Sensorial and Microbiologicical Characteristics of Some Infant Flours Produced in The City of Bongor, Province of Mayo-Kebbi East, Chad

**ABSTTRACT**

The objective of the study was to produce an infantile flour of supplement with local ingredients available in the city of Bongor for children from 6 to 24 months old. The flours formulated are named SHAB (70% sorghum+13% bean+16% peanut+1% baobab), SHAM (70% sorghum+13% bean+16% peanut+1%*Moringa Oleifera*) and SHAP (63% sorghum+20% bean+16% peanut+1% potato). The microbiological analyzes were carried out according to the standard methods which were supplemented by a sensory evaluation were carried out. The flours made are called SHAB (sorghum + bean + peanut + baobab), SHAM (sorghum + bean + peanut + *Moringa oleifera*) and SHAP (sorgho + bean + peanut + potato). The study of the hygienic quality of flours have sometimes exceeded microbiological standards. The presence of microorganisms at 30 ° C and enterobacteria at 37 ° C in SHAB and SHAP flours and the presence of microorganisms at 30 ° C, enterobacteria at 37 ° C, *Escherichia coli* and Staphylococci in SHAM flour. These results show that it takes an improvement in hygienic practices. Overall, 45% of mothers prefer porridge based on SHAB flour on the organoleptic level such as taste, smell and appearance. All these results show that these porridge could be made available to local populations.

 **Keywords:** Infantile flours, supplement food, local ingredients of Bongor, child of 6 to 24 months, malnutrition.

**1.INTRODUCTION**

Malnutrition and micronutrient deficiencies, according to UNICEF ​​(2008), are very present in many developing countries (Grodji*et al*., 2019).This infantile malnutrition is characterized by an imbalance in protein, lipid, energetic and micronutrient intake. Inadequate food is a public health problem. In children from 06 to 24 months old, studies have shown that at times when nutritional needs exceed what they can obtain from breast milk or traditional family dishes, nutritional deficiencies are severe (Brown & Luther, 2000). In Africa, many scientific studies aimed at implementing of fortified infant flours have been carried out to facilitate access to certain nutrients (Angèle *et al*., 2015; Zannou*et al*., 2011). In the context of the Sahelian countries, access in sufficient quantity and at a reasonable price or certain food groups such as fruits and vegeAnexAyurs and products of animal origins, crucial to ensure adequate intake of essential nutrients, is low, particularly in the most arid rural areas. In general, it is obvious that children living in rural areas are more at risk than children living in urban areas (Ins & ICF, 2012). In Chad, industrial supplement foods for children sold in markets and large shops are inaccessible to a large part of the population, for lack of very high prices (Vitafort 750F) (Leyvraz*et al*., 2017).In general, our dear country Chad is faced with questions of food insecurity. A precarious situation such as the low access of populations to health care as well as certain unsuitable practices in question of feeding infants and young children is added to the issue of food insecurity (OCHA, 2017). These malnutrition factors promote the degradation of the nutritional situation of vulnerable strata (from children from zero to two years) (OCHA, 2017). It becomes a crucial problem in Chad. According to MICS 2000 and 2010 data, the weight insufficiency increases from 28 to 30%, chronic malnutrition 28 to 39%and that acute from 14.6 to 16%. In 2021, growth retardation (chronic malnutrition) affected 30.4% of children 6 to 59 months. Emaciation (acute malnutrition) affects 10.9% and 12% of children suffer from weight insufficiency (severe malnutrition) (OCHA, 2021). The province of Mayo-Kebbi is like the other provinces of Chad is not spared from the question of the nutritional crisis. A SMART nutritional survey of September 2017 indicated that the prevalence of acute malnutrition deteriorated on the national level with an emergency threshold of 2% for severe acute malnutrition. As a result, this province has reached a threshold around 3%, which proves a food deficiency (OCHA, 2017). Access to nutrients on the province's markets remains difficult to major part of the population, because of their rarity or their price (such as infantile flours or nutritional legs) (OCHA, 2018).For the entire province of Mayo-Kebbi is, a single infant flour called MANISA has been set up by a project, its access remains precarious to all strata of society and yet the need is felt everywhere (Kamdar, 2019). In view of the overwhelming situation, to combat infant malnutrition in the province of Mayo-Kebbi is we offer an investigation for the implementation of fortified infant flour for children based on local ingredients encountered in the markets of Bongor.

