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Assessment of production, hygiene practices, and consumption of fortified infant flour in the Sahel of Niger

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ABSTRACT: Misola® fortified infant flour is a product that helps prevent and combat moderate malnutrition. The overall objective of this study is to increase the consumption of Misola® fortified infant flour. A descriptive cross-sectional survey was conducted in the Sahel Niger Zone of Niamey, Dogondoutchi, Guidan Roumdji, and Tessaoua, and involved 211 households and three (3) production units (Niamey, Dogondoutchi, and Tessaoua). Data were collected using a household questionnaire, a producer interview guide, and a hygiene assessment grid at the production unit level. Analysis of these data revealed that the production of Misola® fortified infant flour is predominantly carried out by women within the production units, with an average of 88.5%. The output of Misola® fortified infant flour follows the same flowchart in all production units. Regarding hygiene during production, compliance rates of 70%, 58.8%, and 82.4% were observed for hygiene criteria in Niamey, Dogondoutchi, and Tessaoua, respectively. Regarding use, 49.8% of respondents start giving their children Misola® porridge from 6 months. However, the majority of Misola flour users (67.8%) learned to prepare Misola® porridge through self-training (using the instructions on the packaging), and 28.4% learned at the point of sale. Overall, the use of Misola® fortified infant flour in the study area is satisfactory. The production of Misola® fortified infant flour in our facilities is conducted in accordance with Good Manufacturing Practices (GMPs). However, some shortcomings regarding hygiene criteria were noted in the study area. It would be necessary to intensify quality control at the UP level to ensure greater compliance with hygiene standards.

KEYWORDS: production, Misola®, infant flour, hygiene, good manufacturing practices, Niger.

1 INTRODUCTION

The right to adequate food is a fundamental right for every child. Children who receive sufficient nutritious food, in the right way, and at the right time for their development, are more likely to survive, grow, develop, and learn. They are better equipped to thrive, even when faced with illness, disaster, or crisis (UNICEF Program Guide, Improving the Diets of Young Children During the Complementary Feeding Period). Indeed, one of the diseases most implicated in the deterioration of children's nutritional status remains malnutrition. Malnutrition is a condition caused by dietary deficiencies, excesses, and imbalances. When caused by nutrient deficiencies, its prevalence in developing countries and the consequences it engenders constitute a serious threat to public health. However, globally, among children under 5 years of age, 52 million were in a state of emaciation, 17 million were severely emaciated, 155 million were stunted, and an estimated 2.7 million children die each year from undernutrition, accounting for 45% of all child deaths [1]. Joint malnutrition estimates released in April 2021 reveal insufficient progress towards the World Health Assembly (WHA) targets set for 2025 and the Sustainable Development Goals (SDGs) set for 2030 [1,2]. The latest analysis indicates that only a quarter of all countries were on track to halve the number of children affected by stunting by 2030 [2]. Indeed, in Niger, the prevalence of global acute malnutrition (GAM) among children under 5 years of age is estimated at 12.2% [3]. Regarding the prevalence of severe acute malnutrition (SAM), it changes from 1.1 percent (Diffa) to 3.9 percent (Maradi) [3]. In addition, chronic malnutrition or stunting and underweight in children aged 0-59 months are estimated at 47.0 and 33.7% respectively [3]. Several studies show the repercussions of malnutrition on children, including a tendency to fall ill, intellectual weakness, behavioral disorders, etc. [4,5].

