In developing countries, child malnutrition is one of the main causes of public health and social well-being problems, it is the cause of half of child deaths [2]. In Côte d'Ivoire, approximately 45 % of annual deaths of children under 5, i.e. 42,000 deaths per year or 115 deaths per day, are due to malnutrition [3]. All these forms of malnutrition are more severe during the weaning period, the so-called complementary feeding period (6 to 24 months) [4].

During this period, it is necessary to bring new foods in liquid or semi-liquid form to supplement the contributions of breast milk. These new and first foods given to children are called complementary foods and must be of satisfactory nutritional, health and organoleptic quality [5]. Indeed, according to the recommendations of the WHO and UNICEF, infants must receive exclusive breastfeeding up to 6 months. However, beyond 6 months, breast milk alone is not enough to meet their nutritional needs. They should therefore receive complementary feeding while continuing to breastfeed for up to 2 years or more [5]. These complementary foods must be foods of nutritional value appropriate to the age of the child and uncontaminated from both a microbiological and toxicological point of view. Thus, the first complementary foods are most often porridge made from cereals, roots or tubers, rich in carbohydrates and low in protein [6]. Porridge is sold in precarious hygienic conditions, which constitutes a major public health risk for consumers, especially children under five [7].

Like several local products, infant flour, the main complementary food, is produced essentially using an artisanal or semi-artisanal process under conditions of insufficient sanitation by millers with a relatively low level of education [8]. In addition, in Côte d'Ivoire, imported infant flours exist on the market as well as those produced locally as complementary foods. These complementary foods sold in supermarkets and large commercial chains are inaccessible to a large part of the population and are generally not used by low-income households because they are relatively expensive [8].

However, infant flours and porridges made traditionally are accessible to all, but they have a very low nutritional value and cause problems of malnutrition and nutritional deficiencies [9].

Studies have focused on complementary feeding of young children in Côte d'Ivoire [9], [10]. However, at the level of the city of Man, no study has yet been undertaken concerning the microbiological and nutritional quality of complementary foods.

In addition, according to MICS [11], the West of Côte d'Ivoire (area where the city of Man is located) is an area with a high prevalence of malnutrition, making the bed of several childhood pathologies including malaria, respiratory infections acute and diarrhoea. In the west of Côte d'Ivoire, 26 % of children under 5 are chronically malnourished compared to 21.6 % nationally and 6 % of children in this area of Côte d'Ivoire with this same age bracket are emaciated.

These different situations have aroused the interest of carrying out this study which aims to know the formulation and evaluate the nutritional and microbiological quality of complementary foods produced in the city of Man (Côte d'Ivoire).

2 MATERIAL AND METHODS

2.1 MATERIAL

2.1.1 PLANT MATERIAL

Six types of flour constituted the plant material of this study. It is :

- flour made from maize (*Zea mays*), sesame and cocoa (FMSC) ;

- flour made from maize (*Zea mays*) and soya (*Glycine maxima*) (FMS) ;

- flour made from maize (*Zea mays*), soya (*Glycine maxima*), cocoa (*Theobroma cacao*), sesame (*Sesamum indicum*), rice (*Oriza sativa*), millet (*Pennisetum glaucum*) and banana (*Musa paradisiaca*) (FM5B) ;

- flour made from maize (Zea mays), ginger (Zingiber officinale) and/or pepper (Capscicum annuum) used for ''Kokobaka porridge (KP)'',

- flour made from maize (Zea mays) only used for ''Anagobaka porridge (AP)'',

- and the last one based on millet (Pennisetum glaucum) used for ''Millet porridge (MP)''.

2.1.2 TECHNICAL MATERIAL

The technical equipment used to carry out this work consists of survey sheets and usual microbiology and biochemistry laboratory equipment. Plat Count Agar (PCA) culture medium was used for the enumeration of Total Mesophilic Aerobic Flora (TMAF) and Baird Parker (BP) agar was used for the enumeration of *Staphylococcus sp*. As for the count of *Salmonella sp*. and *Escherichia coli* (*E. coli*), it was done with the respective media *Salmonella-Shigella* (*SS*) and Violet Red Bile Lactose (VRBL). VRBL medium was also used for the enumeration of coliforms. Buffered Peptone Water (EPT) broth was used for preparation of the stock solution and for the various dilutions.

2.2 METHODS

2.2.1 SURVEY METHODOLOGY

The study was carried out with 90 households for mothers and 31 porridges sellers and distributed in 6 neighborhoods (grouped into 3 sectors) of the city of Man like the Focolari Medico-Social Center of Man.

The survey of merchants and consumers (mothers of children) was carried out using a questionnaire for each of the entities. The survey sheets were established using the SphinxPlus.V5.TuiTe software. These sheets made it possible to collect information relating to the socioeconomic characteristics of all the people surveyed. Also, for mothers of children, the information collected related to complementary feeding practices and knowledge, the intake of these foods to young children. From the vendors surveyed, relevant information was collected, in particular respect for good hygiene practices, the mode of installation of the vendor (outdoors, under a shelter or itinerant), the formulation of complementary foods. In addition, the degree of wholesomeness of the flours and porridges was evaluated through visual observation of the state of

cleanliness of the sales environment, of the saleswoman, of the equipment, of the presence of flies on the food or any around the place of sale and the existence of a place to deposit garbage.

2.2.2 SAMPLING

Different types of infant flours were sampled in sterile sachets at a rate of 500 g per sachet. The samples were taken and analyzed progressively following five (05) successive productions for each infant flour at the level of the production structure (Medico-Social Center Focolari of Man). As for the porridge, they were purchased and contained in sterile bags through 3 sectors (2 districts per sector) of the city of Man. Five (05) samples of each type of mixture were analyzed at 2-day intervals. A total of 50 samples were used for this study, consisting of fifteen (15) 500 g flour sachets and 35 approximately 300 g sachets of 3 different porridges (Table 1). Each sample was put in a cooler and transported to the laboratory for analysis.

Table 1. Number of samples taken in several districts of the city of Man

Samples	Camp Sea / Cafop	Kôkô / Trade	Dioulabougou / Blockauss	Focolari
KP	5	5	5	None
MP	5	5	5	None
AP	None	5	None	None
FMS	None	None	None	5
FMSC	None	None	None	5
FM5B	None	None	None	5

Total sample number = 50

KP: Kokobaka porridge; MP: Millet porridge; AP: Anagobaka porridge; FMS: Infant maize and soy flour; FMSC: Flour made from maize, sesame and cocoa; FM5B: Infant flour made from maize, sesame, soy, millet, rice, cocoa and banana; None = 0.

2.2.3 MANUFACTURE OF COMPLEMENTARY FOODS

The artisanal processes for preparing the porridges and flours studied are represented by figures 1, 2 and 3 as practiced by the Focolari center and most of the porridge vendors surveyed.

