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Article

Management of Infant Flour Production in the City of Ouagadougou

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Abstract: In Burkina Faso, the infant flours produced are intended for weaning-age and malnourished children. This study was to evaluate the management of infant flour production in Ouagadougou. A survey was conducted among the production units to determine the raw materials used in the production of infant flours, the production processes, the methods of conservation of raw materials and infant flours, the types of infant flours produced as well as their packaging. The results showed that 45.45% of the production units surveyed were of the semi-industrial type against 54.54% from the artisanal and CREN types. Among the raw materials, the most used cereals were millet, sorghum and maize. As for legumes, peanuts and soybeans were the most used at respectively 35% and 31%. For the conservation of raw materials, 85.71% of infant flour producers had storage warehouses and 66% used storage pesticides. These flours produced were intended for children of wean age (37.14%) and children in nutritional recovery (62.86%). Flours were stored in an airy (94.29%), dry area/environment (88.57%) and in the presence of light (91.43%). All the results of this survey reflect that efforts are still expected to further improve the nutritional and sanitary quality of the infant flours produced.

Keywords: infant flours; management; production units; Ouagadougou; Burkina Faso

1. Introduction

Infant flour is a complementary food given to infants and young children in the form of porridge from the age of 6 months [1]. It is 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 [2]. Cereal-based porridges are traditionally used in Burkina Faso as a complementary food at the time of dietary diversification, and at present they are the main commercial complementary foods produced locally, the rest of the production (baby purees, lipid pastes…) being extremely limited [3]. The poor management of the production of these infant flours is a source of contamination by mycotoxins and other microorganisms that are the origin of many diseases including malnutrition and cancers, causes of many deaths. Indeed, according to Størmer, there is a link between mycotoxins, mortality and the decline in the birth rate [4].

In Burkina Faso, there are imported infant flours and locally produced infant flours. In this study, we particularly focused on local infant flours. We have artisanal and semi-industrial production units that produce two types of infant flours, namely instant infant flours and infant flours for cooking. The objective of this study was to evaluate the management of infant flour production in the city of Ouagadougou (Burkina Faso). To do this, we first identified the raw materials intended for the production of infant flours, then we investigated their conservation

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methods and the production processes and finally, we evaluated the quality of the types of infant flours produced and their packaging methods.

2. Materials and Methods

2.1. Study period and sample collection sites

Investigations on the infant flour production units took place during the period from May 22 to June 21, 2021 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 [3,5]. It is a city which covers an area of 2805 km^2 and is subdivided into 12 districts comprising 55 urban sectors. The different samples of infant flours and raw materials for the study were collected from production units and markets in the city (Figure 1).

