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A Study on the Indigenous Methods of Processing Milk in Niger

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Abstract

The purpose of this study was to identify the methods of processing and preserving of local milk within the area of Liptako-Gourma in Niger. A survey was conducted and data were collected from 600 people involved in dairy sector, comprising of 59% producers , 28.7% collectors and 12.3% processors. The study also revealed two main methods of milk processing that is pasteurization and fermentation comprising of natural/ spontaneous fermentation done by 42.9% and fermentation method by backslopping practiced by 57.10% of processors. In addition, four methods of preserving milk were identified, including the cooling of raw milk, pasteurized or fermented milk, the pasteurization of raw milk itself for sale or for processing, the fermentation of raw milk or pasteurized milk and the addition of guinea pepper pods to fermented milk. Milk processing and preserving technology remains traditional with no compliance to hygiene good practices and the use of old material being limited most often to the strict minimum. Due to these results, attention should be paid to the training of the processors on hygiene and good practices at all levels of the local milk industry in order to improve traditional methods related to the processing and preserving of local milk and thus raising the quality of the dairy products in terms of microbiological safety

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Introduction

In Sub-Saharan Africa, with population growth, urbanization and changes in dietary patterns, the consumption of milk and dairy products as well as the local milk production are increasing but that local milk production could not meet the increased demand. This is as a result of most of the local milk production is neither sold or processed (Hamadou and Sano, 2005).[1] Besides, about 25 to 30% of that milk is lost through alteration before reaching the consumer (Gustavsson and al., 2011).[2] The distance between production and consumption areas is partly responsible for this loss of milk which quality may be poor initially. Milk is one of the most accessible sources of protein and plays an important role not only nutritionally, but also economically and socio-culturally (Leksir and al., 2015).[3] Unfortunately, milk constitutes a complex biological system, very reactive and sensitive to alterations (Mekroud, 2018).[4] Indeed, given its water content and its high nutrient content, milk can not be transported or stored easily. It therefore requires stabilization treatments if consumption is not immediate (Croguennec and al., 2008).[5] In Niger, one of the recent studies of ECOWAS (ECOWAS, 2017)[6] mentions a new element that radically changes the configuration of the local milk industry. In fact, in some dairy areas (the Niamey dairy basin), local milk supply is now widely available, given as the major challenges of dairy industry are being tackled. First, the milk industry has been developed and structured without milk processing improvement. More efforts should be done to maintain the milk industry due to the lack of opportunities. Traditionally, local milk industry is charaterized by traditional processing. There is any doubt, milk treatment is not the easiest activity in the harsh conditions of the Sahel (Ferrari, 2017).[7] However, hazards are not necessarily serious if the risks are well managed and traditional methods of milk processing and preservation are effective in reducing these risks. Although milk-borne zoonotic diseases, including brucellosis (Boukari and al., 2013)[8] and Rift Valley fever (Doutchi and al., 2017),[9] are confirmed in Niger, few studies were conducted to evaluate milk quality and to improve traditional methods of processing and preserving of local milk. Nowadays, improvement of traditional methods of milk processing as a means of preserving remains a challenge. The present study aims to investigate about indigenous techniques of processing and preserving of local milk in the area of Liptako Gourma region in Niger.

Material and Methods

Area of Study

This study was conducted in the area of Liptako-Gourma located in between the borders of Burkina Faso, Mali and Niger. It covers 9.7% of the whole Niger's area and is made up of the regions of Dosso, Niamey and Tillaberi. The dairy basins of the capital Niamey, where demand for the dairy products is greater than supply, are located within that area. There are three collection centers located in Kollo, Hamdallaye and Say (Figure 1). The dominant economic activity is agriculture and livestock, which are hampered in their development by the inaccessibility to water and the invasion of the Niger River by the water hyacinth. A cross-sectional survey was conducted to collect data.