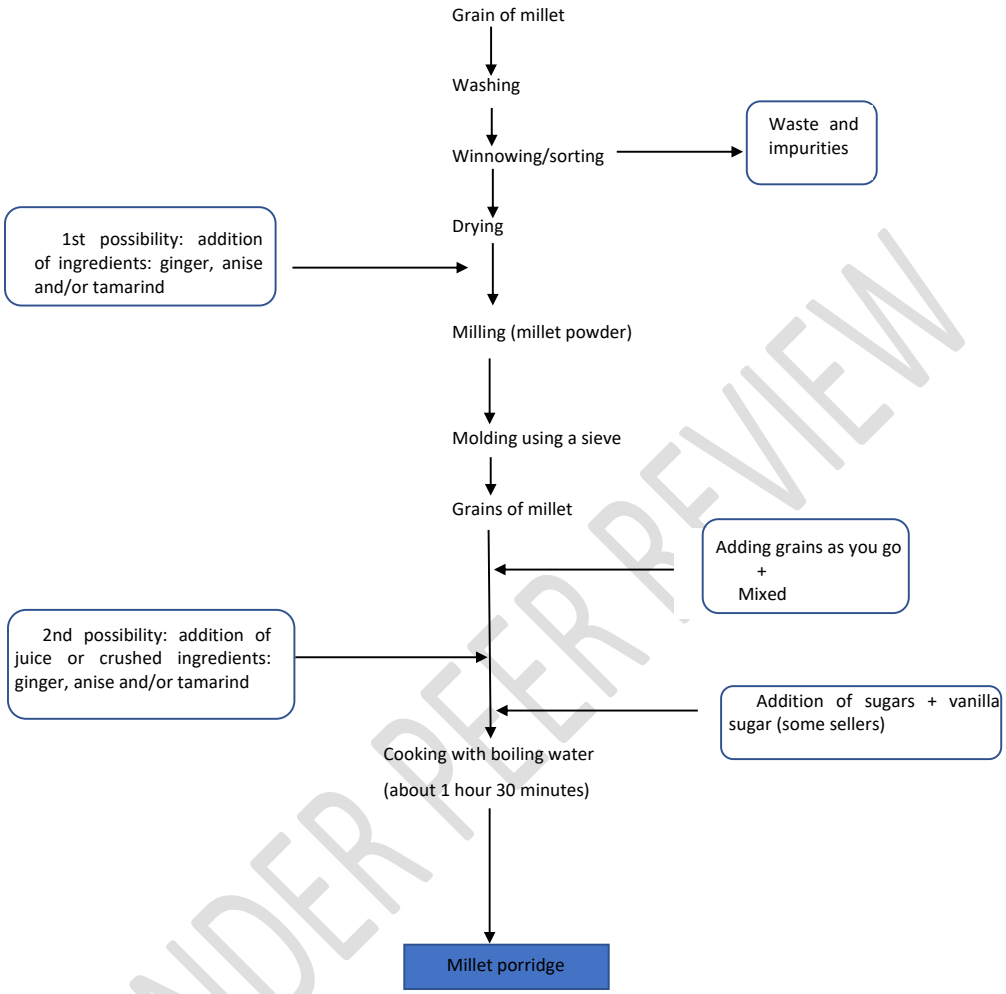

Fig. 1. Millet porridge production diagram

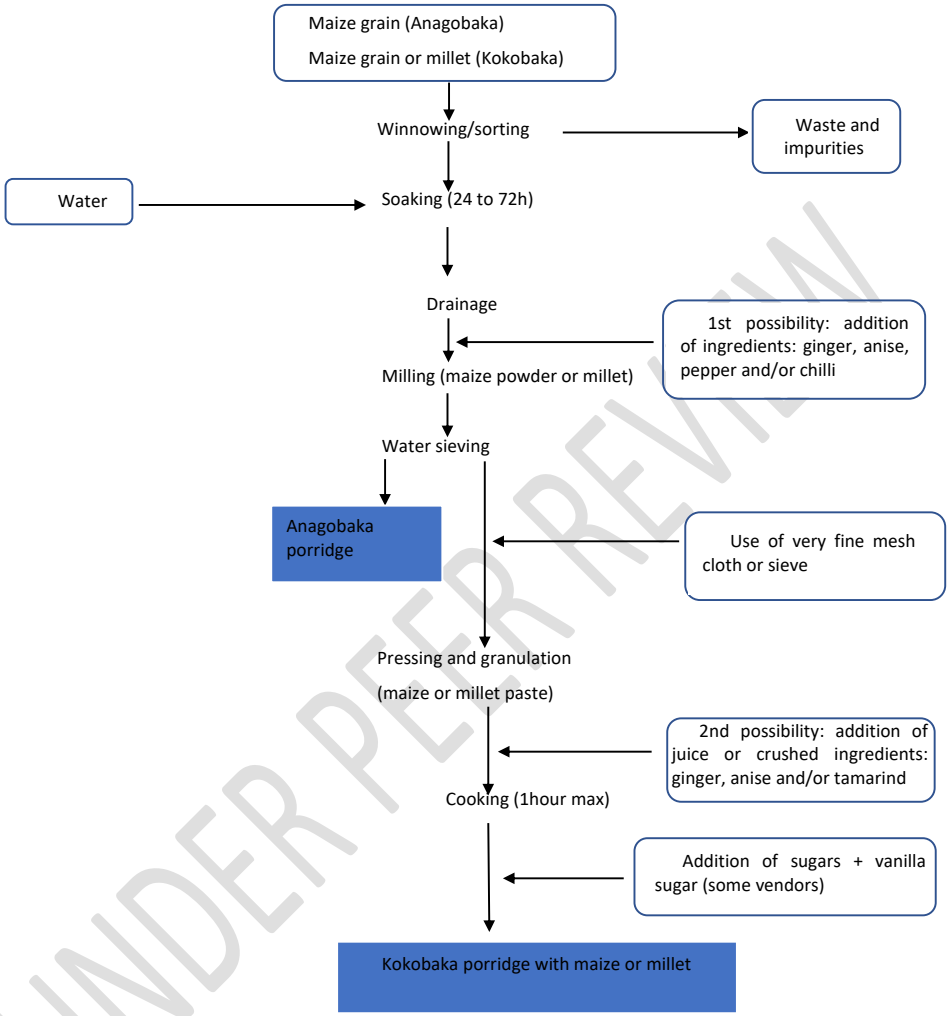

Fig.2. Production diagram of Anagobaka and Kokobaka porridges

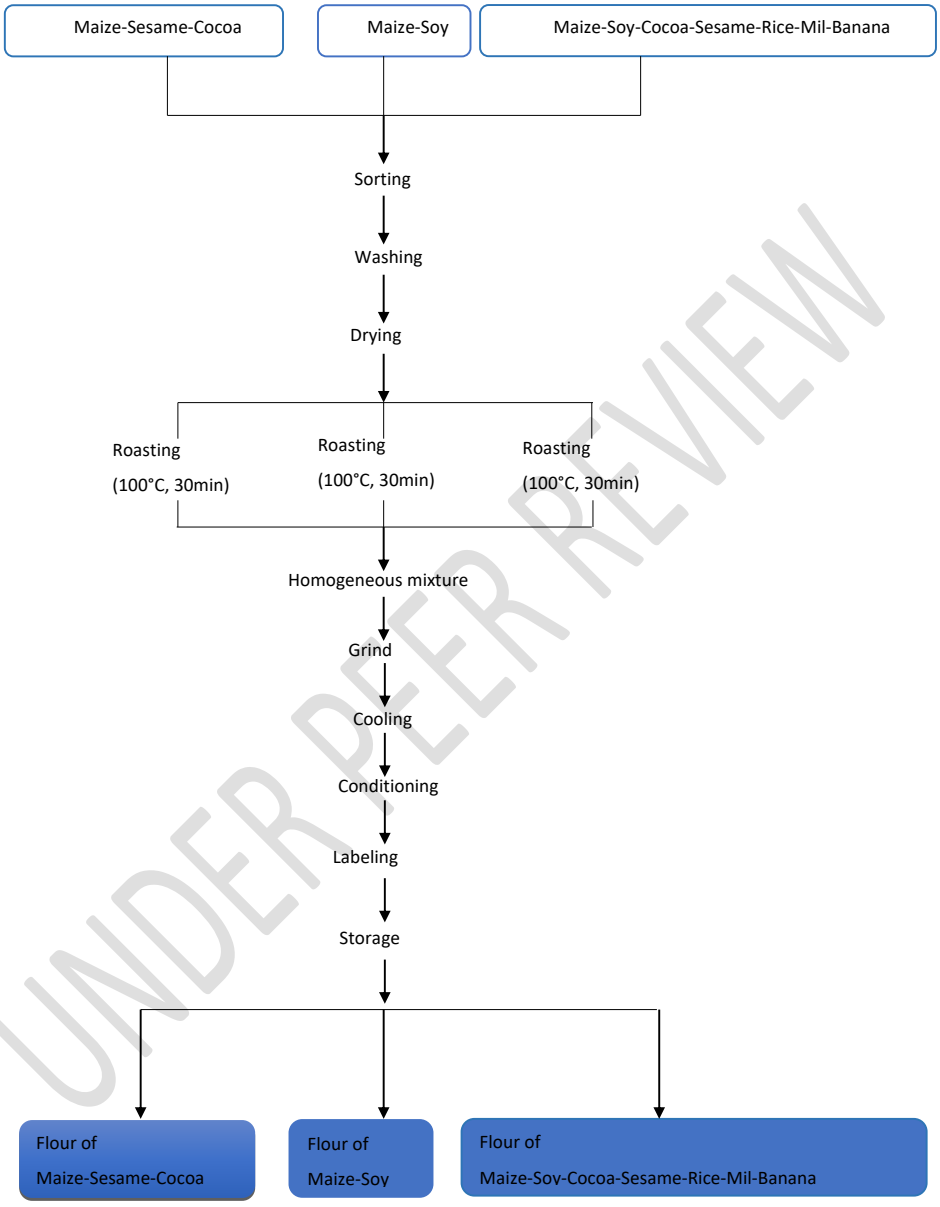

Fig.3. Diagram of flour production at the Focolari medical-social center in Man

2.2.4 Methods of microbiological analysis of flours and porridges

The microbiological analysis of infant flours and porridges is based on techniques for counting, isolating and identifying microorganisms likely to alter the hygienic and/or nutritional qualities of flours and porridges. These are germs such as faecal and total coliforms, *Escherichia coli*, S*taphylococcus sp.*, yeasts and molds, total flora and *Salmonella*. The identification of a germ, qualitative aspect is characterized by the absence or the presence of the latter. On the other hand, the counting of a germ is carried out by counting the colonies followed by a method of calculation and therefore represents the quantitative aspect of it.

Preparation of culture media, stock suspension and dilutions

The culture media were prepared according to the manufacturer's instructions.

Preparation of stock suspension and tenfold dilutions

The preparation of the samples, the stock suspension and the decimal dilutions was carried out according to the international standard ISO 6887-1 (1999). The samples were analyzed immediately after collection. A quantity of 25 g or 25 ml of sample is withdrawn aseptically into a sterile stomacher bag to which 225 ml Buffered Peptone Water (EPT) is added. The mixture was homogenized and left for 15-20 min for revivification of microorganisms. The solution obtained corresponds to the stock suspension. From this stock suspension, a series of successive decimal dilutions was carried out. One milliliter of the stock suspension was taken using a pipette and then introduced into a test tube containing 9 mL of Buffered Peptone Water. This corresponds to the 10^{-1} solution. The operation continued until the 10^{-5} dilution was obtained.