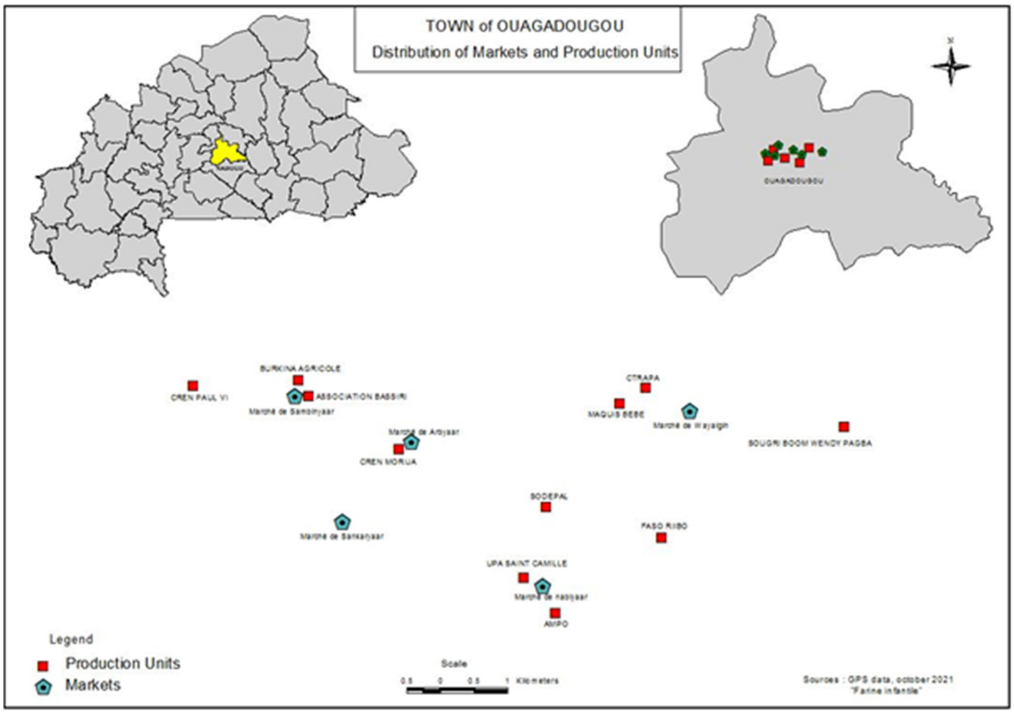

Figure 1. Infant flours and raw material samples collection sites.

2.2. Conduct of the investigation

The survey was conducted within the production units of the city of Ouagadougou in order to collect information on the nature of the raw materials and their management in the production of infant flours. 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 flours. The production frequency, the type of flour produced, the targeted audience, the micronutrients used for the enrichment of infant flours, and the status of quality monitoring (Physico-chemical, microbiological and toxicological) have also been evaluated.

2.3. Sample Collection of raw materials and infant flours

2.3.1. Raw materials

The sampling of raw materials was carried out according to the number of bags available in the stores. Among the production units, there are those that have approved suppliers and those that obtained their supplies directly from the markets of the city of Ouagadougou. For units that have

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approved suppliers, the samples were collected within the production units. With regard to the units that obtain their supplies from the markets, we took samples directly from the markets concerned. In total, 39 raw material samples have been collected in this study.

2.3.2. Infant flours

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 flours were not available in the production units, they were bought at the supermarket level. In total, 26 infant flour samples have been collected in the present study among which 10 samples were intended for children of wean age and 16 for children in nutritional recovery. In addition, infant flours were either instant (11.54%) or cooked (88.46%).

Statistical analysis

The questionnaires used for the survey were developed with the ODK collection software version 4.2 and an electronic collection was carried out (Figure 2). Data cleaning was carried out using STATA 15 and Excel 2016 softwares. 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.