Sampling

Selection of Areas for Survey

The three (3) target regions of the area of Liptako Gourma comprised of 12 dairy basins which, in addition to being areas of milk collection (important dairy production) for the milk supply to large cities, are located within 100 km radius around those three regions and are located on a tarred road to facilitate the safe transport of milk. Niamey, the capital of Niger is supplied by these three (3) regions. The three largest milk collection centers are located in this area.

Selection of People for Survey

A total of 600 people involved in local milk processing were randomly selected from a list provided by the local authorities and interviewed. This choice takes into account their availability to provide information. The 600 targeted samples population belonging to12 dairy basins were distributed at the rate of 50 samples per dairy basin.

Data Collection Methods

A cross-sectional interview survey was conducted for data collection. The information collected are : main activity or cumulative activities, sex, age, ethnic group, type of material and equipment used, origin of the raw material, usual traditional methods processing and preserving of local milk, reasons for

method choosen, advantages and disadvantages of the methods, description of the methods used. To check the mechanism of these methodologies, 37 samples population, 5 women associations and 3 collection milk centers of Kollo, Hamdallaye and Say were interviewed in their processing units.

Statistical Data Analysis

The collected data were entered in Excel and analyzed with the SAS software (Statistical Analysis System, 2012).[10] Frequencies were calculated using Proc freq of the software and compared by the Chi-square test and the bilateral Z test. For each relative frequency, a 95% confidence interval was calculated.

Results

Subjects Involved in Milk Processing

The subjects comprised of producers, collectors and dairy processors who are also involved in selling dairy products. There are no subjects involved in a single activity. Although the activities are overlapping, three main types are identified. They are:

- producers-processors-dairy sellers: dairy producers involved in dairy processing are responsible for the sale of milk either directly to the consumer, to the collectors or to the processing units (raw milk only). They represent 59%;
- collectors-processors-dairy sellers: these actors represent 28.7%. Two collection centers have been identified in the area of Liptako Gourma: the collection centers of Hamdallaye and Kollo. The mini dairy industry of Say is also a collection center for raw milk. There are other raw milk collection centers operating on open air located near the main roads around the capital Niamey (Ouallam, Say, Fillingué and Tallagué);
- Dairy processor-sellers: they are involved in processing and selling of local milk. They are the least numerous (12%).

Indigenous Methods of Milk Processing

Milk processing is carried out within family households, collection centers and processing units. In the area of Liptako Gourma, the main form of milk processing is fermentation after pasteurization. Local milk is the raw material and comes from early morning milking (before 7am) or early evening (after 6 pm). The material used is mainly aluminum pots or pans, gas stoves (mini dairy industries and collection centers) or firewoods (households). Pails, bowls, and cups made of plastic, aluminum or stainless steel,