The Global Strategy on Infant and Young Child Feeding has shown that this is a critical transition period when complementary feeding begins, during which the infant is particularly vulnerable due to the immaturity of their digestive tract. Indeed, it is during the period between 6 months and 2 years, known as the complementary feeding period, that the prevalence of thinness is highest and growth retardation in height is most apparent. Infant and young child nutrition is a priority area for improving child survival and promoting healthy growth and development. Moreover, the first three years of a child's life are crucial, as a good diet during this period reduces mortality and the incidence of other chronic diseases, and ensures better overall development [1]. The practice of exclusive breastfeeding up to 6 months among infants in Niger is estimated at 21.8%, which corresponds to a low rate [3]. Additionally, the introduction of complementary foods to breast milk is typically carried out between 6 and 12 months. This is accompanied by the poor quality of these foods, which are low in energy and micronutrients [6,7]. Complementary foods distributed to young children in Niger are generally low-energy, low-nutrient porridges prepared from simple cereal flours, fermented or unfermented [8,9]. Technological processes or household recipes adapted to various levels of technological development have been proposed for preparing ready-to-cook or instant flours. However, their effectiveness in increasing intake among young children and preventing malnutrition remains controversial. Their low-cost manufacturing, promotion, and use in urban and rural contexts also remain to be defined [9,10]. Moreover, many Sahelian companies offer locally produced infant flour on the market to ensure its accessibility to children [11]. The quality of infant flour used during the food diversification period is of great importance. Unfortunately, processing is subject to insufficient hygiene practices [8, 11]. In Niger, several infant formulas are available on the market, differing in brands and compositions. Some of these flours are imported, while others are produced locally. Among the latter is the fortified infant flour Misola®, an integrated product for the prevention and management of moderate malnutrition. This flour has been manufactured in Burkina Faso, Mali, Cameroon, and Niger since the 1980s, and in Niger since 2006. This study was initiated to assess the production and use of Misola®, a fortified infant flour, to enhance its value. The primary objective of this study is to contribute to the promotion of production units (PU) and the utilization of fortified Misola® infant flour within the study area.

2 MATERIALS AND METHODS

2.1 MATERIALS

2.1.1 STUDY SETTING

The study took place in four areas of Niger, including the city of Niamey and the departments of Dogondoutchi, Tessaoua, and Guidan Roumdji (Figure 1).