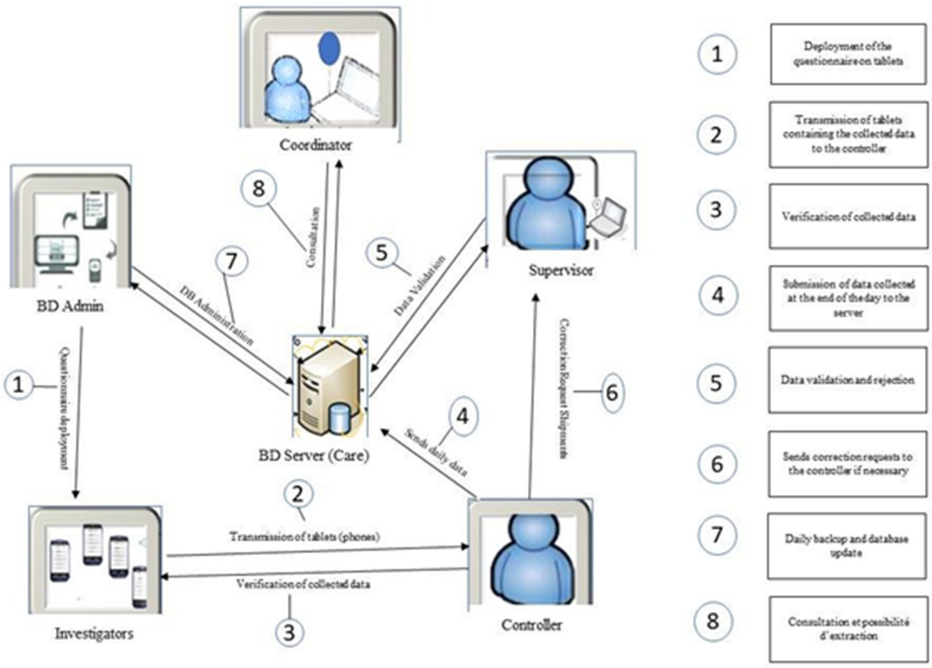

Figure 2. Conceptual diagram of electronic data collection.

3. Results

3.1. Infant flour production units in the city of Ouagadougou

The survey carried out in the city of Ouagadougou showed that infant flour production units were mainly artisanal (6 units) (associations, women's groups and CREN (Recovery and Nutritional Education Centres)) and semi-industrial (5 units). Indeed, 45.45% of the production units surveyed were semi-industrial and 54.54% artisanal (Table 1).

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.

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3.2. Raw materials used for the production of infant flours in Ouagadougou

In total, 39 samples of raw materials intended for the production of infant flours have been collected in this study. It appears that the main raw materials used in the production of infant flours were cereals (millet, maize, sorghum, rice) and legumes (soya, peanuts, cowpeas). Figure 3 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%). Survey results indicated that monkey bread powder was used by 11% of units because of its micronutrient content. Unlike other cereals, rice is used less by infant flour production units in Ouagadougou (17%) and wheat is not used at all (Figure 3).

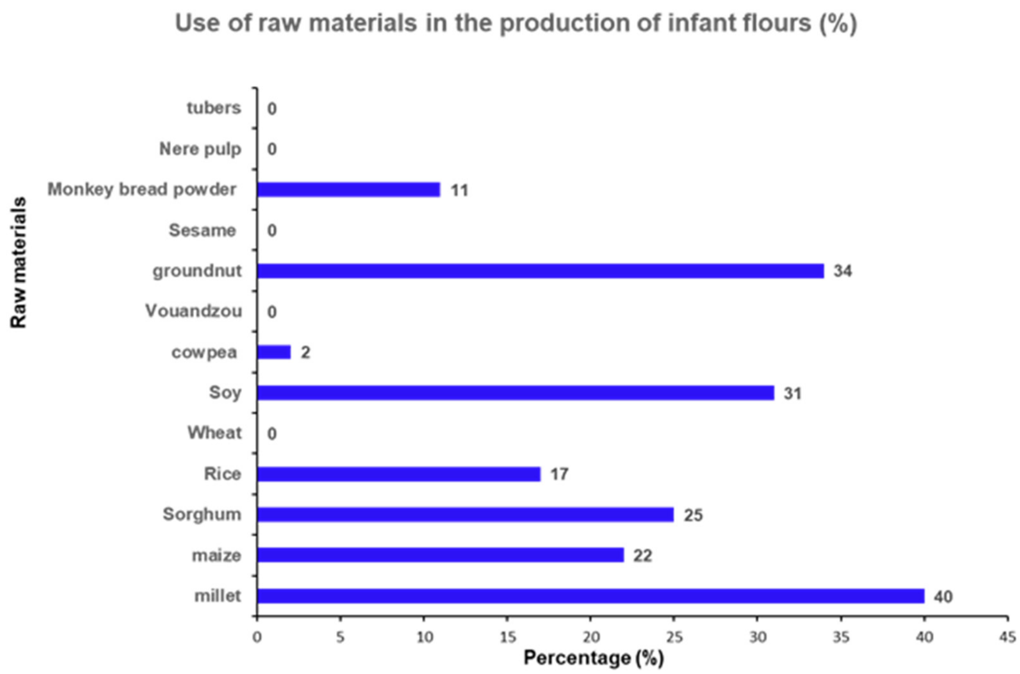

Figure 3. Use of raw materials in the production of infant flours.

