Article

PAMJ One Health

Research

Management of infant flour production in the city of Ouagadougou: a survey study

Léa Kilô Adam Bayala-Yaï, Philippe Augustin Nikièma, Windpanga Aristide Ouédraogo, Ibrahim Dembélé, Zalissa Nébié, Jacques Simpore

Corresponding author: Laboratoire de Biologie Moléculaire et de Génétique, Université Joseph Ki-Zerbo, Ouagadougou, Burkina Faso. leayaiadam@gmail.com

Received: 23 Mar 2024 - **Accepted:** 13 May 2024 - **Published:** 24 Jun 2024

Keywords: infant flour, production process, Burkina Faso

Cite this article: Léa Kilô Adam Bayala-Yaï et al. Management of infant flour production in the city of Ouagadougou: a survey study. PAMJ - One Health. 2024;14(8). 10.11604/pamj-oh.2024.14.8.43373

Available online at: https://www.one-health.panafrican-med-journal.com/content/article/14/8/full

Management of infant flour production in the city of Ouagadougou: a survey study

Léa Kilô Adam Bayala-Yaï[1,&], Philippe Augustin Nikièma[1,2], Windpanga Aristide Ouédraogo[3], Ibrahim Dembélé[1], Zalissa Nébié[1], Jacques Simpore[1]

[1]Laboratoire de Biologie Moléculaire et de Génétique, Université Joseph Ki-Zerbo, Ouagadougou, Burkina Faso, [2]Laboratoire de Biologie Moléculaire, d'Epidémiologie et Surveillance des Agents Transmissibles par les Aliments, Université Joseph Ki-Zerbo, Ouagadougou, Burkina Faso, [3]Laboratoire de population du Centre de Recherche en Santé de Nouna, Institut National de Santé Publique, BP 02 Nouna, rue Namory Keita, Kossi, Burkina Faso

[&]Corresponding author

Léa Kilô Adam Bayala-Yaï, Laboratoire de Biologie Moléculaire et de Génétique, Université Joseph Ki-Zerbo, Ouagadougou, Burkina Faso

PAMJ One Health

Abstract

Introduction: *in Burkina Faso, infant flour produced are for wean-age and malnourished children. Former studies have pointed out the nutritional and sanitary quality of infant flour produced at national level. This cross-sectional study aimed to investigate the management conditions of infant flour produced in Ouagadougou.* ***Methods:*** *a survey was conducted among 11 production units to identify the raw materials used, the production processes of infant flour, the methods of conservation, the types of flour produced as well as their packaging.* ***Results:*** *the results showed that 45.45% of the production units surveyed were of the semi-industrial type while 54.54% were from artisanal and Recovery and Nutritional Education Centres (CRENs) factories. The main cereals used were millet (40%), sorghum (25%) and maize (22%). As for legumes, peanuts and soybeans were most used at 35% and 31% respectively. Infant flour producers had storage warehouses (85.71%) and 66% used storage pesticides. The flours produced for children of wean-age represented 37.14% while 62.86% were for nutritional recovery. The conservation of infant flour was made in an airy condition (94.29%), dry area/environment (88.57%) and in the presence of light (91.43%).* ***Conclusion:*** *the results showed that efforts should be taken to further improve the nutritional and sanitary quality of the infant flour produced.*

Introduction

Infant flour produced in developed countries are generally contaminated by biological, chemical and physical contaminants such as mycotoxins [1], bacteria, yeasts and various substances. In most West African countries, almost half of cereal intended for the production of infant flour has an aflatoxin content higher than international standards [2]. In Burkina Faso, several cases of contamination by both bacteriological germs and mycotoxins from infant flour have been reported [1,3-5]. In addition, the use of poor-quality infant flour packaging does not allow a good conservation. These contaminants and bad practices affect the quality of infant flour and present a health risk to infants and young children who are the main consumers and vulnerable groups. Several studies on food safety have revealed that mycotoxins are of a global public health concern [2].

Infant flour is a complementary food given to infants and young children in the form of porridge from the age of 6 months [6]. They are specially designed to cover the nutritional needs of infants and young children because after 6 months, breast milk is no longer sufficient to provide the nutritional needs of infants in energy and protein [7]. Inadequate nutrition during the weaning period could have irreversible consequences on the child's growth, cognitive development, morbidity, and mortality throughout life and thereby, compromise individual productivity and affect the economic development of the country [8]. Cereal-based porridge is traditionally used in Burkina Faso as complementary food at the time of dietary diversification, and is at present the main commercial complementary food produced locally; the rest of the production (baby purees, lipid pastes, etc.) being extremely limited [9]. The poor management of the production of infant flour is a source of contamination by mycotoxins and other microorganisms that are the origin of many diseases including malnutrition and cancers, causing many deaths. According to Størmer [10], there is a link between mycotoxins, mortality and the decline in the birth rate. Mycotoxins are substances produced by a wide variety of molds growing on raw materials and derived products [11]. They are secondary metabolites produced by toxigenic fungi belonging to the genera *Aspergillus, Fusarium* and *Penicillium* [12].