Research and enumeration of the different bacterial flora

After the incubation period mentioned in the standard specific to each germ, the count of the characteristic colonies for each dish containing less than 300 colonies and 30 colonies at least and between 15 and 150 colonies (for coliforms) was carried out. The number N of colony forming units (CFU)/g present in the sample analyzed and considered as an average of successive dilution is given by the following formula:

$$N= (C_1+ C_2)/ V(n_1+0.1n_2)\, d$$

C_1+C_2 = sum of the characteristic colonies of two boxes of successive dilutions counted

V= volume of inoculum applied to each dish

d = dilution rate corresponding to the first dilution retained

n_1 = number of dishes retained at the first dilution

n2 = number of dishes retained at the second dilution

Enumeration of mesophilic aerobic flora

The enumeration of mesophilic aerobic flora was carried out according to the ISO international standard 4833 (2003). Inoculation was done by exhaustion streaking on Plate Count Agar (PCA) previously poured into Petri dishes and then incubated in an oven at 37 °C for 24 h ± 2 h. After the incubation period the colonies were counted. The characteristic colonies appeared whitish or yellowish.

Search for *Staphylococcus sp.*

For the research of *Staphylococcus sp*. suspected pathogens was carried out according to ISO international standard 6888-1 (2003); 0.1 mL of stock solution and of each dilution were inoculated by streaking on Petri dishes containing BP medium (Baird Parker) and then incubated at 37 °C. for 48 h. Dishes containing 15 and 150 characteristic colonies were retained. The black, shiny, domed colonies surrounded by a white precipitate and a clearing halo were counted.

