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CHARACTERIZATION OF TRADITIONAL PROCESSES FOR THE PRODUCTION AND PRESERVATION OF CURDLED MILK AND BUTTER IN PASTORAL AND AGRO-PASTORAL AREAS OF NIGER

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ABSTRACT

Traditional milk curd and butter production processes remain largely unexplored by research in Niger. The aim of this study was to characterize traditional curd and butter production and preservation processes in two production zones (pastoral and agropastoral) in Niger. The method used was a participatory diagnosis of the curd and butter production process, and the data were collected using a semi-structured survey from 98 producers and sellers of curdled milk and butter. The results demonstrated two types of process, nomadic and sedentary, whose differences lie in spontaneous fermentation and fermentation with the addition of curds, as well as in washing and non-washing of butter. However, butter was obtained by simple churning of the cream recovered after fermentation of the milk. The production utensils were essentially of vegetable origin, the calabash used for fermentation and the gourd as a churn. The calabashes were cleaned using only the roots and/or stems of vegetable plants and the gourd was washed with hot water and small pebbles. The source of most water used was significantly related to the zone ($P=0.037$), with producers in the pastoral zone (PZ) using mostly swamp water (53.3%) and those in the agro-pastoral zone (APZ) using mostly tap water (47.6%). The preservation of curdled milk and butter was also linked to the type of farming ($P=0,000$) wherein nomads used guinea pepper as a preservative for curdled milk, while sedentary farmers in the PZ used manioc tubers and/or ginger, and sedentary farmers in the APZ use cowpea seeds and ginger. For butter preservation, the APZ sedentary used guinea pepper preserved in fermented milk. Processors are faced with conservation constraints and poor sales of their products. Non-compliance with good hygiene and manufacturing practices has an impact on the quality of curdled milk and traditional butter, and can be a source of public health problems. Packaging and storage equipment for dairy products is unsuitable, as it encourages translucency and oxidation. Traditional preservation techniques are promising, but require further scientific investigation. Improvements to these traditional processes are needed to guarantee consumer health safety and increase producer incomes.

Key words: Curdled milk, Butter, Pastoral, Agropastoral, Production, traditional, Preservation, Niger

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INTRODUCTION

In Africa, as elsewhere in the world, milk combines tradition and modernity. Milk is the source of a multitude of products, and is both the heir to a long tradition and the purest symbol of the industrialization of the economies [1]. In addition, this milk is produced in very small-scale facilities in most developing countries. As such, it makes a significant contribution to household livelihoods, food security and nutrition [2]. Indeed, households transform milk into dairy products through the natural fermentation of milk. Fermentation had in fact traditionally been used more or less consciously. Indeed, until the end of the 19th century, dairy products were mainly consumed in fermented form (fermented milk, farm butter, cheeses made from fermented milk) [1]. Niger has a culture of consuming milk and dairy products [3]. The production systems that feed the dairy sectors in Niger are of various types and are dominated by extensive methods of herding [4]. The local milk sector is composed of two sub-sectors: the peri-urban milk subsector, which is present in the major towns, and the rural milk sub-sector, which is the preserve of agricultural and pastoral areas [5]. This represents 70% of the milk sold in local markets in the Sahel regions [6]. Different types of dairy products share the market, but locally produced curdled milk [7] and butter and cooked butter (ghee) are the most consumed in Niger, mainly in Niamey, with 80.3%, 59.6% and 57.1%, respectively. The results of the consumption study revealed that organoleptic characteristics are the most sought-after attribute in curdled milk and butter [8]. The containers used for collecting and processing milk are made from plant materials. The calabash used for milking is not the same as that used for curdling. There are as many types of calabashes as there are uses for the milk. The production and sale of curdled milk and farm butter has always generated exchange opportunities or regular cash inflows for the women of small-scale producers in pastoral (PZ) and agro-pastoral (APZ) areas [9].