3.3. 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 4). These stores were equipped with storage straws and ventilation systems. In addition, 66% of these producers used pesticides for the storage of their raw materials (Table 1).

3.4. Infant flour production processes

The survey revealed that all the production units used cleaning, fermentation and grinding in their production process of infant flours (Figure 5). 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%) and roasting (88.57%) in their infant flour production process. Washing rids the raw materials of certain particles and microparticles. It emerges from this study that 40% of the surveyed production units practiced a simple soaking of seeds and only 8.57% used salt water for soaking.

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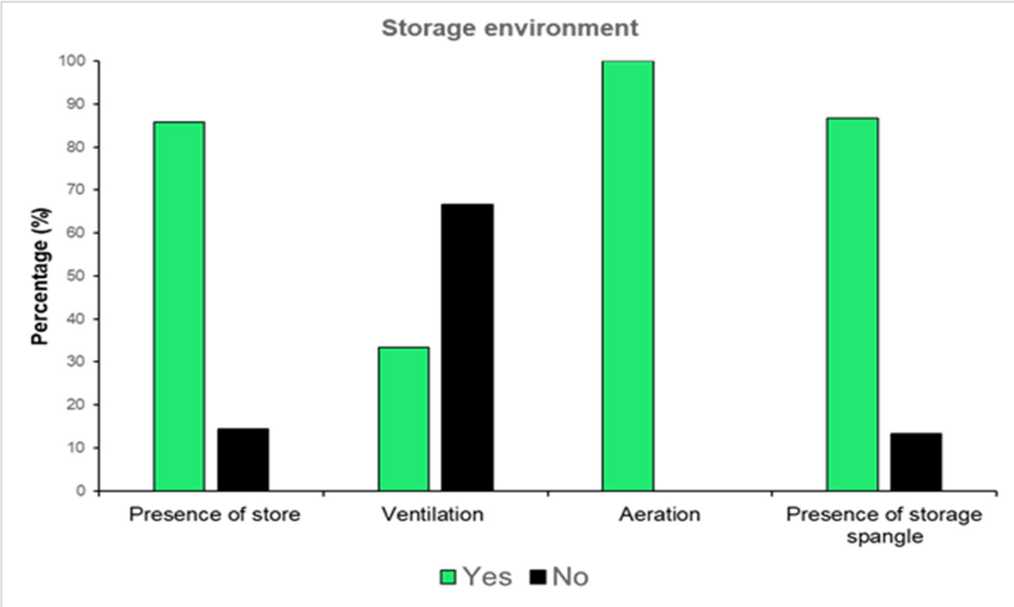

Figure 4. Raw material storage environments by production units.