In Burkina Faso, there are imported and nationally produced types of infant flour. In this study, we particularly focused on the different nationally produced types of infant flour. Infant flour is generally a mixture of cereals, legumes, oilseeds

and/or milk powder, minerals and vitamins, provided in the form of Mineral Vitamin Complexes (CMV). The objective of this study was to evaluate the management of infant flour production in the city of Ouagadougou (Burkina Faso) through a cross-sectional study taking into account the identification of raw materials used in the production of the flour, the conservation methods, the production processes and finally the quality of the types of infant flour produced and their packaging methods. To do this, a survey was conducted among 11 out of 25 production units in the city of Ouagadougou contacted and willing to partake in the study. The results of this survey will allow to assess the impact of the production conditions and processes on the sanitary and nutritional quality of local infant flour.

Methods

Study design

A cross-sectional study was conducted to investigate the management conditions of infant flour produced in Ouagadougou.

Sample collection sites and population

Investigations on the infant flour production units took place in the city of Ouagadougou, capital of Burkina Faso. Located in the centre of Burkina Faso, Ouagadougou has an estimated population of 2 854 356 in 2019 [9,13]. This was a cross-sectional study including infant flour production units (artisanal and semi-industrial) which gave their consent to participate. The artisanal units were mainly constituted of associations, women's groups and CRENs. Depending on the availability of the raw materials and infant flour in the production units, the different samples were collected from the production units or markets in the city (Figure 1). The samples were collected from July to September 2021. An electronic survey form has been designed. This involved collecting from each infant flour production unit the raw materials used, the sources of supply of these raw materials, the preservation methods used, the production, packaging and storage processes of infant flour. The production frequency, the type of flour produced, the targeted audience, the micronutrients used for the enrichment of infant flour, and the status of quality monitoring (physicochemical, microbiological and toxicological) have also been evaluated.

Raw materials and infant flours sample collection

Raw materials: the sampling of raw materials was carried out according the square root of the stock available in the stores. Among the production units, some have approved suppliers and those that obtained their supplies directly from the markets in the city of Ouagadougou. For units that have approved suppliers, the samples were collected within the production units. With regard to the units that obtained their supplies from the markets, we took samples directly from markets concerned.

Infant flour: infant flour samples were collected within the production units either free of charge or after payment. Thus, 500g of each sample were taken from the packaging used by each production unit. When infant formula was not available in the production units, they were bought at the supermarket level.

Variables

Variables included types of production units, raw materials used, storage conditions, infant flour production processes, types of infant flours produced, packaging and storage of infant flour, infant flour quality monitoring.

Data resource and measurement

Data collection tool: a structured questionnaire adapted, a GPS and bags.

Data collection: information provided by production units, raw materials, infant flour and GPS coordinates. The data collection teams collected used questionnaire designed in electronic format (SurveyCTO collect) to collect

data from production units through an interview. Data was downloaded from the tablets to the computer.

Sample size

Concerning raw materials, their number corresponds to the number of raw materials actually used by each production unit of the study. The number of infant flours collected depended on the number of infant flours produced by the production units. Finally, the number of production units included in the study corresponds to the number of production units having given their agreement to participate in the study. Thus, the number of raw materials was 39 and the number of production units was 11. In total, 26 infant flour samples have been collected among which 10 samples were intended for children of wean age and 16 for children in nutritional recovery. In addition, infant formula was either instant (11.54 %) or cooked (88.46 %).

Data analysis

The questionnaires used for the survey were developed with the ODK collection software version 4.2 and an electronic collection was carried out. Data cleaning was carried out using STATA 15 and Excel 2016 software. Summary descriptive statistics were necessary for the development of the various tabulations and graphs. Visual representations of the results were also provided in the form of graphs and tables. The GPS coordinates of the different sample collection sites (production units and markets) were collected for mapping. The different GPS points were mapped using ArcGIS 10.2 software.

Results

Infant flour production units in the city of Ouagadougou

The survey showed that infant flour production units were mainly artisanal (6 units) (associations, women's groups and CRENs) and semi-industrial (5 units). Among the production units surveyed, 45.45% were semi-industrial and 54.54% artisanal (Table 1).

Raw materials used for the production of infant flour in Ouagadougou

In total, 39 samples of raw materials intended for the production of infant flour have been collected in this study. It appears that the main raw materials used were cereals and legumes. These raw materials were used in combination. The most common combinations were mixtures of one or two cereals sources of carbohydrates, with one or more legumes and/or oilseeds sources of proteins and lipids. Figure 2A shows the different percentages of use of these raw materials. Regarding cereals, millet was widely used (40%) followed by sorghum (25%) and maize (22%). As for legumes, peanuts were widely used (34%), followed by soybeans (31%). The survey results indicated that monkey bread powder was used by 11% of the units because of its micronutrient content. Unlike other cereals, rice was less used by infant flour production units in Ouagadougou (17%) and wheat was not used at all (Figure 2A).

Storage conditions of raw materials

The survey revealed that 85.71% of infant flour producers in the city of Ouagadougou had storage warehouses for raw materials (Figure 2B). These stores were equipped with storage straws and ventilation systems. In addition, 66% of these producers used pesticides (rodenticides and insecticides) to treat stores before storage of raw materials and also insecticides during storage to prevent spoilage of grains by insects (Table 1). No further investigation has been conducted to identify the different pesticides used.