However, the lack of organized fresh milk collection networks in pastoral areas, similar to those in some peri-urban areas, means that pastoralists are unable to sell their produce. This situation leads to huge post-production losses, forcing traditional processors to develop conservation initiatives using plant extracts to increase the stability of dairy products. It is within this framework that this study was initiated, the aim of which was to characterize the traditional manufacturing and preserving processes for curdled milk and butter in the pastoral and agro-pastoral zones of Niger, in order to propose ways of improvement.



MATERIALS AND METHODS

Framework

This study was carried out in the pastoral and agro-pastoral areas of the departments of ABALAK (PZ) and KEITA (APZ) in the Tahoua Region, and BERMO (PZ) and DAKORO (APZ) in the Maradi region. These two regions are among the four with $\frac{3}{4}$ of Niger's cattle population and high milk production.

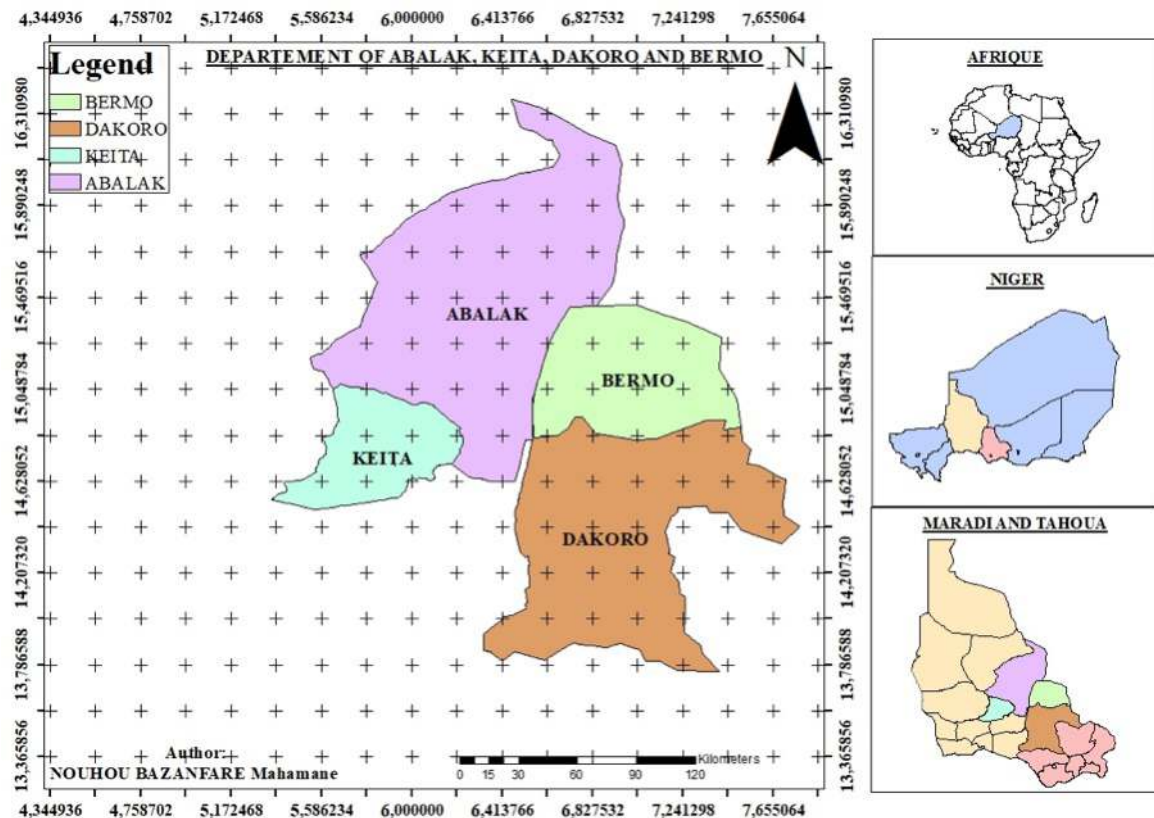


Figure 1: Map of studied areas in Niger

Sampling method

The non-probabilistic snowball method [11] was used to reach the main targets of the study. The first target (women sellers) met at the market served as a guide for meeting the second target, as a common thread leading back to the producers. The producers selected for monitoring during production were chosen on the basis of criteria including the originality of their processes and their experience in the activity. This is a descriptive study carried out between October and November 2023.