**2.METHODOLOGY**

**2.1. Food material**

The criteria that guided our choice of foodstuffs used in the formulation of local flours are: being well suited to the nutritional needs of young children; being locally produced and available all year round; being well accepted from a cultural point of view as a source of vitamin and minerals; moringa (vegetable) as a source of vitamins and minerals; white beans (legumes) as a source of vitamins and minerals and peanuts as a source of lipids and proteins. These ingredients were purchased from the Bongor market.

**2.2. Manufacturing processes for different flours**

**2.2.1. Sweet potato (*Ipomoea batatas*)**

Sweet potato tubers are washed in water, peeled and cut into small pieces then dried and ground using a wooden pestle and mortar to produce flour.

Grinding

Sweet potato

Washing

Peeling

Cutting into slices

Sun dring

Sifting

Washing

#

**Fig.1. Diagram for manufacture *Ipomoea batatas* flour**

**Source: (Kayalto, 2016) with slight modification**

**2.2.2. Moringa leaves**

-The leaves are washed by soaking them in a basin of clear water. All you have to do is put them in the water and take them out immediately, then shake gently to remove the excess water.

-The powder is sifted to remove all stems and twigs.

-The leaves are pulverized using a wooden mortar and pestle. The leaves are dried in the shade in a well-ventilated room.

Moringa leaves

Washing

Drying in the shade

Grinding

Sifting

**Fig.2. *Moringa oleifera* powder manufacture diagram**

**Source: (Kayalto, 2016) with slight modification**

**2.2.3. Peanut (*Arachis hypogaea*)**

- Sorting: the shelled and winnowed seeds are carefully sorted. Sorting is done manually and consists of eliminating bad seeds;

- Roasting the seeds in a pan and over low heat to significantly reduce humidity and viscosity, destroy bacteria and insects and allow the development of a particularly appreciated taste ;

- Cooling: the roasted seeds are spread out in the shade on a clean, dry place to cool them;

- Dehulling: the roasted and cooled seeds are removed from their husks using a board;

- Grinding in a very clean VICTORIA brand disc mill ;

- Winnowing: it consists of removing the hulls from the peeled seeds.

Peanut

Sorting

Roasting

Dehulling

Grinding

Winnowing

**Fig.3. *Arachis hypogaea* paste manufacture diagram**

**Source: (Kayalto, 2016) with slight modification**

**2.2.4.White bean (*Phaseolus vulgaris*)**

-Sorting: is necessary to avoid incorporating damaged products or impurities;

-Dehulling: preliminary step to dehulling is soaking which facilitates removal of the husk. Grains that have been soaked in water for a certain time shell more easily because the husk, absorbing more water, comes off more easily;

-Drying: the hulled seeds are dried in the sun;

-Roasting: the beans are roasted in a pan over low heat;

-Grinding: the bean grains are ground in a wood mortar using a pestle;

-Sifting: the powder is sifted to recover large pieces.

White Bean

Sorting

Soaking, Dehulling

Drying

Grinding

Sifting

Roasting

**Fig.4. *Phaseolus vulgaris* flour manufacture diagram**

**Source: (Kayalto, 2016) with slight modification**

**2.2.5. Red sorghum (*Sorghum bicolor*)**

- Cleaning: it consists of eliminating impurities, straw, foreign cereals, immature grains by sieving, and having a homogeneous raw material. The seeds are then washed and dried in the sun ;

- Roasting: the beans are roasted in a pan over low heat.;

- Grinding is done using a hammer mill. This operation consists of pulverizing the grain against the wall of the grinding chamber in order to obtain a very fine flour ;

- Sieving consists of removing indigestible fibers using a small mesh sieve (0.5mm).