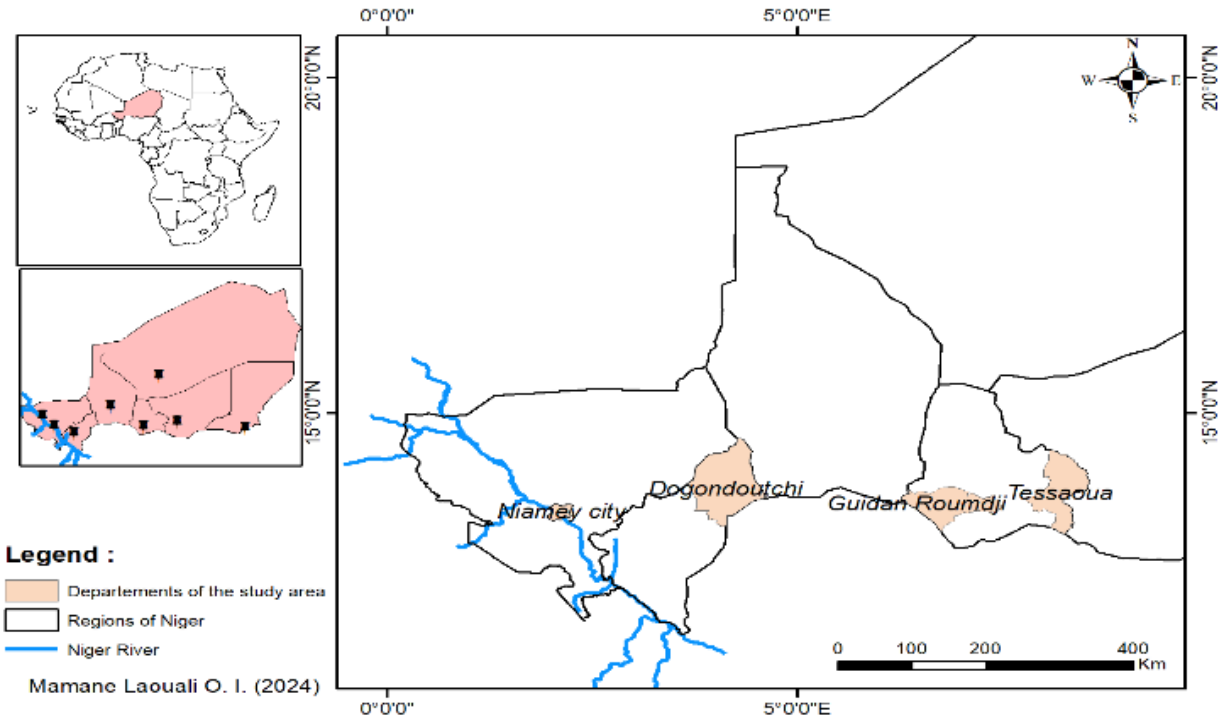

Fig. 1. Location of study areas

2.1.2 DATA COLLECTION TOOLS

To facilitate data collection, an interview guide and questionnaire were previously developed, including the following points: household characteristics, flour usage, hygiene conditions, and child nutrition. Information was also collected on production processes, storage, and distribution techniques, as well as other relevant details (such as quality, controls, hygiene, and the quantity of flour produced). Additionally, an evaluation grid was used to collect information on hygiene practices in production.

2.1.3 DATA PROCESSING TOOLS

The following tools were used for data processing:

- The ODK XLSFORM form was used to enter the questionnaire and the producer interview guide.
- Kobocollect software was used for collecting field data.
- Microsoft Office 2016® was used to create figures and tables and to write the dissertation.
- ArcGIS software was used to create the map of the study area.

In addition to these software programs, the data were organized in Excel and transferred to the R software for advanced analysis.

2.2 METHODS

2.2.1 TYPE OF STUDY

This survey used a descriptive, cross-sectional study to assess the production and use of Misola® fortified infant flour.

2.2.2 TARGET POPULATION

People who use Misola® fortified infant flour in their children's diets.

The presidents of the Misola® fortified infant flour training units.

2.2.3 INCLUSION CRITERIA

This study included all households using Misola® fortified infant formula in the study area.

2.2.4 EXCLUSION CRITERIA

This study excluded all households using Misola® fortified infant formula who did not voluntarily respond to the questionnaires.

2.2.5 SAMPLING

Sampling Method and Techniques

The snowball method was used to identify target households.

The Schwartz formula was used to calculate the sample size:

$$N = \frac{Z^2 * P * (1 - P)}{i^2} Xe$$

N: sample size;

Z: standard deviation corresponding to the 95% confidence level, which is equal to 1.96;

P: The prevalence of Misola® fortified infant formula use is estimated at 50%. i: estimated accuracy of 10%;

e: the cluster effect is: 2

In application:

$$N = \frac{1{,}96^2 * 0{,}5 * (1 - 0{,}5)}{0{,}01} x2 = 192{,}08$$

N=192 households

The resulting sample size is 192.08 + 10% for non-respondents, which equals 19.2; which ultimately yields 211 households to be surveyed.

2.2.6 ETHICAL CONSIDERATIONS

To conduct this survey in a manner that respects the moral, cultural, and traditional values of the respondents, the following procedures were adopted: authorization was obtained from each village chief in Dogondoutchi, Tessaoua, and Guidan Roumdji. Consent was obtained from the compounds/households after a detailed explanation of the study objectives.

2.2.7 DATA COLLECTION TECHNIQUE

Data on the production processes for Misola® fortified infant flour were collected through individual interviews with the presidents of their respective production units. In addition, data on Misola use were collected through personal interviews with the target audience.

2.2.8 HYGIENE EVALUATION OF MISOLA®

The production hygiene of Misola® fortified infant flour was evaluated at the three production units.

2.2.9 DIMENSIONS EVALUATED

During the evaluation process, observations were conducted in three Unit Levels (Niamey, Dogondoutchi, and Tessaoua) for Misola® fortified infant flour. The information was collected using evaluation grids. A rating method was then defined to determine compliance and non-compliance rates.

On the grid, a score of 2 was given to compliant criteria, a score of 1 to partially compliant criteria, and a score of 0 to non-compliant criteria.