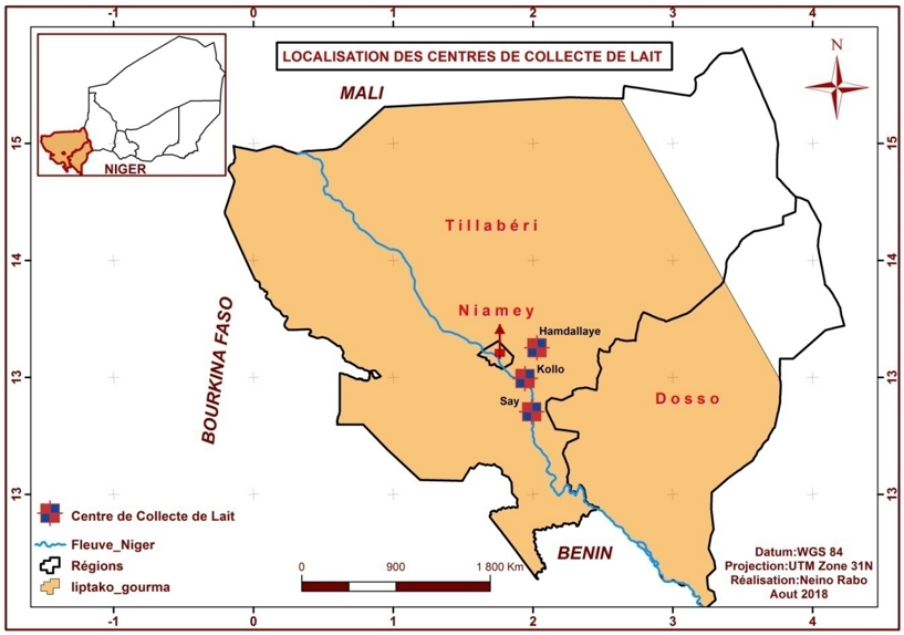

Fig. 1: Regions comprising of area of Liptako Gourma in Niger

pieces of cloths, sieves and gourds are also used. The technology depends on labour , all operations being done manually, sometimes with no compliance to good hygiene practices such as hand washing and utensils. The filtration of pasteurized or fermented milk is done by 87.66% of the subjects whether the milk is being milked or bought.

Pasteurization

One of the processing form of local raw milk is pasteurization, which is practiced by 33.50% of the subjects. The main steps in obtaining pasteurized local milk are the filtration of raw milk using a sieve or a clean piece of cloth and the heating. The milk is gently heated but not allowed to reach boiling point (70 to 80 ° C) and is left to cool at room temperature. The cooled milk is filled in a 0.5L; 1L; 1.5L plastic bottles and packaged in plastic bag by the Fulani people who are the main processors. In case of women's associations and mini-dairy industries dealing with collection centers the filling is done using thermo-welded plastic bags. Figure 1 shows the production flow of pasteurized local milk.

Fermentation

The traditional fermentation of milk, by far the most practiced in the Liptako-Gourma area (66.50% of actors), is carried out in two different ways:

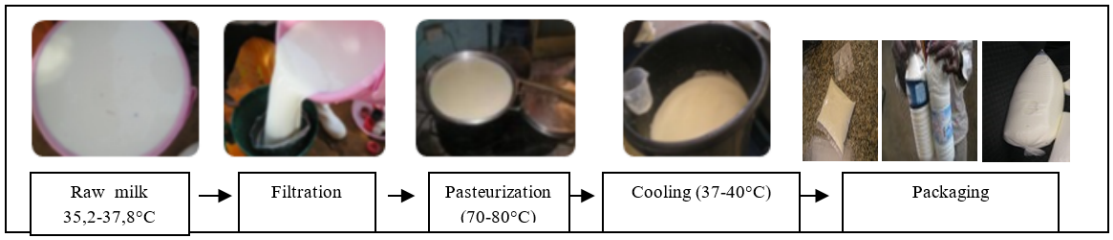

Fig. 2: Steps to obtain pasteurized local milk

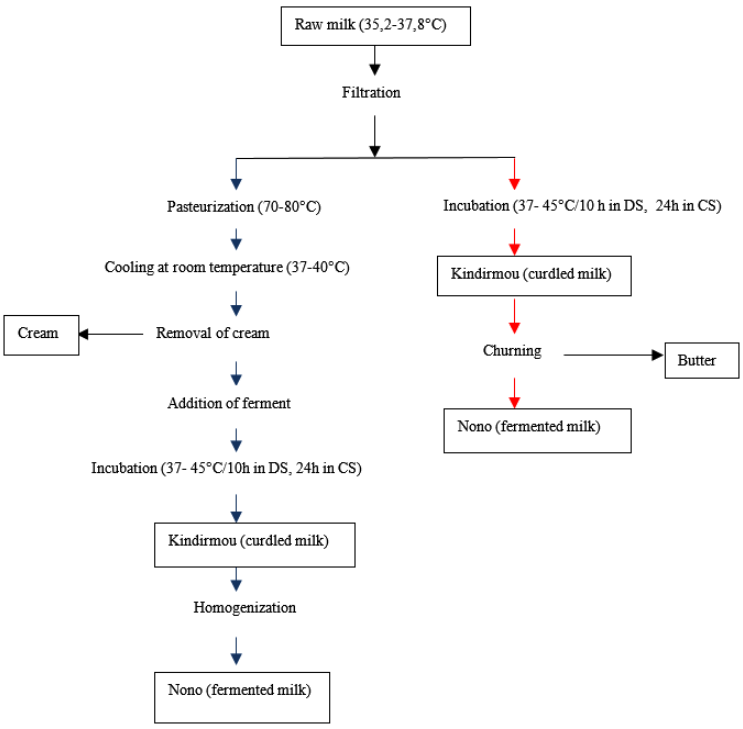

Fig. 3: Steps to obtain fermented milk

- Fermentation of milk is obtained naturally without adding inoculum. This type of fermentation is practiced by 42.90% processors and mainly by the Fulani women. The raw milk milked during the early evening (6 to 7 pm) is allowed to ferment spontaneously overnight at room temperature in the households (Figures 2 and 3). The curdled milk (kindirmou) thus obtained can be sold and consumed, or it is homogenized with a wooden stick to give a product called locally "nono". The consistency of the "nono" varies from slightly smooth to lumpy. It can be kept for 4 to 5 days in the hot season and up to 1 week in the cold season (temperature averages between 15 and 34 °C, down to 9 ° C);
- The fermentation is obtained by the introduction of sourdough or inoculum after heating and then cooling the milk. This inoculum is a portion of fermented milk from the previous batch or commercial curdled milk. The milk is heated for a few minutes (approximately 5 to 10 minutes to 70-80 °C) to reduce the existing level of microbial population. The ambient temperature (35 to 40 °C up to 45 °C.) corresponds to the incubation temperature during the entire fermentation period, which is variable depending on the season. The average fermentation time is 10hours in the hot season, and 24 hours in the cold season. This method is used by most of milk processors (57.10%), including women's associations, mini dairy industries and some Fulani women. The fermented milk is then filled in thermo-welded plastic bags by mini dairy industries and women's associations. The fermented milk is sold by Fulani women at the cost of 50 FCA to 100 FCFA (Figures 2 and 4). The prices are constant; it is only the quantity which varies according to the abundance or the scarcity of the milk.

Indigenous Methods of Milk Preserving

Raw milk is a fragile material, it can only be kept for two hours before breaking down. Preserving is therefore an essential element of the safe use of the milk. The indigenous methods of preserving raw milk and fermented milk, listed in Table 1, are as follows:

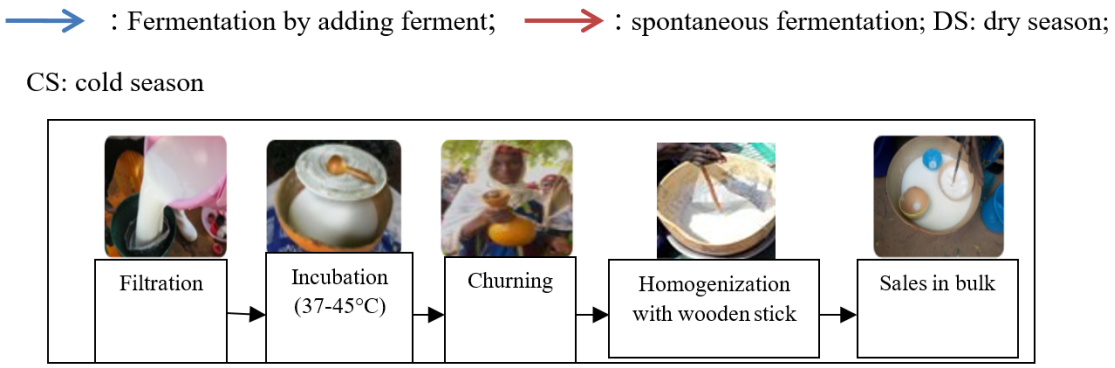

Fig. 4: Steps to obtain spontaneously fermented milk

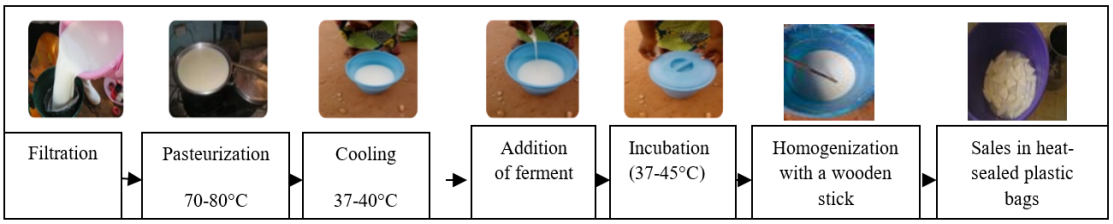

Fig 5: Steps to obtain fermented milk by addition of ferment

- Cooling: this is a technique for lowering the temperature of the milk used by all the subjects, but with variations that are summarized in Table 1. This process is applied directly to raw milk, or coupled with pasteurization and or fermentation;
- Pasteurization: this heat treatment is applied to local raw milk in order to make it suitable for consumption and to increase its preserving time by destroying its pathogenic bacteria. Mechanical cleaning precedes pasteurization, which is followed by cooling in all cases. It is used by 71.50% of subjects;
- Fermentation: it is a method of lowering the pH of raw milk or pasteurized milk by the initial or added microorganisms to make it inappropriate for the development of pathogens and extend its preserving time. It is used by 66.50% of subjects. Both variants of this method are summarized in Table 1 ;
- The use of "kimba" pods or Selim pepper (*Xylopia aethiopica*) to fermented milk to take advantage of its therapeutic properties in addition to increase its preserving time. This method is used by 37.20% of those practicing milk fermentation.

Discussions

Subjects of Local Dairy Industry

Local milk is traditionally produced and marketed without intermediaries; it is a close supply market. But nowadays, with the growing demand for dairy products in proportion to the rampant urbanization, new subjects evolved at different levels of the dairy local milk industry (mainly milk processing). Thus, pre-existing subjects have changed employments (Penot and Razanakoto, 2012)[11] or have been involved to additional jobs. So each subject is also a distributor, and can also be a milk processor. However, it should not be forgotten that in sub-Saharan Africa, most of the milk comes from pastoral and agropastoral farms (Corniaux and al., 2014)[12;] which explains the larger number of producers-processors-sellers.

Indigenous Milk Processing

Preserving and keeping the milk in the absence of cold chain, is always by means of processing it. Milk processing in the area of Liptako-Gourma

Table 1: Indigenous methods of preserving local milk and fermented milk

Preserving methods			Sample size	Level of practice (%)	Confidence Interval (CI)
Raw milk	Cooling	- Immersion of the milk container in fitted parts of the river	36	6,00	0,01
		- Immersion of the milk container in another larger container	93	15,50	0,03
		- Covering the milk container with branches or jute bags wet with water	183	30,50	0,04
		- Storage of the milk container in the shade	288	48,00	0,04
	Pasteurization	Heating of milk until rustling	201	33,50	0,04
	Fermentation	- Spontaneous fermentation not in calabash	14	3,50	0,02
		- Spontaneous Fermentation in calabash	157	39,34	0,05
		- Fermentation by addition of inoculum	228	57,14	0,05
Fermented milk	Cooling	Storage of the fermented milk container in the shade	399	100,00	0,00
	Use of plants extracts	Addition of some Xylopia aethiopica pods in fermented milk	122	30,57	0,05