Sorghum bicolor

Cleaning

Grinding

Roasting

Sifting

**Fig.5. Sorghum bicolor flour manufacture diagram**

**Source: (Kayalto, 2016) with slight modification**

**2.2.6. Baobab pulp (*Adansonia digitata*)**

The extraction of baobab pulp from baobab fruits is as follows: the capsules are crushed to release the seeds coated in pulp. These latter (seeds + pulp) are then dried and then pounded. After extracting the pulp, the pounded product is sieved and the pulp is separated from the seed.

Baobab fruits

Crushing

Drying

Pounding

Sifting

Baobab pulp

**Fig.6. Diagram of preparation of *Adansonia digitata* pulp**

**Source: (Kayalto, 2016) with slight modification**

**2.3.8. Formulation of flours**

Three flours were formulated taking into account the physicochemical composition of each ingredient obtained and the recommendations of the Codex Alimentarius Commission [5]. The formulated SHAB flour (red sorghum, white bean, peanut and baobab) is obtained from an incorporation rate of 70% of red sorghum, 13% white beans, 16% peanuts and 1% Baobab pulp. SHAM flour (red sorghum, bean, peanut and moringa) is obtained from 70% red sorghum, 13% white bean, 16% peanut and 1% moringa and SHAP flour (red sorghum, white bean). , Peanut and Sweet Potato) obtained from 63% red sorghum, 20% bean, 16% peanut and 1% sweet potato [15].

Blend

Pulp Baobab

Crushing

Drying

Pounding

Sieving

Weighing

White bean

Sorting

Soaking

Dehulling

Winnowing

Drying

Weighing (13%)

Roasting

Milling

Sieving

*Arachis*

*Hypogea*

Sorting

Roasting

Dehulling

Winnowing

Weighing (16%)

Milling

Red Sorghum

Sorting

Washing

Drying

Weighing (70%)

Roasting

Mouture

Sieving

**Fig.7. SHAB flour manufacture diagram**

**Source: (Nadia *et al*., 2017) with slight modification**

Blend

Washing

Drying in the shade

Winnowing (1%)

Grinding

Sieving

Moringa leaves

Sorting

Washing

Drying

Weighing (70%)

Roasting

Milling

Sieving

Red Sorghum

Sorting

Roasting

Dehulling

Winnowing

Weighing (16%)

Milling

Arachis

Sorting

Soaking

Dehulling

Winnowing

Drying

Weighing (13%)

Roasting

Milling

Sieving

White Bean

**Fig.8. SHAM flour manufacture diagram**

**Source: (Nadia *et al*., 2017) with slight modification**

Blend

Sorting

Roasting

Dehulling

Winnowinggg

Weighing (16%)

Milling

Arachis

Sorting

Washingg

Drying

Weighing (63%)

Roasting

Mouture

Sieving

Red Sorghum

Sorting

Soaking

Dehulling

Winnowing

Drying

Weighing (13%)

Roasting

Milling

Sieving

White Bean

Washing

Peeling

Washing

Slicing

Dring

*Ipomoea batatas*

Weighing (1%)

Milling

Sieving

**Fig.9. SHAP flour manufacture diagram**

**Source: (Nadia *et al*., 2017) with slight modification**

**2.3. Microbiological analyzes**

Microbiological analyzes are based on surface enumeration techniques according to the French standard (ISO 17025) to search for the following different germs: microorganisms at 30 ° C, enterobacteria, *Escherichia coli*, salmonella spp, yeasts, molds, Staphylococci and *Bacillus cereus*.

**Preparation of the mother solution and the dilutions**

26g of each flour were weighed to which 234 ml of self -sausage papped water was added. The mixture was homogenized at the stomacher for 2 min to obtain themother solution. The supernatant was recovered in the bottle. The successive dilutions were obtained by sampling from the sterilized pipette 1ml from the mother solution to which are added 9ml of NaCl.

**2.3.1.Enumeration of microorganisms at 30 ° C**

 The Flat Count agar (PCA) was used for the counting of microorganisms at 30 ° C according to the French standard ISO 4833-1 (2013). Four dilutions 10-1 to 10-4 were used. The incubation was made in the oven at 30 ° C for 72 hours. The 30 ° C microorganisms give the clear yellow colonies (AFNOR, 2009).