Infant flour production processes

The survey revealed that all the production units used cleaning, fermentation and grinding in their production processes of infant flour (Figure 3A). Cleaning is used to rid the raw materials of

impurities (damaged seeds, sand dust, etc.). In addition, the survey revealed that almost all infant flour production units in Ouagadougou practiced washing (97.14%), drying (97.14%), fermentation (100%) and roasting (88.57%) in their infant flour production processes. Washing rids the raw materials of certain particles and microparticles.

Infant flour produced by production units in Ouagadougou

Types of infant flours produced

Our study showed that 37.14% of infant flour production mainly produced flour intended for children of wean age and 62.86% produced flours intended for children in nutritional recovery situation (Table 1). These types of flours were either instant or for cooking. The survey showed that 80% of infant flour produced by units in Ouagadougou were fortified (Table 1). These flours were enriched with various elements and in various ways by infant flour production units. Almost all of the CREN production units did so with dry fish powder, soumbala, whole milk, groundnut cake and bean flour, which are mainly rich in protein. Some flours from these production units were enriched with monkey bread powder (which is very rich in micronutrients such as vitamins A, C, PP, Calcium, Zinc, etc. [14]) or by directly adding monkey powder, vitamins and minerals.

Packaging and storage of infant flour

The survey revealed that the infant flour produced by the production units in the city of Ouagadougou were packaged in different types of packaging. Thus, the use of metal boxes (45.71%) and simple plastic bags (40%) were more frequent. It should be noticed that these plastic bags were without any indication of the quality/specification of the sachets used. Cardboard packages combined with plastic bags were used by 11.43% of the units (Table 1). On the other hand, during the sampling of infant flour samples in the field, it was found that the packaging used was Polyethylene (PE) or Polypropylene (PP) plastic bags and cardboard boxes with no metal boxes. The flour, once packed, is then stored to be sold or distributed free of charge to children (case of certain CRENs). The majority of production units keep infant flours in a ventilated (94.29%), dry (88.57%) and light (91.43%) areas (Figure 3B).

Infant flour quality monitoring

The study showed that 77.14% of production units had quality monitoring structures for the infant flour produced and that the quality monitoring concerns the physicochemical, microbiological and toxicological parameters. The survey revealed that 80% of production units enriched their flours with micronutrients (Table 1). Also, it emerged that 17.14% of production units used vitamin A, iron and calcium (14.29%) and zinc and iodine (5.71%).

Discussion

Infant flour production units in the city of Ouagadougou

Semi-industrial units generally have mechanised production equipment, even if they may use manual processes for some steps. Manual transformations dominated in their manufacturing processes [9]. This study showed that more than half of the infant flour (65.38 %) were produced in an artisanal way in the city of Ouagadougou. Artisanal production provides access to infant flours at lower cost and helps to improve the problems of severe malnutrition that affect infants and young children in most developing countries [9]. The high cost of production equipment and the lack of means could explain the artisanal production of infant flours by production units in Ouagadougou, unlike in developed countries where they are produced industrially. This could explain the unavailability of infant flours on the local market, favouring the use of imported flour in the feeding and nutritional recovery of children. Furthermore, it should be noted that the lack of raw materials could also be a limiting factor for industrial production.

However, the nutritional and sanitary quality of the infant flour produced do not depend on the type of company or the level of production [9].

Raw materials used for the production of infant flour in Ouagadougou

The results of our study indicate that millet was widely used (40%) followed by sorghum (25%) and maize (22%). A former study conducted on infant flour sold in the city of Ouagadougou showed that cereal raw materials used in the production of these types of flour were mainly composed of maize (60%) followed by millet (30%). However, this study did not start from an investigation at the production unit level [3]. Cereals are sources of energy, dietary fibres and vitamin B [15]. The high use of millet could be explained by its richness in protein compared to sorghum and maize. Also, previous studies have shown that millet flour remains the most energetic cereal grown in Burkina Faso [16] but its availability and high cost could partly justify its association with other cereals, in particular sorghum and maize widely grown in Burkina Faso. For a good composition of infant flours, a mixture of cereals and legumes is needed [17]. Cereals are an important source of carbohydrates while legumes are an important source of proteins and lipids [18]. The combination of these two food groups constitutes the major components of infant flour which, enriched with micronutrients, contain all the nutrients necessary for good growth of infants and young children. Several studies have shown that monkey bread has a high content of micronutrients such as vitamin C, Zinc, Iron and Calcium [14]. In the present study, rice was less used and wheat was not used at all by infant flour production units in Ouagadougou (Figure 3). This could be explained by the fact that they are albeit grown and therefore of high cost. Legumes such as cowpea and Bambara groundnut (vouandzou) were very little or almost not at all used in the production of infant flour. This could be due to the presence of antinutritional factors such as phytates, polyphenols, terpenoids, steroids and alkaloids contents in these legumes. Some antinutrient factors, like phytates, limit protein bioavailability and some minerals like iron and zinc [19,20]. Many studies have reported that 95% of anaemia cases are associated to iron-poor diet [21,22]. The prevalence of anaemia among children at wean age could be explained by the high intake of antinutritional factors present in infant flour. Consumption of these legumes could cause flatulence in children [18].