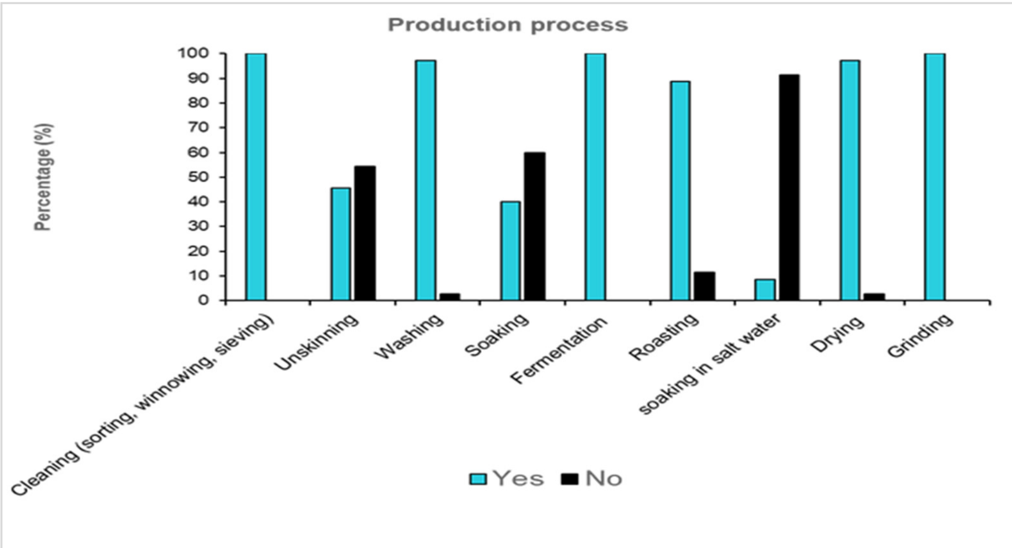

Figure 5. Different infant flour production processes.

3.5. Infant flour produced by production units in Ouagadougou

3.5.1. Types of infant flours produced

Our study showed that 37.14% of infant flour production units in the city of Ouagadougou mainly produced flours intended for children of wean age and 62.86% produced flours intended for children in nutritional recovery situation (Table 1). These flours were either instant or for cooking. The, survey showed that 80% of infant flours 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.) or by directly adding monkey powder, vitamins and minerals.

3.5.2. Packaging and storage of infant flours

The survey revealed that the infant flours produced by the production units of 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 in order 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%) places (Figure 6).

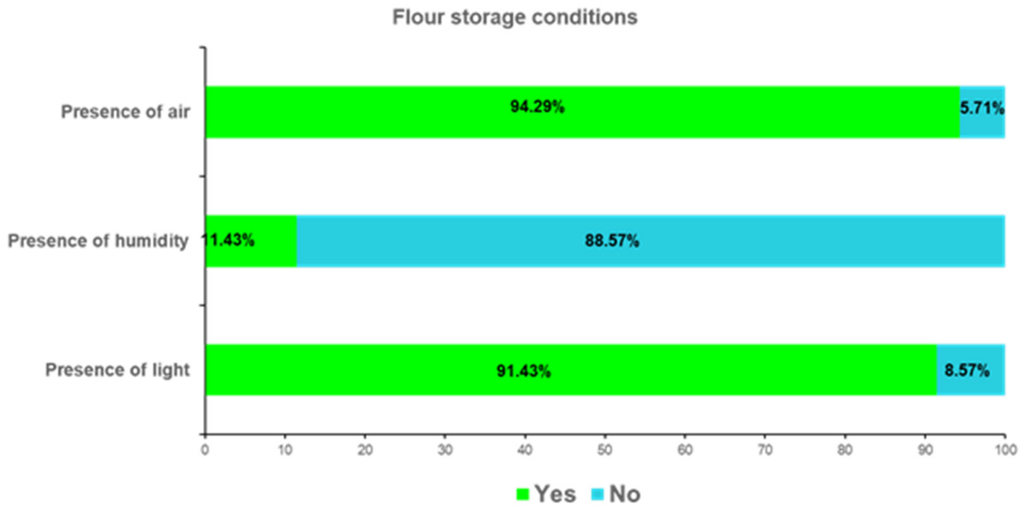

Figure 6. Storage conditions for infant flours.

3.6. Infant flour quality monitoring

The study showed that 77.14% of production units had a quality monitoring structure for the infant flours produced and that the quality monitoring of these structures concerns the physico-chemical, microbiological and toxicological parameters.

The survey revealed that 80% of production units enriched their flours with micronutrients (Table 1). Also, it emerged from this survey that 17.14% of production units used vitamin A; 14.29% iron and calcium and 5.71% zinc and iodine.