The rates are determined using the following formulas [12]:

Compliance rate:

$$\%\ C = \frac{(Number\ of\ noted\ criteria * 2)}{(Total\ number\ of\ criteria * 2)} * 100$$

Partial compliance rate:

$$\%\ CP = \frac{(Number\ of\ noted\ criteria * 1)}{(Total\ number\ of\ criteria * 2)} * 100$$

The non-compliance rate is calculated using the following formula:

$$\%NC = 100 - (\%C + \%CP)$$

2.2.10 DATA PROCESSING TECHNIQUE

The processing of data from the producer interview guide allowed the development of the Misola® fortified infant flour production flowchart. However, the data from the household survey were processed in R software through descriptive analyses to determine the frequency of each variable studied. In addition, cross-tabulations were carried out between certain variables taken two by two; at this level, the frequencies were expressed as percentages using Microsoft Excel 2016 software. Finally, the hygiene assessment grid was used to determine compliance rates.

3 RESULTS AND DISCUSSION

3.1 RESULTS

Figure 2 shows the distribution of flour producers by gender.

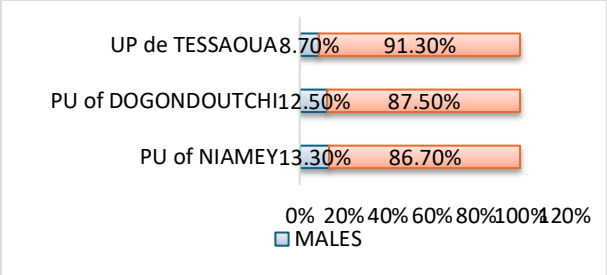

Fig. 2. Distribution of producers by gender

The survey revealed that the production of Misola® fortified infant flour is predominantly carried out by women, with an average of 88.50%.

3.1.1 MISOLA® PRODUCTION PROCESS

The different stages of Misola® fortified infant flour production are illustrated in Figure 3.

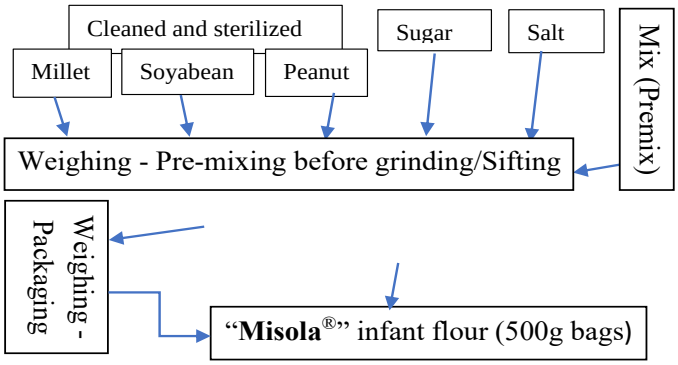

Fig. 3. Misola® Infant Flour Production Flowchart

The production of Misola® fortified infant flour is summarized in three stages, each with one or more unit operations. These stages are as follows:

- Raw material purification: with the unit operation (sorting, winnowing, drying, specific washing for millet, roasting, sterilization or second roasting, cooling, and dehulling/decortication specific for peanuts).
- Milling: with the unit operation (sieving and mixing).
- Packaging.

3.1.2 HYGIENE IN MISOLA® PRODUCTION PROCESS UNITS

The compliance rate with hygiene criteria at the production unit level is presented in Figure 4.

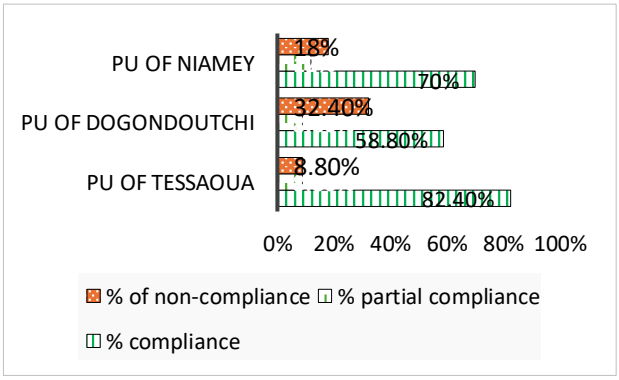

Fig. 4. Hygiene practices assessments within the three production units (PU of Niamey, Dogondoutchi and Tessaoua)

The study reveals a hygiene practices assessment compliance rate of 82.4% in the Tessaoua UP, 58.80% in the Dogondoutchi UP, and 70% in the Niamey UP.