**2.3.2.Entrerobacteria counting**

The search for enterobacteria was made according to the French standard NF ISO 21528-2 (2017) on the purple Red Bile Lactose. Three dilutions10-1 to 10-3 were used and the incubation was made at 37 ° C for 24 hours. Enterobacteria appear pink (AFNOR, 2009).

**2.3.2.*Escherichia coli* enumeration**

The medium of enumeration used for Escherichia coli is the Tryptone Bile Glucuronidmanosis according to the French standard NF ISO 16649-2 (2001). Two 10-1 to 10-2 dilutions were used. The incubation was made at 44 ° C for 24 hours. *Escherichia coli* forms blue colonies (AFNOR, 2009).

**2.3.3.Enumeration of yeasts and mold**

The Sabouraud germs was used for the enumeration of yeasts and molds according to the French standard ISO 21527 (2008). The seeding was made on two dilutions 10-1 to 10-2 which were incubated at 25 ° C for 72 hours. The yeasts give white colonies and the molds of white filaments with black center (AFNOR, 2009).

**2.3.4.Enumeration of staphylococci**

The counting of staphylococci was made according to the French standard NF ISO 6888-1 (1999) /amd.2 (2018) on the Baird Parker environment. Two 10-1 to 10-2 dilutions were used. The incubation was made at 37 ° C for 24 hours. Staphylococci appear black (AFNOR, 2009).

**2.3.5.*Bacillus Cereus***

 The Mannitol Yolk Polymyxin was used for the enumeration of the Bacillus Cereus according to the French standard NF ISO 7932 (07-2005). The sowing was made on two dilutions 10-1 to 10-2 which were incubated at 30 ° C for 24 hours. The Bacillus Cereus form bulging colonies like the fish eye (AFNOR, 2009).

 **2.3.6.Enumeration of Salmonella SPP**

The search for salmonella spp was made according to the French standard NF ISO 6579 (2017) in four stages: -Pre -enrichment:

- The mothering prepared in pampton water was sown on the Muller Kaufmann medium Novobiocine and incubated at 37 ° C for 24 hours;

- Enrichment: it is carried out simultaneously on 2 environments. The pre-enrichie mother solution is sown on the RVS (Rappaport Vassiliadis) and Hektoën Enteric mid-37 ° C for 24 hours;

- Isolation: The separation of bacteria was made using selective selective environments Xylose Lysine Deoxycholate and hektoën. The incubation was made at 37 ° C for 24 hours. Colonies appear black;

- Identification: The APE20E gallery was used for the confirmation of the alleged colonies of Salmonella (AFNOR, 2009).

**2.3.7.Enumeration of microorganisms**

The count was carried out using a counter after the incubation time (AFNOR, 2009). The technique is based on the fact that each viable cell gives birth to a colony. The boxes containing between 15 and 300 colonies were considered. The calculation of the units forming colonies (UFC = n) by ML of inoculum was made according to the AFNOR standard (2009) by the following formula:

Ʃc

(n1+0,1n2xdxv)

 **N=**

N = number of UFC per ml of product

Ʃc = sums of characteristic colonies counted on the whole of two consecutive dilutions

V = volume of the inoculum applied to each box in ml (v = 0.1ml)

 n1 = number of boxes chosen and read at the first dilution

 n2 = number of boxes selected and read to the second dilution

d = rate of dilutions corresponding to the first dilution chosen \*less than 15 colonies

 n = mXd-1

 **2.3.8. Sensory Flour**

Sensory analysis is a tasting test organized with a group of mothers and children meeting a certain number of criteria. Three flour samples were distributed in 40 households (40 mothers and 40 children constituting sampling).The subject of study and the administration of boilers were explained to mothers. The mothers gave their appreciation in relation to the color, taste and texture of the porridge on a scale at 03 points (1 = hates, 2 = loves slightly and 3 = likes extremely) with the choice of a porridge as preference. The appreciation of children was evaluated by their facial expression to taking porridge on a 03-point scale compared to the smell and taste (Mouquet *et al.,* 1998).