Data collection method

The data were collected using the mobile data collection system kobotoolbox, through a semi-structured survey and involved 98 producers and sellers of curdled milk and butter. Four focus group of 8 to 10 people were also used to collect qualitative data. Furthermore, a follow-up of the various manufacturing processes used to preserve curdled milk and butter was also carried out.

The various parts of the surveys were structured as follows: identification of the survey, source of water, modes of milk acquisition, types and utensils used, type of local used, modes of packaging and transport of dairy products, modes of milk acquisition, curd and butter production processes, characteristics of fermented dairy products, modes of curd milk and butter preservation, constraints, challenges and advantages.

Data processing and analysis

Statistical Package for Social Sciences (SPSS) 25.0 software was used for descriptive analysis of the variables age, level of education, main activity, sex and marital status. For the chi-square test, the area variable was used as the dependent variable, and the milk acquisition mode and water source variables as the independent variable. R software was used for factorial correspondence analysis, with livestock rearing mode as the independent variable.

RESULTS AND DISCUSSION

Socio-demographic characteristics of producers of curdled milk and butter

Table 1 shows the socio-demographic characteristics of milk handlers. The analysis of the results in Table 1 show that the individual survey involved 56.1% of milk processors, 25.5% of dairy product sellers and 18.3% of milk producers/breeders. The majority of players in the curdled milk and butter value chain were women (87.7%), compared with 12.2% of men. Also, 90.8% of these stakeholders were married and had an average age of 47.1 with a standard deviation of 12.1. The results revealed a high rate of uneducated actors (87.7%), and low rates of primary school enrolment (3.0%) and Koranic school literacy (9.1%). The Fulani ethnic group was the majority (59.6%), compared with the Hausa (23.3%) and Tuareg (17.2%) ethnic groups.

The Fulani ethnic group was more represented among producers of curdled milk and butter, with a rate of 66.0%. This could be explained by the fact that cattle rearing and milk processing is a recognized activity for the Fulani ethnic group [12] and it was also reported that the Fulani are cow breeders and 'milk people', spread over all the regions of the country, throughout the savannahs of West Africa. The use of calabashes by the majority of producers (88.8%) could be explained by the traditional approach that is involved throughout the chain. The age of the



respondents must be interpreted with caution, as the majority of them did not know their exact dates of birth.

Characterization of curd and butter production in the study area

Source of water used

The relation between source of water supply and zone is shown in Table 2. The chi-square test showed a significant difference ($P=0.037$) in the sources of water used in the different zones. Producers in the APZ (47.6%) used tap water and those in the PZ (53.6%) used swamp water. Well water was also commonly used (30.4% in PZ and 23.8% in APZ).

As far as water treatment is concerned, in the pastoral and agro-pastoral zones, the process of decanting cloudy water from ponds or marshes was done by introducing a piece of 'gypsum (dehydrated calcium sulphate)', locally known as '*Lallâm*'. The technique involves introducing a piece of gypsum and waiting 5 to 10 minutes for the water to clear, then decanting the water into another container, discarding the sludge deposit. This technique does not sanitize the water; therefore, its consumption and use present a biological risk. It is, therefore, essential to heat the water before consumption.

The results of the survey revealed that farmers in the agro-pastoral zone used tap water, unlike those in the pastoral zone, who used swamp water; during the rainy season, surface water is abundant. The ponds are full and are the main source of water for people and animals in the pastoral zone [12]. The use of this water could be a source of contamination for utensils and dairy products.

Typology of production utensils

Processors mainly used vegetable products in the various links of the milk chain. The milk is collected in a medium-sized calabash ('birdidé' in Fulani), with a capacity of 2 to 3 Litres. This is a specific calabash used only for this process. The calabash ('Toumoudé' in Fulani) used for collection and/or family consumption, has a varying capacity from 2 to 10 L or more depending on productivity.