Enumeration of total coliforms and *Escherichia coli*

Total and thermotolerant coliforms were counted respectively according to the standard International ISO 4832 (2006) and ISO 16649-2 (2001). Inoculation was done on bile agar with crystal violet and neutral red (VRBL agar) then incubated at 37 °C for total coliforms and at 44 °C for thermotolerant coliforms, in an oven for 24 h ± 2 h. Characteristic colonies were counted after the incubation period. Thus, the dishes containing 15 and 150 characteristic colonies at the level of 2 successive dilutions were retained.

ENUMERATION OF YEASTS AND MOLDS

The culture medium used is Sabouraud poured into Petri dishes. 1 mL of each dilution was inoculated on Petri dishes and then incubated at 25 °C. for 2 days. Yeast colonies are milky in appearance while mold colonies are filamentous.

SEARCH FOR *SALMONELLA SP.*

Research of *Salmonella sp*. was carried out according to ISO international standard 6579/A1 (2007). The search for *Salmonella* in food involves essential steps : pre-enrichment, enrichment, isolation and confirmation.

- Pre-enrichment

The stock solution containing 25 g of sample mixed in 225 mL of EPT then homogenized, was incubated at a temperature of 37 °C for 24 ± 2 h.

- Selective enrichment

0.1 mL of the solution from the pre-enrichment was inoculated into a test tube containing 10 mL of rappaport vassiliadis broth. The mixture was homogenized and then incubated at 37 °C for 24 ± 2 h.

- Isolation

The isolation is done from the cultures obtained from the selective enrichment medium. Petri dishes containing *Salmonella-Shigella* culture medium were streaked. The plates thus inoculated were incubated for 24 hours at 37°C. The typical colonies of *Salmonella sp*. are black with a transparent halo on *Salmonella-Shigella* agar and small in size (2 to 4 mm in diameter).

- Confirmation

Confirmation is made by purification of the colonies in Petri dishes containing the *Salmonella-Shigella* medium then incubated at 37 °C for 24 hours.

INTERPRETATIONS OF MICROBIOLOGICAL DATA

At the end of the microbiological analysis, the interpretation of the results was made according to a 3-class sampling plan for TMAF, *E. coli*, total coliforms, *Staphylococcus sp*. suspected pathogens, yeasts and molds and a 2-class sampling plan for *Salmonella sp*.

The N values (CFU/g or mL) calculated for each flora studied according to the samples of each type of porridge and flour, were compared with the normative reference of the microbiological criteria applicable to foodstuffs intended for infants and young children (Table 2).

- For the 3-class plan, when the values obtained are lower than the minimum microbiological criterion set by germ according to standard NFV08-010-Mars (1996) and up to three (3) times this criterion, the product is of microbiological quality satisfactory (SMQ) ($m \leq N \leq 3m$).
- The product is of acceptable microbiological quality (AMQ) for the values obtained between three (3) and ten (10) times the criterion ($3\ m < N \leq 10\ m$).
- The microbiological quality is unsatisfactory (UMQ) ; when the germ count values obtained are greater than ten (10) times the criterion ($N > 10\ m$).
- For *salmonella sp*., the presence of *salmonella* indicates that the sample is of unsatisfactory microbiological quality (UMQ). The sample is of microbiological quality satisfactory (acceptable microbiological quality) if they are absent.

Table 2 : Microbiological standards for infant flour and porridge (NFV08-010- March 1996)

Microorganisms	Criteria CFU/g or mL	
Total aerobic mesophilic flora	10^4	10^5
Yeasts and molds	10^3	10^4
Total coliforms	10^3	10^4
Escherichia coli	1	10
Staphylococcus sp	10	10^2
Salmonella sp	Absent in 25 g or mL	

2.2.5 BIOCHEMICAL ANALYSIS METHODS FOR FLOURS AND PORRIDGES

The water content of the flours was obtained according to AOAC method [12] using an oven at a temperature between 103 and 105 °C until a constant weight was obtained. The water content corresponding to the variation in weight of the flour during the operation. The ash content was determined by dry incineration according to AOAC method [12]. Total lipids were extracted from samples homogenized in chloroform-methanol-water (1:2:1, v/v/v) as described by Folch et al. [13] and determined by gravimetry. As for total carbohydrates, they were quantified by the method of Munson and Walker [14]. Regarding the content of minerals, it was determined by the X-ray fluorescence spectrometry technique described by Thirion-Merle [15].

3 RESULTS

3.1 SURVEY RESULTS

3.1.1 SURVEY OF MOTHERS/CHILDREN

At the end of the survey carried out among mothers with children aged between 6-24 months, the results obtained are shown in Table 3. A proportion of 20 % of the mothers questioned know what a complementary food against 80 % of them who ignore it. In addition, 94.4% of these women use a complementary food produced locally in the city of Man, against 5.6 % of them who do not use it. The cross table of these two characteristics reveals that only 20 % of these mothers know and use a complementary food (Table 3).

In terms of age of complementary food consumption, 61.1 % of mothers claim to have introduced complementary food before the age of 6 months, 27.8% of them introduced it at from 6 months and 11.1 % beyond 6 months (Table 3).

The mothers were asked about the most common food given to children. Thus, 32.2% declare that Anagobaka porridge is the most given to children, followed by millet porridge (24.4 %), flour from the Focolari medical-social center in Man (20 %), Kokobaka porridge (18.9 %), rice porridge (3.3 %) and other food (1.1 %) (Table 3).

Different advisors for feeding children aged 6 to 24 months were interviewed. For the choice of complementary food produced locally, this choice is dominated by the mother herself (62.5 %), then the health center (19.2 %), friends and parents (13.3 %), culture 4.2 % and other (0.8 %) (Table 3).

Most complementary foods are bought by mothers at the market or at the supermarket, i.e. 39.5 %. Those who design these foods themselves at home are 27.6 %. A proportion of 17.8 % say they buy these foods in the neighborhood, 11.8% in a health center and 3.3 % of the mothers questioned did not answer the question (Table 3).

3.1.2 Survey carried out among sellers

The survey carried out among the vendors revealed that the level of education of the vendors questioned is distributed as follows: 38.7 % of these women have a primary education level; 32.3 % of them have not been to school; 16.1 % of these women have attended Koranic school and 12.9% have a secondary education. No saleswoman has a higher level of education (Table 3). Concerning the knowledge of complementary food, 74.2 % of saleswomen are unaware of the concept against 25.8 % of them who know it (Table 3). Regarding the knowledge and practice of hygiene of saleswomen along the production line, 88.9 % of saleswomen know and practice hygiene, unlike 11.1 % of saleswomen (Table 3). The degree of healthiness based on observation of the place of sale and the environment around this place reveals that 54.8 % of these foods have a poor degree of healthiness, 41.9 % have an acceptable degree against only 3.2 % where it is considered good (Table 3). None of the sellers surveyed (100 %) know the proportion of components and the nutritional intake of complementary foods. Several relevant data were collected through this survey sheet addressed to vendors of locally produced complementary food in the city of Man. Among these data we have the mode of installation of the saleswoman, the duration of sale of the complementary food.