Storage conditions of raw materials

The use of storage straws prevents the raw materials from being in direct contact with the ground, thus reducing their humidity level. Humidity is favourable to the development of fungi and moulds, sources of mycotoxin production [23]. Storage pesticides are used to prevent and/or eliminate insects and other rodents present in storage stores and responsible for the deterioration of seed quality. Damaged seeds have a negative impact on the nutritional quality of infant flour [24]. Otherwise, the abusive and unregulated use of pesticides in the management of raw materials used for the production of infant flour can be a long-term source of chronic diseases such as cancers in infants and young children [25,26]. It would therefore be wise to encourage the use of natural pesticides and insecticides for example for the treatment of raw materials and warehouses. Natural insecticides have the potential to improve crop protection [27,28].

Infant flour production processes

The cleaning of the raw materials leads to a significant reduction in the contamination of mycotoxins such as aflatoxins [24]. As for fermentation, it makes the flours produced much more digestible. It significantly reduces anti-nutritional factors [29]. The results indicate that 100% of production units used fermentation in their infant flour production processes. In fact, fermentation makes micronutrients as well as macronutrients much more bioavailable [17]. All of these processes improve the sanitary and

nutritional quality of infant flours. Washing rids the raw materials of certain particles and microparticles. As for drying and roasting, they reduce the moisture content in the infant flour produced and thus, limiting the contamination/production of mycotoxins. If roasting is not well controlled, it could lead to the destruction of many nutrients such as phenolic compounds [30]. A previous study conducted in Ouagadougou on infant formulas showed that maize and rice used for the production of infant flour were contaminated at 23.5% by AFB1 and 17.6% by total aflatoxins [1]. If the roasting of the raw materials carried out by the production units can modify the sensory profile of the flour produced and makes them more appetizing, it cannot, on the other hand, completely eliminate some mycotoxins. However, similar roasting conditions may allow their elimination but also compromise the sensory attributes of the flours produced [31]. Soaking facilitates peeling. Deshelling operation leads to a marked decrease in the insoluble fibre content of the infant flour produced [32]. The survey carried out showed that 45.71% of infant flour production units deshell raw materials. Reducing the fibre content by deshelling increases obtaining infant flour with a higher concentration of digestible elements [33]. The rigorous implementation in the production units of steps allowing a reduction of the microbial load such as shelling, washing followed by fermentation, drying and/or roasting, associated with the practice of walking forward to avoid cross-contamination guarantee adequate microbiological quality.

Infant flour produced by production units in Ouagadougou

Four types of infant flour production units, produced instant infant flour. Unlike infant flour for cooking, instant infant flours reduce meal preparation time which is an important factor in energy saving. On the other hand, they can be risky in places where potable water is not available and not boiled before consumption. Thus, porridge prepared under these conditions can cause various disorders (diarrhoea, stomach aches, vomiting, etc.) in children [34]. However, the use of infant flour for cooking limits these problems insofar the water boils for more than 5 minutes during preparation [9]. Ultimately, these aspects involving the health of children should not be neglected. The high number of enriched flours used for nutritional recovery that were produced by units could be explained by the strong demand for nutritional recovery flours at the national level given the large number of malnourished children in Burkina Faso [35]. In fact, flours enrichment increases the energy value of the infant flours necessary to improve the nutritional status of children in nutritional recovery situation [36]. About packaging and storage of infant flour, the discrepancy between the information given on the packaging during the survey and the findings in the field during sampling could be explained by the reluctance of certain infant flour producers to give all the information on their products in order to certainly avoid repression by State services and unfair competition, among other things. It should be noted that the use of plastic bags leads to problems during recycling. These plastic bags are made of a mixture of polymers and contain a range of components, such as paper, organic residues, metals (Ca, Al, Na, Zn and Fe), and halogens (Cl and F) which are present at concentrations between 1 and 3000 ppm [37]. Defective packaging can alter the quality of the finished product. It is therefore important to make the right choice. For longer storage, the thickness of these bags must be between 150 µm and 200 µm for PE and at least 100 µm for PP [29]. These "complex" sachets are rarely available in developing countries because they are much more expensive [9]. Cardboard boxes are not recommended in single packaging because they offer great permeability to water and air, but they can be used as an overpack of a sachet [9]. Metal boxes used by production units were many composed of aluminium. Aluminium is known to be toxic to the organism. Metal boxes used must be made of non-toxic substances and non-endocrine disruptors. The plastic bags used by the

production units (40%) are not referenced. The constituent elements of these plastic bags can migrate into infant flour during their storage, negatively impacting the health of the consumer. These plastic bags also cause environmental problems. A more ventilated, dried and lighted conditions are necessary for good conservation of infant flour [29]. Poor storage conditions negatively affect the health and nutritional quality of infant flour [29]. Relative Humidity, temperature and storage environment promote development of pathogenic germs and also rancidity of lipids.

Infant flour quality monitoring

Infant flour quality monitoring corroborate those of Olive *et al.* (2020) [9] according to which all producers of infant flour do not always carry out systematic quality controls. These quality control structures (generally laboratories) are responsible for checking the health and nutritional quality of the finished products. Infant flour must not contain pathogenic germs, toxins or toxic chemical residues likely to have repercussions on the health of infants and young children [38]. The germs most frequently sought during quality analysis in Burkina Faso are generally aerobic mesophilic bacteria, faecal coliforms, *Escherichia coli*, yeasts and moulds, and salmonella. In addition, good infant flour must also have a good nutritional value. Quality monitoring structures are responsible for checking the nutritional composition of the infant flour produced by these production units. Infant flour intended to supplement breastfeeding must provide 68% carbohydrates, 13% protein, 7% lipids and 400 Kcal per 100 g of flour [39]. Otherwise, low micronutrient intake leads to deficiencies in children [40]. The presence of vitamins (A, D, C, B12, K1, Thiamine, Folic acid…) and minerals (potassium, calcium, phosphorus, iron, iodine, zinc, chlorine…) are also essential for infants and young children. The micronutrient supplies to the body through the foods consumed does not fully cover their needs. It is therefore extremely difficult or almost impossible to achieve the micronutrient densities recommended for the body using only raw materials and without resorting to fortification [9].