**2.3.9.Statistical data analyzes**

The Microsoft Office Excel 2007 software was used for data entry, statistical analysis and construction of graphics and tables. SPSS 20.0 software has been used means sized comparison analysis through the descriptive analysis and the meaning of results was defined at 5 %.

**3.RESULTS AND DISCUSSION**

**3.1. Sensory evaluation of flours**

 The appreciation of the color and texture of the porridge by mothers is described in Table 1. The appreciation of taste as well as the preference of the porridge is described in Table 2 and the appreciation of the smell and taste by children is described in Table 3.

**Table 1. Appreciation of the color and texture of the porridge by mothers**

|  |  |  |
| --- | --- | --- |
| **Flours** | **Color** | **Texture** |
| Likes extremely (in number and in %) | Loves slightly (in number and in %) | Hate (in number and %)  | Likes extremely (in number and in %) | Loves slightly (in number and in %) | Hate (in number and %)  |
| SHAB | 40 or 100% | - | - | 40 or 100% | - | - |
| SHAM | 40 or 100% | - | - | 38 or 95% | 2 or 5% | - |
| SHAP | 40 or100% | - | - | 39 or 97.5% | 1 or 2.5% | - |

* Appreciation of color: all women have 100% liked the color of the porridge of our study.
* Appreciation of the texture: it is a question of appreciating the degree of finesse of the porridge by the mothers of children (say if after version and sieving the flour was fine).Moms liked extremely 100% the SHAB porridge because it has a fine appearance followed by the SHAP porridge which is extremely loved by 97.5% and 2.5% have.
* loved slightly because it has a less fine appearance and finally 95% of mothers have extremely Liked the SHAM porridge and 5% have loved slightly because it has a less fine appearance.

**Table 2. Taste appreciation as well as the preference of porridge by mothers**

|  |  |  |
| --- | --- | --- |
| **Flours** | **Taste** | **Preference** |
| Likes extremely (in %) | Loves slightly (in %) | Hate (in %)  |
| SHAB | 100% | - | - | 18 or 45% |
| SHAM | 100% | - | - |  8 or 20% |
| SHAP | 100% | - | - | 14 or35% |

- Assessment of taste: 100% mothers like the taste of the three porridges.

- Preference: SHAB porridge is the most preferred by mothers because of the presence of the Baobab pulp which made the porridge tangy and then sweet porridge because they say that this porridge is a bit Sweet then the SHAP porridge because they say that this porridge is a little sweet, however the sham porridge is less preferred because this porridge is a bit sticky. 45% of mothers preferred the SHAB porridge by what it has a good color, A good taste and a good texture. SHAB flour is preferred at 35% and 20% SHAM flour by mothers by what they have a good color, a less fine texture and good taste.

**Table 3. Appreciation of the smell and taste of porridge by children**

|  |  |  |
| --- | --- | --- |
| **Flours** | **Smell** | **Taste** |
| Likes extremely (in number and in %) | Loves slightly (in number and in %) | Hate (in number and %)  | Likes extremely (in number and in %) | Loves slightly (in number and in %) | Hate (in number and %)  |
| SHAB | 40 or 100% | - | - | 40 or 100% | - | - |
| SHAM | 40 or 100% | - | - | 22 or 55% | 12 or 30% | 6 or 15% |
| SHAP | 40 or 100% | - | - | 39 or 97.5% | - | 1 or 2.5% |

* Finding the smell: the smell of the three porridges pleases children 100%. Taste appreciation: 100% children like the taste of SHAB porridge followed by SHAP porridge (97.5%). Children seem to love Sham porridge less (55%). SHAB porridge is 100% loved because it has a slightly sweet and tangy taste follows SHAP porridge which is loved at 97.5% because it has a slightly sweet taste and Sham porridge is less loved 57% by what 'She has a bland taste.

# 3.2. Evaluation of the hygienic quality of the elaborate flours

Microbiological analysis is described in Table 4.