The calabash ('Yanerdé' in Fulani) used for fermenting the milk is the most important in the whole chain, with a capacity of 5–20 L or more, depending on productivity. Cleaning is carried out without detergent, and the crushed root of *Prosopis africana* (kirya in Hausa) and/or the crushed stems of *Combretum glutinosum* (Taramniya in Hausa) are used as brushes during washing. Parts of these species are crushed and dried, and used until they are exhausted.



For the churning, the liana calabash or gourd 'fruit of *Lagenaria siceraria* (Cucurbitaceae)' is used. Small pebbles are sometimes used to facilitate churning, but also for cleaning by incorporating hot water. The capacity of the gourd varies from 1 to 4 L or more, depending on productivity (Figure 2).

The use of plant products as utensils in the various process of milk processing shows that the technological processes have retained their traditional character, the same practices have been observed in Burkina Fasso [14]. Good curdling is achieved with a calabash made from mature, firm wood, and a lid of plant material. However, in Senegal, plastic utensils are increasingly being used due to the scarcity of plant-based calabashes [15]. According to the author, Senegalese farmers feel that plastic utensils do not produce good curdling, as the steam sinks into the curd and makes it less firm.

Plant products are by nature biologically active, and these species are also used to remove bitterness from new gourds. These plants have been recognized for their wealth of active compounds (antibacterial, antioxidant, antiparasitic properties) [16].

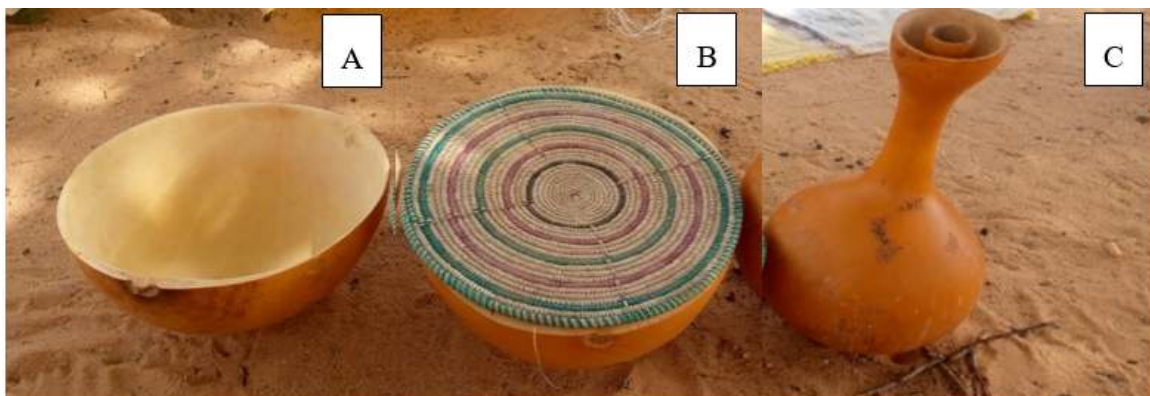


Figure 2: Utensils used for milk collection (A), fermentation (B) and churning (C)

Type of processor premises

The different types of curd and butter production environments are shown in Figure 3. The results of this figure show that the majority (63.3%) of transformers used an open environment for processing. The closed environment was used by 36.6%. With regard to processing premises, 66.3% of processors used an open environment for the manufacture of curdled milk and butter, which could be a source of environmental contamination of the product.