Commented [AN1]: Concept of what?

Commented [AN2]: How was the degree of healthiness measured? Is there any ranking or other quantification method applied? Need to explain in methodology

3.2 Results of bacteriological analyzes

3.2.1 Bacterial load of complementary foods (porridges and flours)

A total of 50 samples were analyzed. Tables 4, 5, 6 and 7 give a summary of the average contamination level of the porridge and flour germs of all the samples for each germ. The average microbial load of the Anagobaka porridge of the samples analyzed revealed an unsatisfactory microbiological quality (UMQ) for each type of germ, thus testifying to a very high level of contamination. Thus, for the total aerobic mesophilic flora the average load is $3.43x10^5$ CFU/mL, yeasts and molds have a charge of $2.41x10^4$ CFU/mL, total coliforms showed a load of $4.08x10^4$ CFU/mL, *Escherichia coli* revealed an average load of $3.91x10^3$ CFU/mL, *Staphylococcus aureus* revealed an average load of $5.34x10^4$ CFU/mL and *Salmonella* was found in the samples.

3.2.2 Total mesophilic aerobic flora (TMAF)

The microbiological quality analysis revealed an average load (N) of the TMAF of acceptable microbiological quality (AMQ) for the millet porridge. These values range from $4.97x10^4$ to $8.58x10^4$ CFU/mL. Concerning the Kokobaka porridge, the results revealed a AMQ of $8.52x10^4$ CFU/mL for the Camp Sea/Cafop sector and an unsatisfactory microbiological quality (UMQ) for the Kôkô/trade and Dioulabougou/Blockauss sectors with average loads of 2.78 10^5 and 3.99. 10^5 CFU/mL, respectively. Focolari flours showed a satisfactory microbiological quality (QMS) with a value of $1.90x10^4$ CFU/g. At Camp Sea/Cafop, the analysis gave an acceptable microbiological quality (AMQ) of a load of $7.83x10^4$ CFU/mL. The Kôkô/Trade sector and an unsatisfactory microbiological quality (UMQ) with a load of $1.79x10^5$ for maize-soya-cocoa flour (FMSC).

3.2.3 Yeasts and molds

The results of the microbiological analysis show a satisfactory microbiological quality (QMS) for all the porridges of millet, Kokobaka and FocolarI flours. The millet porridges analyzed have an average load of 0 CFU/mL in all sectors, that of the Kokobaka porridges varies from 0 to $2.27x10^2$ CFU/mL. Focolari flours have a load of 90.9 CFU/g; $1.65x10^3$ CFU/g and 30.3 CFU/g respectively for FMS, FM5B and FMSC.

3.2.4 Total coliforms

For total coliforms, the contamination level of the millet porridge is of acceptable microbiological quality with a load of $4.14x10^3$ CFU/mL. For the Camp Sea/Cafop sector, the microbiological quality is unsatisfactory with an average microbial load of $4.58x10^4$ CFU/mL and $3.58x10^4$ CFU/mL respectively in the Kôkô/Trade and Dioulabougou/Blockauss sectors. Kokobaka porridge, on the other hand, testifies to a microbiological quality that is unsatisfactory in all sectors with a load of $5.81x10^4$; $6.55x10^4$ CFU/mL and $6.78x10^4$ CFU/mL at Camp Sea/Cafop, Kôkô/Trade and Dioulabougou/Blockauss. Conversely, all the flours from Focolari have an acceptable microbiological quality with an average load equal to $4.79x10^3$ CFU/g, $3.52x10^3$ CFU/g and $5.58x10^3$CFU/g respectively for FMS, FM5B and FMSC.

3.2.5 *Escherichia coli*

Concerning *E. coli*, the results of microbiological analysis show a satisfactory microbiological quality (QMS) for all the porridges of millet, Kokobaka and FocolarI flours. The average load is 0 CFU/mL in all sectors for porridge and also 0 CFU/g for all flours.

Table 3. Socio-economic characteristics and data on complementary foods distributed in Man

Survey results data					
Mothers			**Saleswomen**		
Complementary food knowledge	Yes	20%	Educational level	Primary	38,70%
	No	80%		Not in school	32,30%
Age of start of consumption of the complementary food	<6 month	61,10%		Koranic school	16,10%
	6 month	27,80%		Secondary	12,90%
	> 6 month	11,10%	Level of knowledge of complementary food	Oui	74,20%
Use of locally manufactured complementary food	Yes	94,40%		Non	25,80%
	No	5,60%	Knowledge and practice of hygiene	Yes	88,90%
Food preference given to children	Anagobaka porridge	32,20%		No	11,10%
	Porridge from the Focolari medical and social center	20%	Proportion of components and nutritional value of complementary foods	Yes	0%
	Kokobaka porridge	18,90%		No	100%
	millet porridge	24,40%	Sanitary level of the place of sale	Poor	54,80%
	rice porridge	3,30%		Acceptable degree	41,90%
	other food	1,10%		Good	3,20%
Advice for the use of the complementary food	Feeders	62,50%			
	Health center	19,20%			
	Friends and parents	13,30%			
	Culture	4,20%			
	Other	0,80%			
Place of supply of complementary foods	Market or supermarket	39,50%			
	At home	27,60%			
	The neighborhood	17,80%			
	Health center	3,30%			

3.2.5 *STAPHYLOCOCCUS AUREUS*

The results of the microbiological analysis show a satisfactory microbiological quality (SMQ) for all the porridges of millet, Kokobaka and Focolari flour concerning *Staphylococcus aureus*. The millet porridges analyzed have an average load which varies from $2.21x10^3$ CFU/mL (Camp Sea/Cafop) at $5.33x10^3$ CFU/mL (Dioulabougou/Blockauss). The Kokobaka porridges revealed an average load ranging from $6.26x10^3$ CFU/mL at $2.95x10^3$ CFU/mL. The load of the Focolari flours has a load of $1.42x10^3$ CFU/g ; $2.82x10^3$ CFU/g and $3.03x10^1$ CFU/g respectively for FMS, FM5B and FMSC.

3.2.6 *SALMONELLA*

Concerning Salmonella, results of microbiological analysis show a satisfactory microbiological quality for all the millet and Kokobaka porridges and the Focolari flours analysed. An absence of salmonella was found in all samples.