Conclusion

Good management of the production of infant flour conditions their sanitary and nutritional quality. This survey aimed to determine the production management of infant flour through the determination of the raw materials most used in the production of these types of infant flour and the different methods of conservation of the raw materials and infant flour. It appears that more than half of infant flours were produced in an artisanal way in the city of Ouagadougou. The main raw materials used in the production of these types of infant flour were cereals and legumes. The vast majority of infant flour producers in the city of Ouagadougou had raw material storage warehouses equipped with storage straws and ventilation systems. These stores were mostly treated with insecticides which can be dangerous if they are misused or unsuitable. The infant flour production units in the city of Ouagadougou mainly produced flours, either instant or for cooking, intended for children in a situation of nutritional recovery. This study also revealed that the majority of production units had a quality monitoring structure for the infant flour produced. These structures are of great importance for production units because the quality of infant flour depends on the support that producers have received for the development of their products. The risk of contamination with mycotoxins and particularly aflatoxins deserve special attention. Indeed, studies on infant flour in Burkina Faso reported high levels of contamination which mainly concern peanuts and other raw materials such as maize, millet or sorghum. Investing in the management of the quality of raw materials throughout the sector will contribute to better control the risks observed in certain infant flour production units.

What is known about this topic

- *Infant flours are mainly produced artisanally in Burkina Faso;*
- *The raw materials used in the production of infant flours in Burkina Faso are mainly cereals and legumes based.*

What this study adds

- *A novel approach on the management of infant flour production in the city of Ouagadougou starting from the production units to the end products;*
- *The management of the production of infant flour in Burkina Faso for better health and nutritional quality.*

Competing interests

The authors declare no competing interests.

Authors' contributions

Conceptualization, data curation and writing: Léa Kilô Adam Bayala-Yaï and Philippe Augustin Nikièma; investigation: Léa Kilô Adam Bayala-Yaï, Philippe Augustin Nikièma, Ibrahim Dembélé and Zalissa Nébié. All authors have read and agreed to the published version of the manuscript.

Acknowledgments

We would particularly like to thank the managers of infant flour production units and the suppliers of raw materials in the city of Ouagadougou (Burkina Faso) who agreed to take part in these surveys. Moreover, this study was supported by the Molecular Biology and Genetics Laboratory (LABIOGENE), Department of Biochemistry-Microbiology, Joseph Ki-Zerbo University and by the National Research and Innovation Fund for Development (FONRID) through the call for special youth projects 2022 (N° FONRID/AAP-Spécial-Jeunes/NCP/PCD/2022).

Tables and figures

Table 1: distribution of production units and management methods for infant flours

Figure 1: infant flours and raw material samples collection sites

Figure 2: use of raw materials in the production of infant flour and raw material storage environments by production units

Figure 3: different infant flour production processes and storage conditions for infant flour

References

1. Ware LY, Durand N, Nikiema PA, Alter P, Fontana A, Montet D *et al*. Occurrence of mycotoxins in commercial infant formulas locally produced in Ouagadougou (Burkina Faso). Food Control. 2017;73: 518-523. **Google Scholar**
2. Dieme E, Fall R, Sarr I, Sarr F, Traore D, Seydi M. Contamination des céréales par l'aflatoxine en Afrique: revue des méthodes de lutte existantes. International Journal of Biological and Chemical Sciences. 2016;10: 5. **PubMed**| **Google Scholar**
3. Bougma S, Oboulbiga EB, Tarnagda B, Zongo O, Kaboré B, Ouedraogo HS *et al*. Evaluation de la qualité physico-chimique et microbiologique de quelques farines infantiles locales vendues à Ouagadougou, Burkina Faso. PAMJ One Health. 2022;9(NA): 1-10. **Google Scholar**
4. Sanou A, Tapsoba F, Zongo C, Savadogo A, Traore Y. Etude de la qualité nutritionnelle et microbiologique des farines infantiles de quatre unités de production: CMA saint Camille de Nanoro, CSPS Saint Louis de Temnaoré, CM saint Camille d'Ouagadougou et CHR de Koudougou. Nature & Technology. 2017;17: 25-39. **Google Scholar**