is done most often within family households (Galal and al., 2014).[13] The collection centers in this area also serve as places of milk processing. Fermented milk is the predominant form of valorization and processing of local milk not only because it is the most appreciated (Knight-Jones and al., 2016)[14] but also because it is preserved longer than raw milk and pasteurized milk. Indeed, the high temperatures of this area are not favorable for the preserving of the milk because the temperature plays a primordial role on the bacterial growth (Hamiroune and al., 2017).[15] In the absence of a refrigeration device, it should be noted that early morning milking takes place as soon as possible and is followed immediately by collection (Koye and al., 2015, Dassou and al., 2017)[16,17] because the long duration of these operations (milking, collection, transport) affect the microbiological quality of the milk (Gran and al., 2002a).[18] The traditional methods of transformation make use of the inexpensive material of frequent use in the domestic tasks. The use of plastic materials of various origin mainly recovered plastic (Bagré and al., 2015)[19] can considered better suited to the task, is very common although plastic has major health disadvantages given the difficulty of suitable cleaning. In reality, these plastics can sometimes be recovered from dust bins which are not sterilizable and the washing method used is not sufficient to contain a sterile substance (pasteurized milk). This results in recontaminations of "clean" milk by "dirty" containers; which is accentuated by the lack of good hygiene practices during the filling process. It should be noted, however, that the collection centers that benefit from some grants, have a more efficient equipment: cooling milk tank, aluminum utensils, small equipment for quality control of milk, gas stove. The level of hygiene good practices is very low especially when manipulations are carried out on small farms (Kamana and al., 2017, Knight-Jones and al., 2016).[20,14] During the washing of hands and processing equipment, the water used sometimes has low quality, with or without soap. The utensils, after washing, are exposed to open air for drying in the presence of insects and dust. If plastic and stainless steel can be cleaned properly when soap and drinking water are available, this is not the case for the calabash. It's porous nature does not facilitate disinfection and for which the use of soap is not suitable because as the smell is later on felt in the milk. Poor hygiene increases microbial contamination (EFSA, 2015; FAO, 2016).[21,22] Heating the milk after milking makes it easier to preserve it. But the problem at this level is that milk processors do not master the control of the couple time and temperature for sterilization; which leads to the production of low heated or overheated milk. Another problem of pasteurization in rural areas is the lack of cold chain leading to subsequent microbial growth during transport or non-refrigerated distribution. In addition, it is more difficult to ensure that pasteurization is done correctly by many processors. Although milk does not show a noticeable change when pasteurized, there is a risk that pasteurization may not be done properly. It must also be taken into account that poor hygiene can not be fully mitigated by pasteurization, especially if the milk is contaminated with microbial spores or if the handling after pasteurization is unhygienic. Pasteurization also does not inactivate toxins produced by certain strains of *Staphylococcus aureus* (Dinges and al., 2000)[23] Boiling certainly requires more energy, but is easily observable and can be more reliable (Kouamé-Sina and al., 2010)[24] provided that the temperature is monitored because exceeding the sterilization time, is not without unpleasant consequences (cooked taste).

Regarding the fermentation technique, women involved in milk processing have an empirical knowledge and sufficient experience that allow them to master the process. However, they ignore or neglect basic notions of hygiene and food processing; this does not allow them to use all their knowledge in order to control the quality of their products. To achieve natural fermentation, the raw milk is filtered and left at room temperature (Dahou and al., 2015)[25] in containers (plastic or stainless steel buckets, calabashes, plastic cans) which are later covered. The ambient lactic flora (environmental, utensils, milk) develops spontaneously and produces lactic acid which causes curdling. This lactic flora that develops there inhibits the proliferation of pathogens. In general, good lactic acidification leads to inhibition of growth of pathogenic bacteria (Ismaili and al., 2016).[26] However, the reseeding method (which consists of adding some of the previous fermented milk (Holzapfel, 2002; Duteutre, 2003, Josephsen and al., 2004)[27,28,29] to enhance the fermentation of the new batch is a potential source of contamination because