3.1.3 PREPARATION AND USAGE OF MISOLA®

A preparation protocol has been defined to obtain porridge with a high energy density (100kcal per 100g of porridge) and an appropriate consistency (100mm per 30s of Bostwick flow).

This protocol allows for the preparation of approximately 150g of porridge, which should be given to children at least twice a day as a supplement to breast milk. The preparation instructions are as follows:

- Before preparing any porridge, hands and utensils must be thoroughly washed;
- Mix one (1) part MISOLA flour and three (3) parts of water in a container;
- The ideal amount is a glass of tea for a child's meal;
- Mix everything well and bring to a boil over low heat;
- Boil for at least 5 minutes while stirring.

At first, the porridge will become thick, then runny, thick again; at this point, it is cooked. • Allow the porridge to cool, and it's ready to give to your child;

- Close the package tightly after use.
- Store the flour in a clean, dry, and cool place.

3.1.4 SOCIOECONOMIC CHARACTERISTICS OF HOUSEHOLDS USING MISOLA®

Table 1. Socioeconomic characteristics of households using Misola® fortified infant flour in the study area.

Characteristics	Frequency (N=211)	Percentage (%)
Gender		
Female	201	95.2
Male	10	4.8
Age		
Under 20	9	18.5
20 to 40	163	77.2
40 to 60	39	4.3
Marital Status		
Divorced	1	0.5
Monogamously Married	136	64.5
Polygamously Married	64	30.5
Widowed	10	4.5
Occupation		
Students	9	4
Civil Servants	34	16
Housewives	168	80
Educational Level		
None	43	20.4
Quranic 1st Level (1 to 30 hizb)	75	35.5
Quranic 1st Level (1 to 60 hizb)	01	0.5
Primary	30	142
Secondary	49	23.2
Higher	13	6.2
Ethnicity		
Hausa	171	81
Fulani	2	1
Tuareg	2	1
Zarma-Sonrai	36	17

The majority of respondents were female (95.2%) and fell within the 20 -40 age range (77.2%) (Table 1).

Most of these respondents were monogamously married (64.5%) with a secondary education (23.2%). This study also shows that the majority of respondents were housewives (80%). However, 81% and 17% of the respondents spoke Hausa and Zarma-Sunrai, respectively.

3.1.5 HOUSEHOLD TYPOLOGY ACCORDING TO FLOUR USE PRACTICES

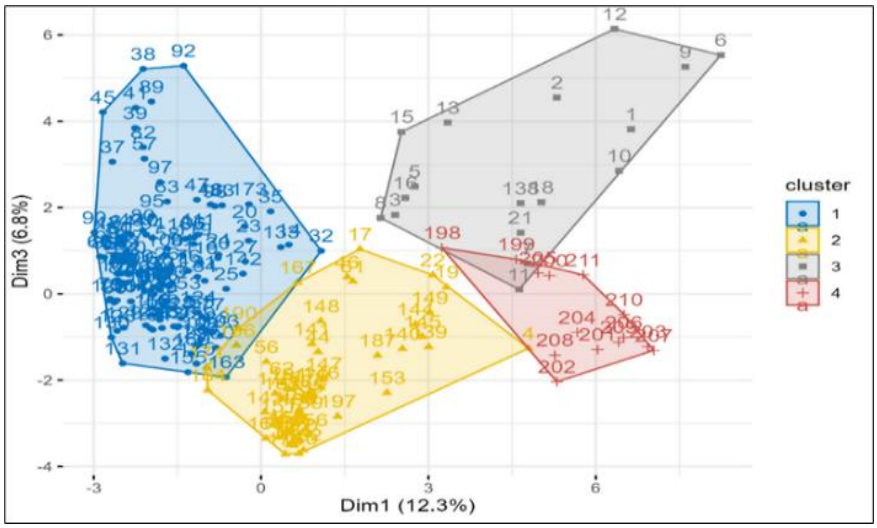

Fig. 5. Household typology according to their flour use practices

Figure 5 highlights four groups of households based on their flour-use practices. Specifically, households with a higher number of young children and shorter porridge shelf life; families at risk of delayed consumption and limited shelf life of porridge; households with longer shelf life and better hygiene practices for porridge; and households where the youngest child's age is relatively high.