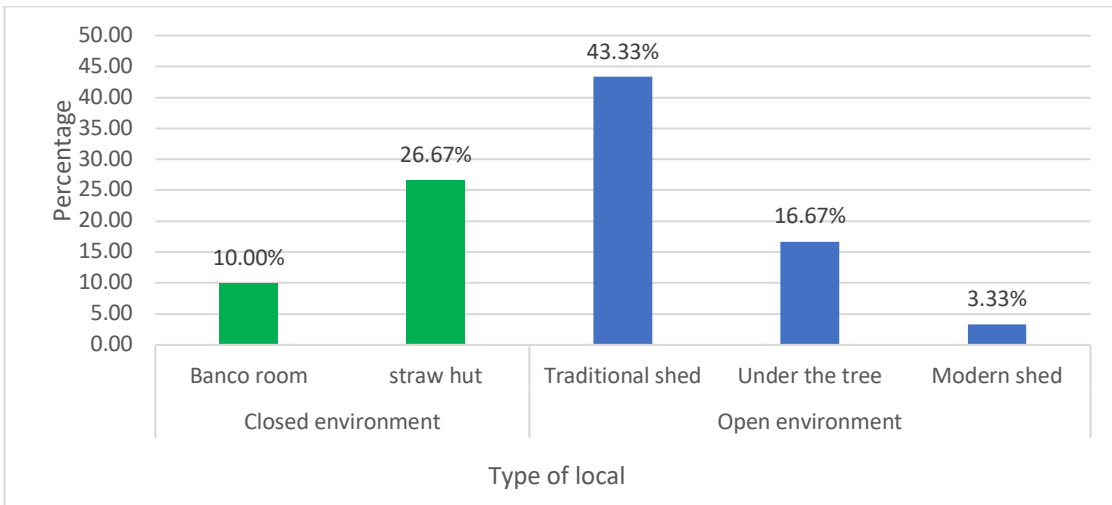


Figure 3: Type of local equipment used for milk processing in the pastoral and agropastoral zones

Traditional manufacturing processes for curdled milk and butter

Methods of acquiring milk

The results in Figure 4 show that all the producers in the pastoral and agropastoral zones used all their entire milk production in their processing activities. Nevertheless, some of these processors (12.5% and 7.7%), from the pastoral and agropastoral zones, respectively, also purchased the milk they used for processing. The purchase of supplementary milk takes place mainly during the dry season, due to the movement of grazing herds (transhumance and/or nomadism).