of the harmful microorganisms which may have been introduced during manipulations of this inoculum (Kouamé-Sina, 2013).[30] The lack of control of the incubation temperature of fermented milk remains a critical point in the fermentation process, because *E. coli* 0157 H7 is perfectly capable to multiply in fermented milk when the incubation is between 25 and 37 °C. On the other hand, its growth is almost impossible when the incubation temperature is 43 °C. (Ogwaro and al., 2002)[31] .There is no definite duration for the fermentation, it is the visual appreciation of the gel that determined the end of the process. The churning to homogenize the curd obtained at the end of fermentation is optional and is especially done by Fulani women. However, the standard practice of manual mixing with a wooden stick may be a potential source of milk recontamination. Another source of problem is the conditions the fermented milk is sold. Its transport to the selling place and even its sale are done under the sun; which facilitates its deterioration. In addition, containers that are plastic and metal are very sensitive to heat. The recurrent instability of the milk sales price is undoubtedly linked to the strong seasonal fluctuation in production and supply. In the dry season, there is a significant drop in milk production and obviously an increase in the price of milk. In rainy weather, however, the increase in milk production and the lack of market regulation cause a drop in the price of milk. Processors only adapt to this situation of high variability in milk availability (Andrianarisoa and al., 2016).[32] On the other hand, the lack of regulation in determining the price of milk leads to changes of price by producers according to the period and to the decision from milk processors that are used to buy the raw milk. The sale of dairy products is based on the price and service provided by existing marketing channels (Ishaq and al., 2016).[33]

Preservation of Milk by Indigenous Methods

The different methods of processing and preserving the local milk in this area is all about the research of a matching condition between a good temperature of preservation and the fermentation temperature of the milk. However, temperature variations (20 ° C to more than 40 ° C) are hardly suitable. The methods of lowering the temperature, if properly carried out, allow a decrease in microbial growth. The immersion cooling of the milk container in the fitted parts of the river (running water) may be effective in the case where these containers are mobilized without overturning, and when they are hermetically closed. This last precaution is better as the recontamination could come in this case from the river water. For an effective immersion, the level of the water must be sufficient to cover the milk's container while avoiding the water entering the container. In fact, stagnant water does not allow to quickly eliminate heat, in this case it is necessary to renew the water from time to time. Branches and bags used to cover containers must be cleaned because they can hide microorganisms that can be transferred to the milk. Shady places for storing milk should be cleaned. Pasteurization of milk as a method of preservation is a common practice to protect consumers against food-borne pathogenic bacteria (Ranieri and al., 2009).[34] This practice is used world wide to increase the preservation period of this highly perishable food product (Ivy and al., 2012; Cherif-Antar and al., 2016).[35,36] Destruction of part of the microorganisms by heat through pasteurization helps to obtain milk that can be stored for 7 days with refrigeration, and to stabilize milk intended for processing. However, the preservation period of milk is closely related to the initial microbial load (Yabrir and al., 2018).[37] The use of the traditional calabash is also a risk factor. It should be noted, however, that Lagenaria siceraria, a Cucurbitacea used to make these calabashes, is a medicinal plant with many virtues (Shah and al., 2010).[38] Regarding the use of Xylopia aethiopica to extend the preservation period of fermented milk for a few days (3 to 4 days and sometimes more), it deserves to be investigated to verify the real antibacterial aspects of this plant.

Conclusion

Immediate consumption of raw milk is no longer an option, Pasteurization and fermentation are the most common methods of processing and preserving of local milk, which seem to be the most appropriate in the adverse conditions of the area of Liptako Gourma in Niger. They do not require a large investment in equipments, and are adaptable to local traditions and climate. Other techniques ranging from cooling by natural methods of raw milk, pasteurized milk and fermented milk as well as the use of Xylopia aethiopica pods for the specific storage of fermented milk are used. Hygiene and technology could be controlled as soon as processors are supported in their practices.

Conflict of Interests

The authors have not declared any conflict of interests.

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