5. Ware LY. Evaluation de la qualité sanitaire des farines infantiles produites au Burkina Faso. 2018.
6. Nishida C, Uauy R, Kumanyika S, Shetty P. The joint WHO/FAO expert consultation on diet, nutrition and the prevention of chronic diseases: process, product and policy implications. Public Health Nutr. 2004 Feb;7(1A): 245-50. **PubMed**
7. OMS. Principes directeurs pour l'alimentation des enfants agés de 6 a 24 mois qui ne sont pas allaités au sein. World Health Organisation. 2006. Accessed 23 Mar 24.
8. Scott N, Delport D, Hainsworth S, Pearson R, Morgan C, Huang S *et al*. Ending malnutrition in all its forms requires scaling up proven nutrition interventions and much more: a 129-country analysis. BMC Med. 2020 Nov 13;18(1): 356. **PubMed**| **Google Scholar**
9. Olive F, Mouquet Rivier C, Fioroni N, Bichard A, Boulle-Martinaud N, Kaboré C *et al*. La filière des farines infantiles produites localement dans six pays sahéliens: Burkina Faso, Mali, Mauritanie, Niger, Sénégal, Tchad. 2020: 1-164. **Google Scholar**
10. Størmer FC. [Significance of mycotoxins for health-present and past]. Tidsskr Nor Laegeforen. 1993 Mar 30;113(9): 1061-3. **PubMed**| **Google Scholar**
11. Royer G, TAP J. Les mycotoxines. Université Paris XII. Année 2003/2004. Accessed 23 Mar 24.
12. Skrzydlewski P, Twaruzek M, Grajewski J. Cytotoxicity of Mycotoxins and Their Combinations on Different Cell Lines: A Review. Toxins (Basel). 2022 Mar 30;14(4): 244. **PubMed**| **Google Scholar**
13. Comité National du Recensement Institut National de la Statistique et de la Démographie. Cinquième Recensement Général de la Population et de l'Habitation du Burkina Faso. 2019. Accessed 23 Mar 24.
14. Cissé I. Caractérisation des propriétés biochimiques et nutritionnelles de la pulpe de baobab des espèces endémiques de Madagascar et d'Afrique continentale en vue de leur valorisation. 2012.
15. Atsa'am DD, Oyelere SS, Balogun OS, Wario R, Blamah NV. K-means cluster analysis of the West African species of cereals based on nutritional value composition. African Journal of Food, Agriculture, Nutrition and Development. 2021;21(1): 17195-17212. **Google Scholar**
16. Ministère de la santé du Burkina Faso. Table de composition des aliments du Burkina Faso. Ouagadougou, Juillet 2005. Accessed 23 Mar 24.
17. Amoin A, Agbo EA, Dago AG, Gbogouri AG, Brou DK, Dago G. Comparaison des caractéristiques nutritionnelles et rhéologiques des bouillies infantiles préparées par les techniques de germination et de fermentation. International Journal of Biological and Chemical Sciences. 2015;9(2): 944-953. **Google Scholar**
18. Rémond D, Walrand S. Les graines de légumineuses: caractéristiques nutritionnelles et effets sur la santé. Innovations Agronomiques. 2017;60: 133-144. **Google Scholar**
19. Augustin NN, Pierre NN, Antoine LK, Marcel MM, Adrien KM. Evaluation des Facteurs Antinutritionnels de Quelques Génotypes de Haricot Commun (Phaseolus vulgaris L.) Biofortifié. Research Gate. 2017. **Google Scholar**
20. Sarwar Gilani G, Wu Xiao C, Cockell KA. Impact of antinutritional factors in food proteins on the digestibility of protein and the bioavailability of amino acids and on protein quality. Br J Nutr. 2012 Aug;108 Suppl 2: S315-32. **PubMed**| **Google Scholar**

21. De Andrade Cairo RC, Rodrigues Silva L, Carneiro Bustani N, Ferreira Marques CD. Iron deficiency anemia in adolescents; a literature review. Nutr Hosp. 2014 Jun 1;29(6): 1240-9. **PubMed**| **Google Scholar**
22. Tesfaye TS, Tessema F, Jarso H. Prevalence of Anemia and Associated Factors Among "Apparently Healthy" Urban and Rural Residents in Ethiopia: A Comparative Cross-Sectional Study. J Blood Med. 2020 Mar 11;11: 89-96. **PubMed**| **Google Scholar**
23. Nadjet GT, Noureddine B, Didi OEHM. Les mycotoxines: un danger de santé public. Algerian Journal of Arid Environment. 2016;6: 1. **Google Scholar**
24. Benlameur Z. Les ravageurs des denrées stockées et leur impact sur la santé humaine. (Doctoral dissertation, ENSA). 2016. **Google Scholar**
25. Badenhausser I, Lallemand J. Se passer des pesticides en agriculture? In: Conference CPO. 2017.
26. Barouki R. Risque de cancer du sein et estrogènes: actualités: Xéno-estrogènes et cancer du sein. 28eJournées de la Société française de sénologie et de pathologie mammaire, Lille, FRA, 2006-11-08 Lille, 8-10 novembre 2006. **Google Scholar**
27. Anjarwalla P, Belmain S, Sola P, Jamnadass R, Stevenson PC. Guide des plantes pesticides. World Agroforestry Center (ICRAF), Nairobi, Kenya. 2016. **Google Scholar**
28. Cissokho PS, Gueye MT, Sow EH, Diarra K. Substances inertes et plantes à effet insecticide utilisées dans la lutte contre les insectes ravageurs des céréales et légumineuses au Sénégal et en Afrique de l'Ouest. International Journal of Biological and Chemical Sciences. 2015;9: 3. **Google Scholar**
29. Adjadogbedji Cyrille CB. Aptitude au stockage de quelques farines infantiles à base de ressources alimentaires locales du Bénin. 2017. Thèse.
30. Atia Lilia HIF. L'effet de la torréfaction sur les polyphénols totaux et l'activité antioxydante du café Arabica et Robusta. 2021. Mémoire.
31. Olagunju O, Mchunu N, Durand N, Alter P, Montet D, Ijabadeniyi O. Effect of milling, fermentation or roasting on water activity, fungal growth, and aflatoxin contamination of Bambara groundnut (Vigna subterranea (L.) Verdc). Lwt. 2018;98: 533-539. **Google Scholar**
32. Furbeyre H, Guillevic M, Chesneau G, Labussière E. Effets du dépelliculage et de l'extrusion sur la valeur nutritionnelle de la graine de féverole chez le porc en croissance. 52. Journées de la Recherche Porcine, Feb 2020, Paris, France. pp.87-92. **Google Scholar**
33. Mariscal-Landin G, Lebreton Y, Sève B. Apparent and standardised true ileal digestibility of protein and amino acids from faba bean, lupin and pea, provided as whole seeds, dehulled or extruded in pig diets. Animal Feed Science and Technology. 2002;97(3-4): 183-198. **Google Scholar**
34. Razafindrazaka VL. Elaboration et évaluation d'une stratégie d'amélioration de l'alimentation de complément des jeunes enfants à Brickaville (côte Est de Madagascar). 2006. Thèse de Doctorat. **Google Scholar**
35. Ndamobissi R. La malnutrition des enfants dans les pays du Sahel et de la Corne de l'Afrique: défis sociodémographiques et politiques (Burkina Faso, Niger, Sénégal, Ethiopie, Ghana). La malnutrition des enfants dans les pays du Sahel et de la Corne de l'Afrique. L'Harmattan. 2018;256. **Google Scholar**
36. Tou EHK-P. Caractérisation et amélioration du procédé traditionnel de préparation de la bouillie de mil fermenté, Ben-Saalga, utilisée comme aliment de complément au Burkina Faso. 2006.