3.1.6 HYGIENE PRACTICES OF HOUSEHOLDS

- Handwashing

  Figure 6 shows the distribution of handwashing before preparing Misola® porridge.

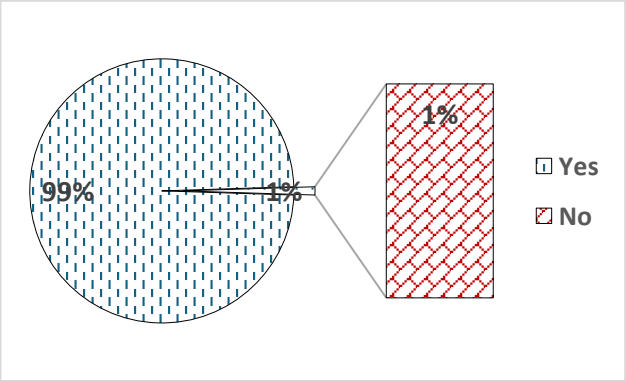

Fig. 6. Hand washing before preparing Misola® porridge

Analysis of Figure 6 shows that 99% of users of Misola® fortified infant flour wash their hands before preparing the porridge.

- Storage technique for Misola® fortified infant flour

  The storage technique for Misola® fortified infant flour is shown in Figure 7.

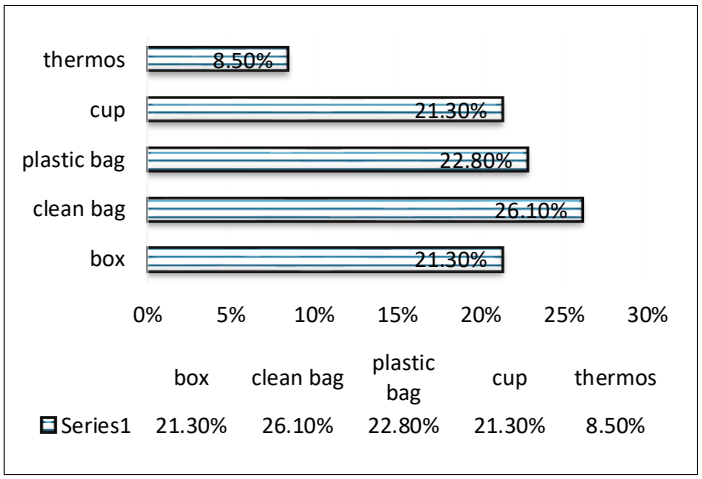

Fig. 7. Distribution of Misola® Infant Flour Storage Techniques

The analysis in Figure 7 indicates that (26.1%) of households using Misola® fortified infant flour store Misola® infant flour in its sachet.

3.1.7 LEVEL OF USE OF MISOLA®

- Reasons for Using Misola® Fortified Infant Flour

  Table 2 highlights the reasons for using Misola® Fortified Infant Flour.

Table 2. Distribution of Reasons for Using Misola® Flour

Reason	Frequency	Percentage (%)
Dietary Supplement	2	0.9
Availability	7	3.3
Availability; Nutrients	3	1.4
Availability; Nutrients; Taste	8	3.8
Availability; Nutrients; Natural Taste	3	1.4
Diversification	26	12.3
Diversification ; Nutrients	2	0.9
Taste	2	0.9
Taste ; Nutrients	6	2.8
Nutrients	**122**	**57.8**
Nutrients ; Diversification	11	5.2
Malnutrition Prevention	7	3.3
Price	4	1.9
Price ; Availability ; Nutrients	8	3.8
Total	**211**	**100**

Table 2 shows that 57.8% of households using Misola® fortified infant flour use it because they consider it nutritious.

- Infant age of introduction of Misola®

  Figure 8 illustrates the age at which Misola® porridge was introduced into children's diets.