Table 4 : Contamination level of millet porridge

	Samples of millet porridge taken from quarters (n=5 per quarter)					
Germs studied		**Camp Sea/Cafop**	**Kôkô/Trade**	**Dioulabougougou/ Blockauss**	**Microbiological standards**	
TMAF	Charge UFC/mL	$4,79.10^4 \pm 0,10$	$8.92.10^4 \pm 2.12$	$8.58.10^4 \pm 0.09$	10^4	10^5
	Quality	AMQ	AMQ	AMQ		
Yeasts and molds	Charge UFC/mL	0	0	0	10^3	10^4
	Quality	SMQ	SMQ	SMQ		
Total coliforms	Charge UFC/mL	$4.14x10^3 \pm 0.07$	$4.58x10^4 \pm 1.05$	$3.58x10^4 \pm 0.05$	10^3	10^4
	Quality	AMQ	UMQ	UMQ		
Escherichia coli	Charge UFC/mL	0	0	0	1	10
	Quality	SMQ	SMQ	SMQ		
***Staphylococcus* sp.**	Charge UFC/mL	$2.21x10^3 \pm 0.07$	$3.21x10^3 \pm 0.04$	$5.33x10^3 \pm 0.16$	10	10^2
	Quality	UMQ	UMQ	UMQ		
***Salmonella* sp.**	Absent in 25 mL	Absent	Absent	Absent	Absent in 25 mL	
	Quality	SMQ	SMQ	SMQ		

Table 5 : Contamination level of Kokobaka porridge

	Samples of millet porridge taken from quarters (n=5 per quarter)					
Germs studied		**Camp Sea/Cafop**	**Kôkô/Trade**	**Dioulabougougou/ Blockauss**	**Microbiological standards**	
TMAF	Charge UFC/mL	$8.52x10^4 \pm 0.08$	$2.78x10^5 \pm 0.14$	$3.99x10^5 \pm 0.34$	10^4	10^5
	Quality	AMQ	UMQ	UMQ		
Yeasts and molds	Charge UFC/mL	0	$9.09x10^2 \pm 0.48$	$2.27x10^2 \pm 1.08$	10^3	10^4
	Quality	SMQ	SMQ	SMQ		
Total coliforms	Charge UFC/mL	$5.81x10^4 \pm 1.18$	$6.55x10^4 \pm 0.78$	$6.78x10^4 \pm 0.57$	10^3	10^4
	Quality	UMQ	UMQ	UMQ		
Escherichia coli	Charge UFC/mL	0	0	0	1	10
	Quality	SMQ	SMQ	SMQ		
Staphylococcus sp.	Charge UFC/mL	$6.26x10^3 \pm 0.35$	$1.88x10^4 \pm 0.07$	$2.95x10^4 \pm 0.04$	10	10^2
	Quality	UMQ	UMQ	UMQ		
Salmonella sp.	Absent in 25 mL	Absent	Present	Present	Absent in 25 mL	
	Quality	SMQ	UMQ	UMQ		

Table6 : Contamination level of Anagobaka porridge

	Samples of Anagobaka porridge taken from quarter (n=5 per quarter)			
Germs studied		**Kôkô/Trade**	**Microbiological standards**	
TMAF	Charge UFC/mL	$3.43x10^5 \pm 0.22$	10^4	10^5
	Quality	UMQ		
Yeasts and molds	Charge UFC/mL	$2.41x10^4 \pm 0.13$	10^3	10^4
	Quality	UMQ		
Total coliforms	Charge UFC/mL	$4.08x10^4 \pm 0.48$	10^3	10^4
	Quality	UMQ		
Escherichia coli	Charge UFC/mL	$3.91x10^3 \pm 0.09$	1	10
	Quality	UMQ		
Staphylococcus sp.	Charge UFC/mL	$5.34x10^4 \pm 0.10$	10	10^2
	Quality	UMQ		
Salmonella sp.	Absent in 25 mL	Present	Absent in 25 mL	
	Quality	UMQ		

Table 7 : Contamination level of Focolari flour

	Flour samples taken at CMS Focolari (n=5 per type of flour)					
Germs studied		**FM5B**	**FMS**	**FMSC**	**Microbiological standards**	
TMAF	Charge UFC/mL	$1.90x10^4 \pm 0.13$	$7.83x10^4 \pm 0.38$	$1.79x10^5 \pm 1.24$	10^4	10^5
	Quality	AMQ	AMQ	UMQ		
Yeasts and molds	Charge UFC/mL	$9.09x10^2 \pm 0.59$	$1.65x10^3 \pm 0.78$	$1.72x10^4 \pm 1.04$	10^3	10^4
	Quality	SMQ	SMQ	UMQ		
Total coliforms	Charge UFC/mL	$4.97x10^3 \pm 0.04$	$3.62x10^3 \pm 1.12$	$5.58x10^3 \pm 0.07$	10^3	10^4
	Quality	AMQ	AMQ	AMQ		
Escherichia coli	Charge UFC/mL	0	0	0	1	10
	Quality	SMQ	SMQ	SMQ		
Staphylococcus sp.	Charge UFC/mL	$1.42x10^2 \pm 0.31$	$1.04x10^2 \pm 0.14$	$2.82x10^3 \pm 0.59$	10	10^2
	Quality	UMQ	UMQ	UMQ		
Salmonella sp.	Absent in 25 mL	Absent	Absent	Absent	Absent in 25 mL	
	Quality	SMQ	SMQ	SMQ		

3.3 RESULTS OF PHYSICOCHEMICAL AND BIOCHEMICAL ANALYZES

3.3.1 MACRONUTRIENT CONTENT

The carbohydrate content of all the samples analyzed respects the recommended standard which is 68 g/100g Dry Weight (DW). Regarding the lipids content, all the flours from the Focolari medical-social center and flour of Kokobaka porridge (FKP) respect the standard set, unlike the flours for porridge of millet and Anagobaka which do not respect this standard with respective values averages of 7.80 ± 0.08 g/100g DW and 6.93 ± 0.09 g/100g DW which is below 8 g/100g DW. The moisture content of all the flours from the Focolari Center analyzed do not meet the set standard, which is the coating of the flours of millet porridge (8.74 ± 0.21 %), Kokobaka (6.55 ± 0.17 %) and Anagobaka (13.15 ± 0.5 0%), the norm being 5%. In terms of ash content, all the samples do not meet the standard set, such as the FM5B flour from Focolari, which has a value of 3.21 ± 0.24 % which is much higher than the 2.9 % standard (Table 8).