37. Roosen M, Mys N, Kusenberg M, Billen P, Dumoulin A, Dewulf J *et al*. Detailed Analysis of the Composition of Selected Plastic Packaging Waste Products and Its Implications for Mechanical and Thermochemical Recycling. Environ Sci Technol. 2020 Oct 20;54(20): 13282-13293. **PubMed**| **Google Scholar**
38. Somakou M. Appreciation de la qualite nutritionnelle de la farine infantile cereso ouando et evaluation de l'effet de la cuisson-extrusion sur la farine. EPAC/UAC; 2017. **Google Scholar**
39. Grodji Albarin G, Mandoué Stephanie B, Dogoré Yolande D, Kouakou B. Elaboration d'une Farine infantile composée à base d'ingrédients locaux de Côte d'Ivoire?: quelles stratégies d'enrichissement en acides gras polyinsaturés oméga 3? 2019;13: 1. **Google Scholar**
40. Rohner F, Leyvraz M, Konan AG, Esso LJ, Wirth JP, Norte A *et al*. The Potential of Food Fortification to Add Micronutrients in Young Children and Women of Reproductive Age - Findings from a Cross-Sectional Survey in Abidjan, Côte d'Ivoire. PLoS One. 2016 Jul 6;11(7): e0158552. **PubMed**| **Google Scholar**

Table 1: distribution of production units and management methods for infant flours

Flour fortification, breakdown of production units by type and use of store treatment pesticides									**Type of flours and packaging**					
	Flour fortification		**Breakdown of production units by type**				**Use of store treatment pesticides**			**Type of flours**		**Type of packaging**		
	YES	**NO**		**Artisanal**	**CREN**	**Semi-industrial**	**YES**	**NO**		**Weaning**	**Recovery**	**Plastic sachet and cardboard package**	**Aluminum complex sachet (Doypa type)**	**Simple sachet**	**Métallic box**
NIF	21	5	**NPU**	3	3	5	7	4	**NIF**	10	16	3	1	10	12
P (%)	80	20		27.27	27.27	45.45	66	34		37.14	62.86	11.43	2.86	40	45.71

NPU: number of production units **NIF:** number of infant flours **P:** Percentage