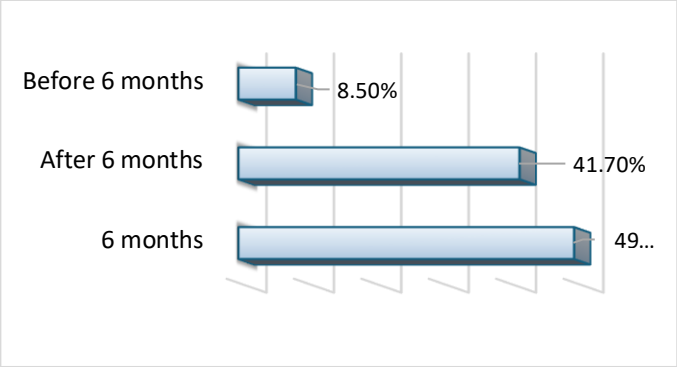

Fig. 8. Infant age of introduction of Misola® porridge into children's diet

The results in Figure 8 show that 49.8% of households using Misola® fortified infant flour begin giving their children Misola® porridge at 6 months of age. Furthermore, 8.5% of respondents introduced Misola® porridge before 6 months of age.

- Misola® porridge preparation technique learning

Figure 9 illustrates the location where Misola porridge preparation skills are acquired.

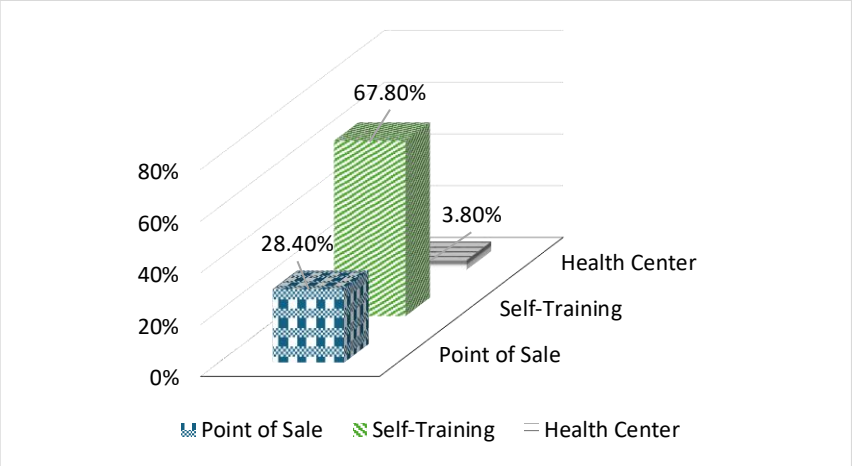

Fig. 9. Place of learning the Misola® porridge preparation skills

Analysis of Figure 9 shows that the majority of users (67%) acquired the Misola® porridge preparation technique through self-training (using the preparation instructions on the packaging), while 3.8% acquired the method at the health center.

- Correlation between socioeconomic characteristics and Misola® porridge use.
- Use of Misola® flour.

Table 3. Correlation between Misola® porridge preparation skills and people's occupation

Occupation	Knowledge of the Misola® porridge preparation technique		
	NO	YES	P-value
Students	0.9%	3.3%	
Civil Servants	3.8%	12.3%	0.981
Housekeepers	17.5%	62.1%	

There is no statistically significant relationship between knowledge of the Misola® porridge preparation skills and profession (P-value = 0.981).