4. 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. Artisanal units generally have only simple equipment, including basins, sieves, roasters, mixers and bag sealers. Manual transformations dominated in their manufacturing processes [3]. This study showed that more than half of the infant flours (65.38%) were produced in an artisanal way in the city of Ouagadougou. 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 insufficiency of infant flours on the local market, favouring the use of imported flours in the feeding and nutritional recovery of children. Furthermore, it should be noted that the unavailability of raw materials could also be a limiting factor for industrial production. However, the nutritional and sanitary quality of the infant flours produced do not depend on the type of company or the level of production [3].

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Raw materials used for the production of infant flours in Ouagadougou

A study conducted on infant fours sold in the city of Ouagadougou showed that cereal raw materials used in the production of these flours were mainly composed of maize (60%) followed by millet (30%). However, this study did not start from an investigation at the production units' level [6]. Cereals are sources of energy, dietary fibres and vitamin B [7]. 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 [8]. However, 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, you need a mixture of cereals and legumes [9]. Cereals are an important source of carbohydrates while legumes are an important source of proteins and lipids [10]. The combination of these two food groups makes infant flours available which, enriched with micronutrients, contain all the nutrients necessary for a 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, Calcium [11]. The rice is used less and wheat is not used by infant flour production units in Ouagadougou (Figure 3). This could be explained by the fact that they are very little cultivated and therefore of high cost. Legumes such as cowpea and vouandzou were used very little or almost not at all in the production of infant flours. This could be due to the presence of antinutritional factors such as phytates, polyphenols, terpenoids, steroids and alkaloids contents in these legumes. These compounds have the drawbacks of reducing the bioavailability of macro- and micronutrients and inhibiting the enzymes necessary for digestion. Some antinutrient factors, like phytates, limit protein bioavailability and some minerals like iron and zinc [12,13]. Many studies have reported that 95% of anaemia cases are associated to iron-poor diet [14,15]. The prevalence of anaemia among children at wean age could be explained by the high intake of antinutritional factors present in infant flours. Consumption of these legumes could cause flatulence in children [10].

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. Indeed, humidity is favourable to the development of fungi and moulds, sources of mycotoxin production [16]. 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 flours [17]. Otherwise, the abusive and unregulated use of pesticides in the management of raw materials used for the production of infant flours can be a long-term source of chronic diseases such as cancer in infants and young children who consume them [18,19]. It would therefore be wise to encourage the use of natural pesticides and insecticides such as neem oil, the ash of *Eucalyptus grandis* leaves, the essential oils of *Ocimum gratissimum* and *Xylopia aethiopica*, for example for the treatment of warehouses if needed. *Natural* insecticides have the potential to improve safe crop protection [20,21].

Infant flour production processes

The cleaning of the seeds leads to a significant reduction in the rate of mycotoxins such as aflatoxin [17]. As for fermentation, it makes the flours produced much more digestible. It significantly reduces anti-nutritional factors [22]. 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 flours produced; thus, limiting the contamination/production of mycotoxins. A previous study conducted in Ouagadougou on infant formulas showed the maize and rice used for the production of infant flours were contaminated at 23.5% by AFB1 and 17.6% by total aflatoxins [23]. If the roasting of the seeds carried out by the production units makes it possible to modify the sensory profile of the flours produced and makes them more appetizing, it cannot, on the other hand, completely eliminate the mycotoxins. In fact, to achieve the elimination of mycotoxins, the seeds must be roasted at a temperature of 200 °C for 30 minutes. However, similar roasting conditions may allow their elimination but also compromise the sensory attributes of the flours produced [24]. Soaking facilitates peeling. The deshelling operation leads to a marked decrease in the insoluble fibre content of the infant flour produced [25]. The survey carried out showed that 45.71% of infant flour production units deshell seeds. Reducing the fibre content by deshelling makes it possible to obtain infant flours with a higher concentration of digestible elements [26]. The rigorous implementation in the production units of steps allowing a reduction of the microbial load such as shelling, washing followed by 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