**Table 4. Microbiological results**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Landed microorganisms** | **SHAB** | **SHAM** | **SHAP** | **Microbiological criteria in UFC/G (DSA)** | **Conclusion** |
| Microorganisms at 30°C | 5.103 | 6.105 | 6.103 | ≤ 103 | (SHAB, SHAM and SHAP) **NS** |
| Enterobacteria at 37°C  | Mo est présent mais <40 | 3.103 | 4,2.102 | Absence in 10g | (SHAB, SHAM and SHAP) **NS** |
| *Escherichia coli B-glucuronidase positive* | <10 | Mo est présent mais< 40 | <10 | Absence in 10g | (SHAB and SHAP): **S**SHAM: **NS** |
| Staphylococci at Coagulase+(37 ° C) | <102 | 3.103 | <102 | ≤102 | (SHAB and SHAP): SSHAM: **NS** |
| *Bacillus cereus* | <102 | <102 | <102 | ≤102 | (SHAB, SHAM and SHAP) **S** |
| Molds and moistures | <102 | <102 | <102 | ≤103 | (SHAB, SHAM and SHAP) **S** |
| *Salmonella spp* | Absence | Absence | Absence | Absence in 25g | (SHAB, SHAM and SHAP) **S** |

**UFC/G: Unit forming colonies by Food, DSA: Division Security Minister of Health. Grand Duchy of Luxembourg, 2016, NS: Not Satisfactory, S: Satisfactory**

Microbiological analyzes show that in our flours the values ​​obtained for microorganisms at 30 ° C including 5x103 UFC/G for SHAB, 6x105 UFC/G flour for SHAM and 6x103UFC/g flour for SHAP flour and enterobacteria including <40Uufc/g for SHAB flour, 3x103 UFC/G for sham flour and 4.2x102 UFC/G for SHAP flour are superior to DSA standards (microorganisms: ≤103 and enterobacteria: absence in 10g). A presence with abnormal proportions of *Escherichia coli* and staphylococci with coagulase +(37 ° C) whose values ​​are respectively 3x103 and <40 is noted in SHAM flour. These high results of microorganisms can be explained by a bad hygiene rule during the peeling and seed milling and exposure to the air of the ingredients during drying (Abdoullahi *et al*., 2016). We have also noted the presence of *Escherichia coli* (<10UFC/g), staphylococci to coagulase+(37° C) (<102 UFC/G), *Bacillus cereus* (<102 UFC/G), and yeasts and molds (<102 UFC /g) in SHAB and SHAP flours but their values ​​are lower than the standard. We also note the presence of *Bacillus Cereus* (102) and Break and mold (102) in SHAM flour which is lower than the standard. The three flours are free from Salmonella SPP (absence). Their absence is due to good respect for good hygiene practices during the infant flour manufacturing process. The presence of microorganisms (5.102 to 6.105 UFC/G) in our flours is greater than that found by Boureima Kagambega et al. (2019) in Burkina Faso (10UFC/g). On the other hand, the coliforms found in these flours (5, 5.102UFC/g) are higher than those found in our flours (40 to 4.2.102 UFC/G). The loads of yeasts and molds (102UFC/G) are lower than the fact reported in a study carried out in Madagascar by Razafindrazaka (2006) which brought in a variation in yeasts and molds 102 to 7.105 UFC/G. The absence of colonies of *Salmonella* SPP in our flours is similar to that reported by Sika et al. (2019) in Côte d'Ivoire. There is the presence of *Escherichia coli* in one of our flours, especially in SHAM flour (˂40) when we do not find it in the flours studied by Sika et al. (2019).

**CONCLUSION**

The study of the sensory and hygienic quality of infant flours in the city of Bongor presented several significant results. The sensory results were generally appreciated by mothers. The results on hygienic quality have sometimes exceeded microbiological standards in this case microorganisms at 30 ° C, enterobacteria at 37 ° C in SHAB and SHAP, *Escherichia coli* and staphylococcus flour in SHAM flour. Improvement of hygienic practices is necessary for improving the hygienic quality of the flours made.

**Disclaimer (Artificial intelligence)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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