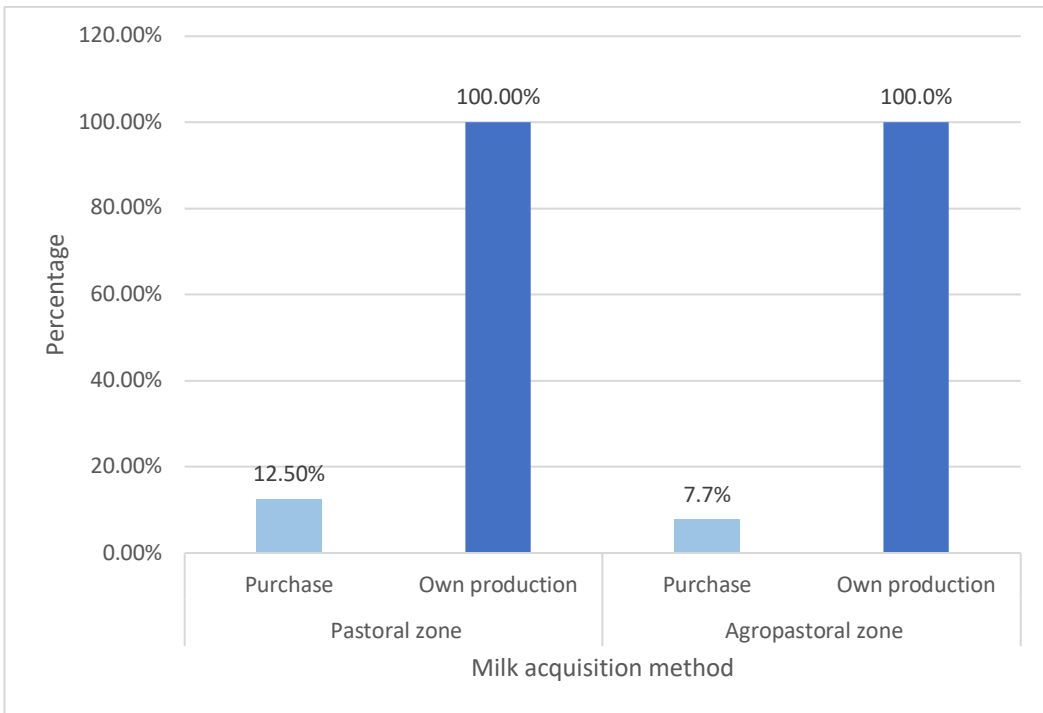


Figure 4: Milk procurement by curd and butter producers



Process of curd production in agropastoral and pastoral areas

The quantity of raw milk used per day varies according to the processor, the season and the zone. In the APZ, the quantity of milk processed per day was between 2L and 12L, and in the PZ it was between 2L and 25L. Figure 5 shows the production diagram for curdled milk and butter.

The following are the 7 steps for making curdled milk and butter in a traditional manner:

1. Filtration

Filtration is carried out if the raw milk has impurities on the surface. The equipment used is a sieve or, a piece of light clothing.

2. Heating the Milk

Sedentary farmers heat the raw milk during the cold season. The temperature is not controlled, the milk is heated before boiling and left to cool to room temperature before undergoing the fermentation process.

3. Fermentation

Two types of fermentation were noted: spontaneous fermentation and fermentation by adding the curd from the previous day (ferment). The fermentation process varies according to the type of farming and the season. Whatever the type of farming, the 'yanerdé' calabash is used for fermentation. In the cold season, sedentary farmers heat the milk before introducing it into the fermentation calabash. Others add a few millilitres of hot water (50 to 100 ml) or fermented milk from the previous day (50 to 200 ml). Nomads, on the other hand, put the milk directly into the 'yanerdé' calabash and place it on the traditional cooking stove, taking care to remove the embers. The heat from the stove warms the milk and speeds up the fermentation process. In the hot season, the milk is poured directly into the 'yanerdé' calabash without adding any ferment. The calabash is not hermetically sealed, but covered by a valve. The duration varies from 12h to 24h. The formation of the clot and the rise of the cream to the surface are signs that the fermentation process is complete.

4. Skimming the Milk

After the milk has been curdled, the cream is removed from the surface of the curdled milk by scraping with a ladle or a piece of a calabash. The curdled milk thus becomes partially skimmed, 'Wouloure' in Fulani (Woodabé-bororo) and 'Saré' in Hausa in the PZ, or 'Nono' in Hausa and 'Kossom' in Fulani (fulbé) in the APZ. Sedentary farmers with a small production (on average 10 L) collect cream two or three days before churning, while nomads with a large production (on average 18 L) churn it directly after skimming.



5. Churning

Churning is done very early, in the cool of the morning, using the gourd (figure 2C), it can also be done during the day (cold season). The process consists of introducing the cream into the gourd and shaking it for 15 to 20 minutes for a quantity of less than or equal to 2L of cream. When the butter seeds start to take shape, a few milliliters of water (100 to 300 ml) are added to break them up from the milk. Sedentary people do not add water during churning when the butter is to be used as a traditional remedy. After churning, the contents of the gourd are poured into a calabash, and the butter seeds are then grouped together using a ladle or a traditional whisk. The lumps of butter thus formed are immersed in the 'nono' curdled milk for storage and sale, mainly in the case of sedentary people, or they follow the rest of the process in the case of nomads.

6. Washing

Butter is mainly washed by nomads to remove milk residues. After the butter has been shaped into clumps, they are placed in clean, slightly chilled water to prevent the butter from melting. The clumps of butter are rinsed with a ladle until the water has turned white, then it is changed constantly until the water runs clear. The water from the washing is then separated from the butter. Nomads mix the first rinsing water with buttermilk. This product is called 'Tordeh' (Fulani) or 'Nono kaddade' (Hausa) and is intended for sale in the markets. Among sedentary people, buttermilk is not intended for sale, but is consumed by family members or fed to animals.