For types of infant flours produced, instant infant flours, unlike baking flours, reduce meal preparation time, which is an important factor in energy saving. On the other hand, they can be risky in places where the available water is not drinkable and is not boiled before consumption. Thus, porridge prepared under these conditions can cause various disorders (diarrhoea, stomach aches, vomiting, etc.) in children [27]. However, the use of an infant flour for cooking limits these problems insofar the water boils for more than 5 minutes during the preparation [3]. Ultimately, these aspects involving the health of children should not be neglected. Otherwise, we noted during this study that the flours intended for children in a situation of nutritional recovery (malnourished children) were much more enriched than those intended for children of wean age. The high number of enriched flours used for recovery that were produced by these units could be explained by the strong demand for recovery flours at the national level given the large number of malnourished children in Burkina Faso [28]. In fact, flours enrichment make it possible to increase the energy value of the infant flours necessary to improve the nutritional status of children in nutritional recovery situation [29]. About packaging and storage of infant flours, the discrepancy between the information given on the packaging of infant flours 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. Indeed, 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 [30]. Defective packaging can alter the quality of the finished product. It is therefore important to make the right choice. The sale of a product goes through its packaging, because not only to attract the eye of the potential buyer but also to inform him on the correct use of this product [3]. The frequent use of PE or PP bags is explained by their wide availability at the local level. For long storage, the thickness of these bags must be between 150 µm and 200 µm for PE and at least 100 µm for PP [22]. However, “complex” sachets (e.g., Bi-Oriented Polypropylene/Polyethylene/Aluminum/Polyethylene (BOPP/PE/Al/PE)) are of better quality than PE or PP because these models make it possible to envisage a longer shelf life. These "complex" sachets are rarely available in developing countries because they are much more expensive [3]. 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 [3]. The boxes allow a very good presentation of the product, like quality imported products, but generally too expensive for local production units. The metal boxes used must be made of aluminium or varnished to prevent rust. Thus, PVC or PP boxes would be interesting insofar this packaging is reusable. And more, ventilated, dry and light conditions are necessary for a good conservation of infant flours [22].

Infant flour quality monitoring

Infant flour quality monitoring corroborate those of Olive et al., (2020) [3] according to which all producers of infant flours 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 be safe. It must not contain pathogenic germs, toxins or toxic chemical residues likely to have repercussions on the health of infants and young children [31]. 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, a good infant flour must also have a good nutritional value. The quality monitoring structures are responsible for checking the nutritional composition of the infant flours produced by these production units. The macro and micronutrient content determine the nutritional value of an infant flour. Infant flours intended to supplement breastfeeding must provide 68% carbohydrates, 13% protein, 7% lipids and 400 Kcal per 100 g of flour [32]. Otherwise, low micronutrient intake leads to deficiencies in children [33]. 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 its needs. It is extremely difficult or almost impossible to achieve the micronutrient densities recommended for the body using only raw materials and without resorting to fortification [3].

5. Conclusions

Good management of the production of infant flours conditions their sanitary and nutritional quality. This survey made it possible to determine the production management of infant flours through the determination of the raw materials most used in the production of these infant flours and the different methods of conservation of the raw materials and infant flours. It allowed not only to know the different types of infant flours produced but also the processes used. It appears that more than half of the infant flours were produced in an artisanal way in the city of Ouagadougou. The main raw materials used in the production of these infant flours were cereals (millet, maize, sorghum, rice) and legumes (soya, peanuts, cowpeas). 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. These infant flours were mostly packaged in plastic bags after production. This study also revealed that the majority of production units had a quality monitoring structure for the infant flours produced. These structures are of great importance for production units because the quality of infant flours depends on the support that producers have received for the development of their products. The risk of contamination with mycotoxins and particularly aflatoxins deserves special attention. Indeed, studies on infant flours 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.

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Conflicts of Interest: The authors declare no conflict of interest.

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