3.3.2 MICRONUTRIENT CONTENT

The phosphorus content of Focolari flours varies from 194.05 mg/100g DW (FM5B) to 503.45 mg/100g DW (FMS). Regarding porridge flour, this content is 178.93 mg/100g, 505.57 mg/100g and 271.77 mg/100g respectively for flour, millet porridge (FBM), Kokobaka (FKP) and Anagobaka (FAP). The potassium content of flours from Focolari ranges from 295.74 mg/100g DW (FMSC) to 605.80 mg/100g DW (FMS). Potassium content of porridge flours vary from 23.06 mg/100g DW to 49.23 mg/100g DW. The calcium contents vary from 192.71 mg/100g DW to 441.70 mg/100g DW and from 21.15 mg/100g DW to 35.52 mg/100g DW for the flours from the medical-social center and those from the porridges respectively. The iron content varies from 30.64 mg/100g DW to 52.04 mg/100g DW for the Focolari flours and from 48.24 mg/100g DW to 64.34 mg/100g DW for the vendors' porridge flours. The zinc contents varies from 1.76 mg/100g DW to 2.56 mg/100g DW for the Focolari flours and from 1.26 mg/100g DW to 2.92 mg/100g DW for the porridge flours. The copper content varies from 7.80 mg/100g DW to 13.43 mg/100g DW and from 0.38 mg/100g DW to 1.31 mg/100g DW respectively for Focolari flours and porridge flours. The results of micronutrient contents of the various flours analyzed show that, with the exception of iron and copper which comply with the standard, the mineral contents of the flours used as a complementary food are generally lower than the recommended standards (Table 9).

Table 8: Macronutrients and physico-chemical parameters

Macronutrients (g/100g DW) and physico-chemical parameters				
Samples	Carbohydrates	Lipids	Moisture (%)	Ash (%)
FMS	75.86 ± 0.06	8.10 ± 0.11	4.90 ± 0.08	1.22 ± 0.19
FMSC	70.17 ± 0.15	9.50 ± 0.50	4.86 ± 0.05	2.50 ± 0.09
FM5B	77.45 ± 0.11	10.40 ± 0.31	4.59 ± 0.15	3.21 ± 0.24
FMP	80.14 ± 0.31	7.80 ± 0.08	8.74 ± 0.21	1.75 ± 0.10
FKP	85.08 ± 0.17	8.04 ± 0.05	6.55 ± 0.17	1.05 ± 0.05
FAP	79.25 ± 0.12	6.93 ± 0.09	13.15 ± 0.50	1.50 ± 0.13
FAO/WHO (2006) Standard	68	8	5	2.9

FKP: Flour of Kokobaka porridge; FMP: Flour of Millet porridge; FAP: Flour of Anagobaka porridge; FMS: Infant maize and soy flour; FMSC: Flour made from maize, sesame and cocoa; FM5B: Infant flour made from maize, sesame, soy, millet, rice, cocoa and banana.

Table 9: Micronutrients of the samples studied

Micronutrients in flours (mg/100g DW)						
Samples	P	K	Ca	Fe	Zn	Cu
FMS	503.45 ± 0.01	305.8 ± 0.01	192.91 ± 0.01	52.04 ± 0.03	2.56 ± 0.02	13.43 ± 0.01
FMSC	333.08 ± 0.02	295.74 ± 0.01	323.61 ± 0.01	30.64 ± 0.01	2.2 ± 0.01	9.3 ± 0.01
FM5B	505.57 ± 0.01	413.14 ± 0.01	441.7 ± 0.01	35.02 ± 0.01	1.76 ± 0.02	7.8 ± 0.02
FBM	178.93 ± 0.01	49.23 ± 0.01	35.52 ± 0.04	64.34 ± 0.02	2.92 ± 0.01	1.32 ± 0.01
FBK	194.07 ± 0.01	34.86 ± 0.02	21.15 ± 0.02	63.56 ± 0.01	1.26 ± 0.02	1.31 ± 0.01
FBA	271.77 ± 0.01	23.06 ± 0.01	30.01 ± 0.01	48.24 ± 0.01	2.6 ± 0.01	0.38 ± 0.02
FAO/WHO (2006) Standard	281.2	408.7	341.2	8.5	3.7	0.1

FKP: Flour of Kokobaka porridge; FMP: Flour of Millet porridge; FAP: Flour of Anagobaka porridge; FMS: Infant maize and soy flour; FMSC: Flour made from maize, sesame and cocoa; FM5B: Infant flour made from maize, sesame, soy, millet, rice, cocoa and banana.

4 DISCUSSION

At the end of the results of the survey carried out among mothers and vendors, it appears that 80 % of mothers do not know the concept of complementary food. Indeed, more than half of these mothers (62.5 %) self-advise on complementary food against only 12.9 % of them who have recourse to a health agent. The role of the health worker is indeed to explain the importance of the complementary food and therefore to provide some nutritional education to nursing mothers. These results coincide with those of Azagoh *et al.* [16] who found similar results where 74 % of mothers were unaware of the notion of complementary feeding during their study on the knowledge and practices of mothers of children aged 6 to 18 months relating to weaning. However, these results differ from those of Diallo [17] who worked on knowledge of mothers' attitudes and practices on the feeding of children from 0 to 23 months in the health district of Niafunké in Mali.

Commented [AN3]: Differ in terms of what? Please explain

In addition, the food most given to children is Anagobaka porridge (32.2 %), followed by millet porridge (24.4 %). In general, the most used complementary foods are foods based on cereals and legumes. This assertion is supported by Koné *et al.* [6] who worked on the formulation and physicochemical characterization of infant flour composed of: dehydrated attiéké-cashew kernel. Similarly, Mühlemann [9] confirmed the use of porridges made from cereals, tubers and roots during his study on complementary feeding of children during their first two years of life.

In addition, the sellers have no knowledge of the proportion of the components and the nutritional intake of the complementary food they sell. This observation is the same at the level of the Focolari medico-social center, where the flour samples are collected. This is dangerous for consumers as fragile and vulnerable as children aged between 6 and 24 months. Aissi *et al.* [18] found this same fact in their study. This is why the Codex Alimentarius requires disclosure of food content in food labeling [19].

These complementary foods are introduced into the life of the child according to the appreciation of the mother. Indeed, 61.1 % said they had given the child the complementary food before the age of six (06) months. Against only 27.8 % of mothers who claim to start this diet from six (06) months. These results are not consistent with those promoted by the WHO [5] which recommends that complementary foods should only be introduced into the diet of young children from the age of six months. The ignorance of the notion of complementary feeding, the advisers (the mothers themselves) could justify this situation. The work carried out by Azagoh *et al.* [16] had already mentioned that the majority of mothers did not respect the WHO recommendations concerning the start of the introduction of complementary foods in children under 24 months.

A proportion of 39.5 % of mothers buy the locally produced complementary food at the market or supermarket. While 27.6 % of mothers conceive these foods themselves at home for their child, 17.8 % claim to buy these foods in the neighborhood and 11.8 % in a health center. This low proportion of purchases in health centers translates into the fact that mothers do not take their child's feeding advice from health workers [17].

In terms of hygiene, 54.8 % of vendors operate in an inappropriate environment and place of sale. On the other hand, 41.9 % of those sell in an acceptable sanitary environment. In addition, their observed level of education is low. Indeed, 38.7 % of these women have reached the level of primary education against 32.3 % of them who have not been to school. According to Azagoh *et al.* [17], the level of education has a correlation with the knowledge and practice of hygiene.