3.2 DISCUSSION

This study was conducted to evaluate the production and use of Misola® fortified infant flour in Niamey, Dogondoutchi, Guidan Roumdji, and Tessaoua, to increase its consumption. This study shows that Misola® fortified infant flour is produced at the production units in Niamey, Dogondoutchi, and Tessaoua using the same processes. Women in Niamey, Dogondoutchi, and Tessaoua account for 86.7%, 87.5%, and 91.3% of the production, respectively. These results can be attributed to Misola's NGO's commitment to promoting women's empowerment and child protection. Furthermore, Misola® fortified infant flour production involves three steps: raw material purification, milling, and packaging. These steps are essential measures for producing high-quality infant formula. This could explain the current nutritional and microbiological quality of Misola® fortified infant formula. The results obtained for production hygiene at the Tessaoua production units are the most compliant, with 82.4% compliance, followed by the Niamey and Dogondoutchi production units, which achieved 70% and 58.8% compliance, respectively. This result is higher than that of el Ghaza et al. [12] in Morocco, who found 33.6%, 33.0%, and 47.0% in three study areas. These findings could be mainly due to staff training on good hygiene practices. Regarding gender, it was observed that 95.2% of users of Misola® fortified infant formula in Niamey, Dogondoutchi, Guidan Roumdji, and Tessaoua, respectively, are female. This could be explained by the fact that preparing porridge is a well-known activity among women in African society. The majority of users of Misola® fortified infant flour are aged 20 to 40, at 77.2%. This could be due to the relatively young population of Niger [3]. A majority of Misola® fortified infant flour users are in monogamous marriages, accounting for 64.5% of the total. This result is lower than that found by Laleye et al. [13], who reported that 92% of households are outside of the economic reach. This could be explained by the fact that the majority of users of Misola® fortified infant flour are in rural areas. Thus, the educational level of users of Misola® fortified infant flour is low [3], which is consistent with findings that the education of rural girls has long been a significant problem in Niger. Niger's low school enrollment rate justifies this finding. It was found that the majority of users of Misola® fortified infant flour are housewives (80%). This high proportion is attributed to their low socioeconomic status [14]. In this study, the Hausa ethnic group was the most represented, at 81%. This could be related to the selection of the departments of Dogondoutchi, Guidan Roumdji, and Tessaoua, where Hausa is the primary language spoken. However, these results also revealed that almost all users of Misola® fortified infant flour wash their hands before preparing porridge. These results are higher than those of N'Golo [15], who found a 68.8% rate. This could be explained by the fact that the surveyed population places great importance on hygiene, as well as by their basic level of Quranic education. In this study, 26.1% of users of Misola® fortified infant flour stored it in its original sachet, and 21.3% stored it in a box. This result could be explained by the fact that the sachet and box are suitable for preserving the flour when stored under the right conditions [16]. Most households (57.8%) use Misola® fortified infant flour because it is nutritious. This may be because respondents are aware of the flour's quality.

Although the majority of users of Misola® fortified infant flour (49.8%) introduce it as a complementary food from six months of age, 8.5% introduce it before this age. In some societies, the timing of complementary food introduction varies by infant; however, the ideal is for the diet to be diversified from the age of 6 months [17,18,19]. Introducing dietary diversification too early may raise the risk of morbidity and hinder the absorption of essential nutrients from breast milk. Additionally, premature diversification could impact psychomotor development [20]. This could be explained by the presence of civil servants among the respondents.

This study indicates that 48.8% of households using Misola® fortified infant flour continue to give Misola® porridge to their children beyond 24 months; however, only 20.4% of these households stop feeding Misola® porridge after 12 months. This could be explained by the fact that Misola® porridge is part of the child's eating habits. Furthermore, 67.8% of households using Misola® fortified infant flour have learned to prepare porridge through self-training. This finding was consistent with the Multiple Indicator Cluster Survey (MICS) conducted in 2016 by the National Institute of Statistics in Côte d'Ivoire [21].

There is no statistically significant relationship between knowledge of the Misola® porridge preparation technique and occupation. This could be explained by the fact that occupation does not necessarily determine knowledge of the porridge preparation technique, as even homemakers are familiar with the method.

4 CONCLUSION

It can be concluded that this study, which aims to contribute to the promotion of the production and use of Misola® fortified infant flour, has been achieved. Indeed, the output of Misola® fortified infant flour is organized as a network and carried out under Good Manufacturing Practices. Furthermore, the evaluation of hygiene rules across the various production units revealed compliance rates that meet international standards. The results and information collected during this field study will provide the MISOLA network and its partners with additional data to improve the production process and strengthen the use of Misola® fortified infant flour. However, some shortcomings were noted (67.8% of respondents learned the porridge preparation technique through self-training, and 8.5% of respondents introduced Misola® porridge as a complementary food before the age of six months) in the study areas. Overall, the use of Misola® fortified infant flour in the study areas is satisfactory. Furthermore, most mothers of children aged 0-59 months surveyed have a good understanding of the Misola porridge preparation technique and the appropriate time to introduce complementary foods into their children's diets.

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