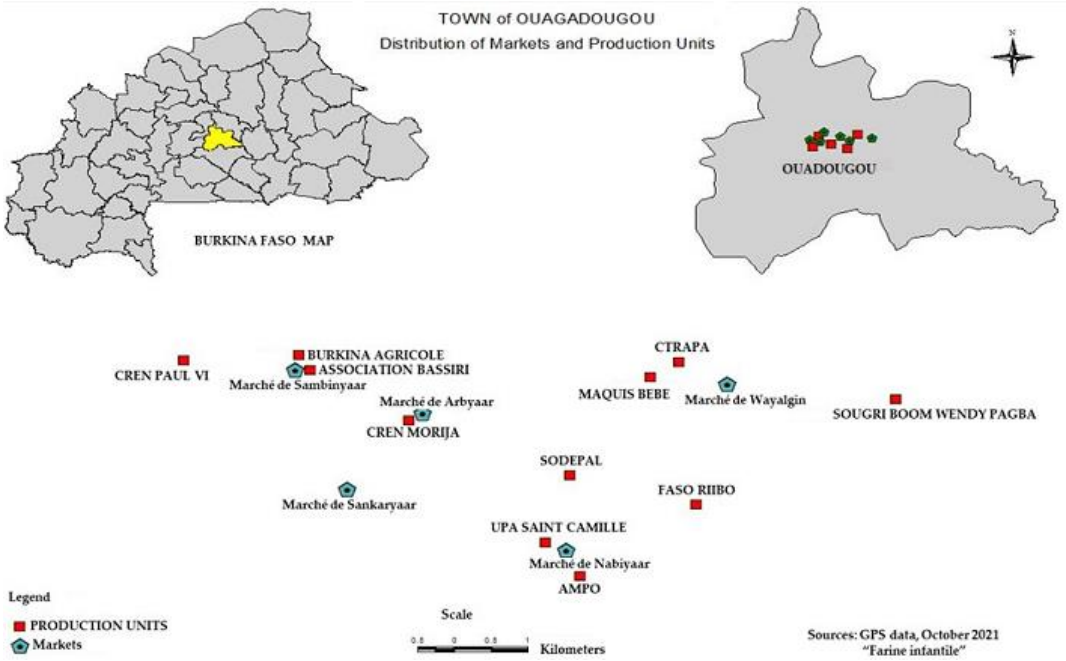

Figure 1: infant flours and raw material samples collection sites

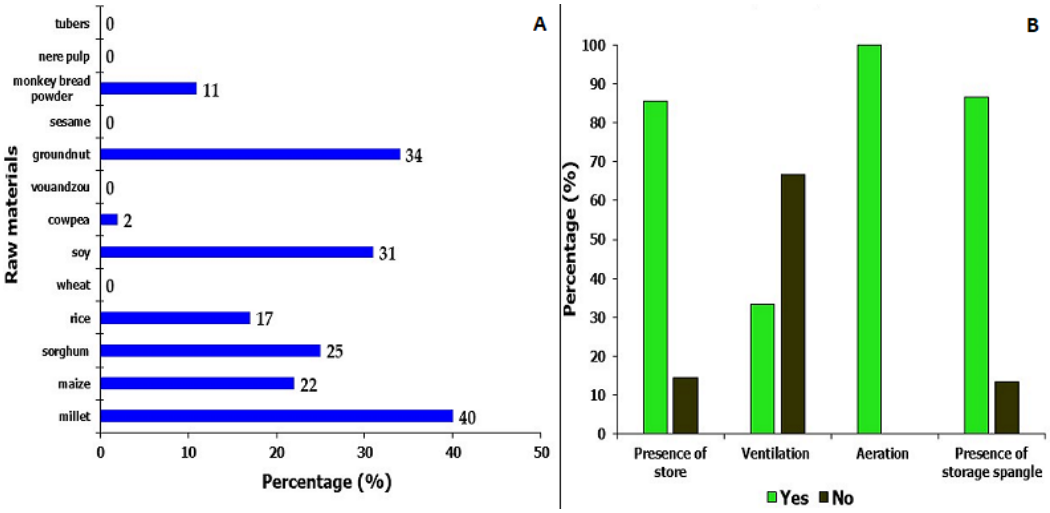

Figure 2: use of raw materials in the production of infant flour and raw material storage environments by production units

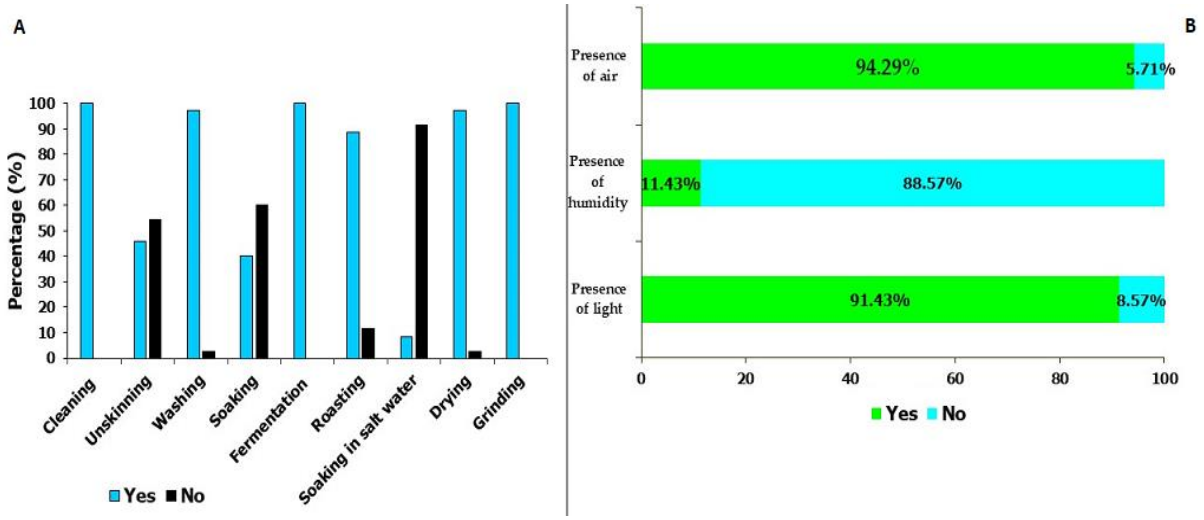

Figure 3: different infant flour production processes and storage conditions for infant flour