The microbiological criteria of millet porridges, Kokobaka, Anagobaka and flours (FMS, FM5B and FMSC), have a more or less high presence of spoilage germs as well as the absence or presence of pathogenic germs which are respectively responsible for food poisoning and impairment of commercial and hygienic quality. The results of the microbiological analyzes indicate a high level of contamination of the porridges and supplementary flours. The samples of millet porridge in the 3 sectors sampled show an acceptable microbiological quality for the research of the total aerobic mesophilic flora (TMAF). This flora is an indicator of the general level of hygiene of a product, it provides information on factors such as the environment, cross-contamination during handling, the environment, packaging and storage of the product [20]. These germs do not have a major impact on the health of the consumer, however, they cause significant economic losses due to the alteration of products. In terms of porridge, the results obtained differ from that of Dossa [20] who found a low presence of total flora in his sample of millet porridge ($1.6x10^3$ CFU/mL). The flour results are similar to that of Sanou *et al.* [21] who worked on the nutritional and microbiological quality of infant flours from four production units in Ouagadougou.

The results concerning the presence of coliforms in the porridge of this present study are similar to those of Noutais [22] who found the presence of coliforms in a sample ($22x10^3$ CFU/mL) of his study on the evaluation of the microbiological quality of two types of fermented sorghum-based porridges. The presence of total coliforms could be translated by faecal contamination during the production process, attributable to the lack of hygiene of the saleswomen. The acceptability shows that a certain vigilance is observed during the production of porridge and flour produced by some vendors and producers.

According to Houssou et al. [23], milling would be a critical step, it depends on the sunshine and the level of sanitation of the places and influences the microbiological quality of the flours.

Staphylococcus sp. is present in all the samples with an unsatisfactory microbiological quality. The results obtained could be explained by handling during the sale and the absence of wearing professional sales clothing. The presence of these germs could be due to a lack of hygiene (direct contact of the saleswomen with the product) during production and marketing, *staphylococcus sp.* is a vector of oral and cutaneous contamination. These bacteria are the cause of food poisoning, despite being part of the commensal flora of humans. The results obtained are similar to those of N'Goran-Aw et al. [8] and Nouais [22].

Escherichia coli and *Salmonella sp.* were absent in all the samples of millet porridge, Kokobaka and infant flours (FMS, FM5B and FMSC) unlike the Anagobaka porridge which revealed an unsatisfactory microbiological quality for *E. coli* and the presence of *Salmonella*. These porridges therefore demonstrate satisfactory microbiological quality. *Escherichia coli* is called "faecal contamination control" germ, it indicates that there is dirty handling and is characteristic of contamination from faeces. *Salmonella sp*. is itself a pathogenic germ, its presence concludes that the product is dangerous for consumption and would be due to poor processing conditions (contaminated environment or insufficient cooking) [24]. These results differ from those of N'Goran-Aw *et al*. [8] and agrees with that of Sanou *et al*. [21].

Concerning the macronutrient contents and the physicochemical parameters, the total carbohydrate content of all the flours analyzed is very high and does not respect the standard set (68 g/100 g DW) by FAO/WHO [4]. These results are similar to those of Sanou *et al.* [21] and Kpan *et al.* [10]. The lipid content of all the samples practically meets the standard set by FAO/WHO [4] except that of the Anagobaka porridge flours. The lipids content of this flour is certainly lower than the norm but differs from that obtained by Anigo *et al.* [25] in their work on complementary food gruels formulated from malted cereals, soybeans and groundnut in North-western Nigeria. Lipids play an important role in satiety and weight gain. A food low in fat and energy promotes weight loss [25]. The moisture content of all flours is lower than the norm except those of millet porridge (8.74 %), Kokobaka porridge (6.55 %) and Anagobaka porridge (13.15 %). The high flour moisture content of the Anagobaka porridge far above the recommended standard could be due to the long soaking time of the maize kernels and less drying of the flour. The low moisture content of flours increases their shelf life and, from a microbiological point of view, limits the development of microorganisms, with the exception of molds [4].

In terms of the micronutrient contents of the flours analyzed, the phosphorus contents of all the flours of the Focolari medical-social center are higher than the recommended standard, unlike the flours of the porridge where the phosphorus contents are below the standard prescribed by FAO/ WHO [4]. These results differ from those of Kpan *et al*. [10] who worked on the nutritional quality of Anagobaka weaning flours marketed in the markets of four municipalities in the district of Abidjan, for Focolare flours and are identical for porridge flours. The potassium and calcium contents of all the flours analyzed do not meet the recommended standard except infant flour made from maize, sesame, oy, millet, rice, cocoa and banana (FM5B). This result could be due to the diversity of raw materials used in the formulation of this flour unlike other flours. The work carried out by Kpan *et al.* [10] presented potassium and calcium levels below the norm in their study. Potassium is necessary for the regulation of cell water balance, the utilization of carbohydrates and the construction of proteins. Calcium is the mineral par excellence because it ensures the rigidity of the bones and promotes the growth of children [26]. The iron and copper contents of all the types of flour analyzed meet the set standard. These results differ from those of Badham *et al*. [27] (for iron) and are identical to those of Kpan *et al.* [10] (for copper). Iron is involved in the constitution of enzymes and the transport of oxygen. An iron deficiency causes a decrease in physical abilities and a drop in resistance to infections. The most vulnerable people are women and children under two [27]. The zinc content of all types of flour analyzed is below the set standard. Zinc deficiency is one of the main causes of stunted growth in children.

5 CONCLUSION

This study revealed that complementary feeding for children (6-24 months) is unknown by the population of Man, specifically mothers. These nursing women give food other than their breast milk to their child before the age of six (06) months. The locally produced complementary food given the most to children is Anagobaka porridge, followed by that of millet, porridge made from flour from the Focolari medical-social center and Kokobaka porridge. Regarding marketing, the places of supply par excellence of complementary foods produced in the said city are markets and neighborhoods. Porridge sellers market these foods in an unsanitary environment. Also, they do not know the proportion of the components and the nutritional content of the complementary foods they sell.

The microbiological analysis of locally produced food supplements (Man) revealed a potential contamination of these by various spoilage germs and pathogens. This contamination is linked to the poor hygienic conditions of the environment and

the place of sale of complementary foods. The contamination rate of Anagobaka porridge is very worrying especially with the presence of Salmonella and the high rate of Escherichia coli, staphylococcus sp unlike other porridges and flours.

The study of the chemical composition of the flours revealed that their carbohydrate, iron and copper contents are high, unlike their lipid and other micronutrient contents and their moisture and ash content, which are generally relatively low compared to to set standards. However, it is important to specify that the flour (FM5B) from the Focolari centre, made up of a variety of raw materials, meets all the standards (except for the zinc content). The results of this study have shed light on the existence of a potential health risk and possible nutritional deficiencies in infants and young children who consume these locally produced complementary foods.

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