7. Kneading

After washing, the lumps of butter are placed in a calabash, stirring carefully, or in a ladle with a shaking motion, for an average of 2 to 3 minutes, until it is smooth and compact. The kneaded butter is then packed into small calabashes or cups for sale. Figure 5 shows the curd and butter production diagrams for nomads in the pastoral zone (A) and sedentary people in the pastoral and agropastoral zones (B), respectively.

Milk Fermentation

The results of the study show two types of milk fermentation: spontaneous fermentation in the special 'yanerdé' calabash and fermentation by adding a small amount of curds from a previous fermentation, which is practiced during the cold season. These two types of fermentation are also practiced in N'Djamena (Chad), but the calabash is not specifically used for spontaneous fermentation [17]. The use of the calabash specifically for fermentation could be seen as seeding, since the porous structure of the calabash can favor the infiltration of lactic bacteria, hence the non-use of detergent when washing the 'yanerdé' calabash.



Loutan [12] reported three types of fermentation in the pastoral zone, using the calabash as a non-spontaneous type of fermentation (either spontaneously with heat, through the ferments retained in the calabash pores, or by adding a little old curdled milk). However, the ability of gourds to retain lactic acid bacteria has not been thoroughly studied by science. This method is different from the traditional 'Raib' fermented milk in Algeria, where raw milk is fermented spontaneously at room temperature until it coagulates [17]. In Chad, skimming is optional, and is done only after the raw milk has been filtered [17], whereas in Niger (APZ and PZ) skimming is done after the milk has been fermented. This difference is due to the lack of suitable equipment and the traditional nature of the processes in Niger.

Butter Production

Butter is made in pastoral and agro-pastoral areas by churning the cream that has risen to the surface after the fermentation of the milk. In both areas, the cream collected is stored at room temperature without the addition of preservatives, and putrefaction of the stored cream is very common.

Churning takes between 15 and 20 minutes for quantities of no more than 2 L of cream. However, 40 years ago, curdled milk was churned for 1 hour in the same pastoral area [12]. The difference in churning time could explain this change in method, as the physical effort of the work is too arduous. Although it has been reported that in the agropastoral area of Filingué [18], as in pastoral Ethiopia [19], churning is done without separating the cream. The same practice was reported in Chad, with a churning time after optimization ranging from 31 to 40 minutes and a filling rate of 71 to 88% of the gourd [20]. The churning times after optimization in Chad are much longer than in the pastoral and agro-pastoral environment of Niger. The reason for this could be the use of cream in the pastoral environment of Niger to the detriment of Rouaba or Rayeb whole curdled milk in Chad. The latter is identical to Kindirmou, although it is not sold in pastoral and agro-pastoral areas. However, in terms of butter productivity the churning method for whole curdled milk seems to be better because when it is the cream that is churned, the quantity of fat removed from the milk does not exceed 80 to 85% [21]. It should be noted that sour cream is churned more quickly and more thoroughly than sweet cream [22]. This means that the method used in the pastoral and agro-pastoral areas of Niger is effective in terms of physical effort, because in most cases the cream taken is not churned directly, it is accumulated until a certain quantity is obtained, which allows the cream to be more acidic. The use of acidic cream therefore, has a positive effect on churning, as it considerably reduces the physical effort required.



The types of curd and butter found on markets in pastoral and agro-pastoral areas are as follows: Nono, saré, tordeh and two types of butter: washed butter produced by sedentary people and unwashed butter produced by nomads. Unwashed butter deteriorates very quickly, which is why it is washed by the nomads, who keep the butter for three days to a week before selling it at the weekly markets. The fact that butter is not washed by sedentary people can be explained by the accessibility of markets and the presence of consumers, which facilitates sales, and by the need not to wash butter in order to use it for the care of influenza in infants. The packaging material for curdled milk and butter in the two study areas was not hermetically sealed, and some were translucent: calabashes covered with a suction cup, transparent plastic pots, transparent drinks bottles, and sometimes not hermetically sealed. In fact, light is the cause of many changes in the flavour and nutritional properties of dairy products like vitamins [23]. The rapid deterioration of dairy products in pastoral and agro-pastoral areas could also be explained by poor packaging.



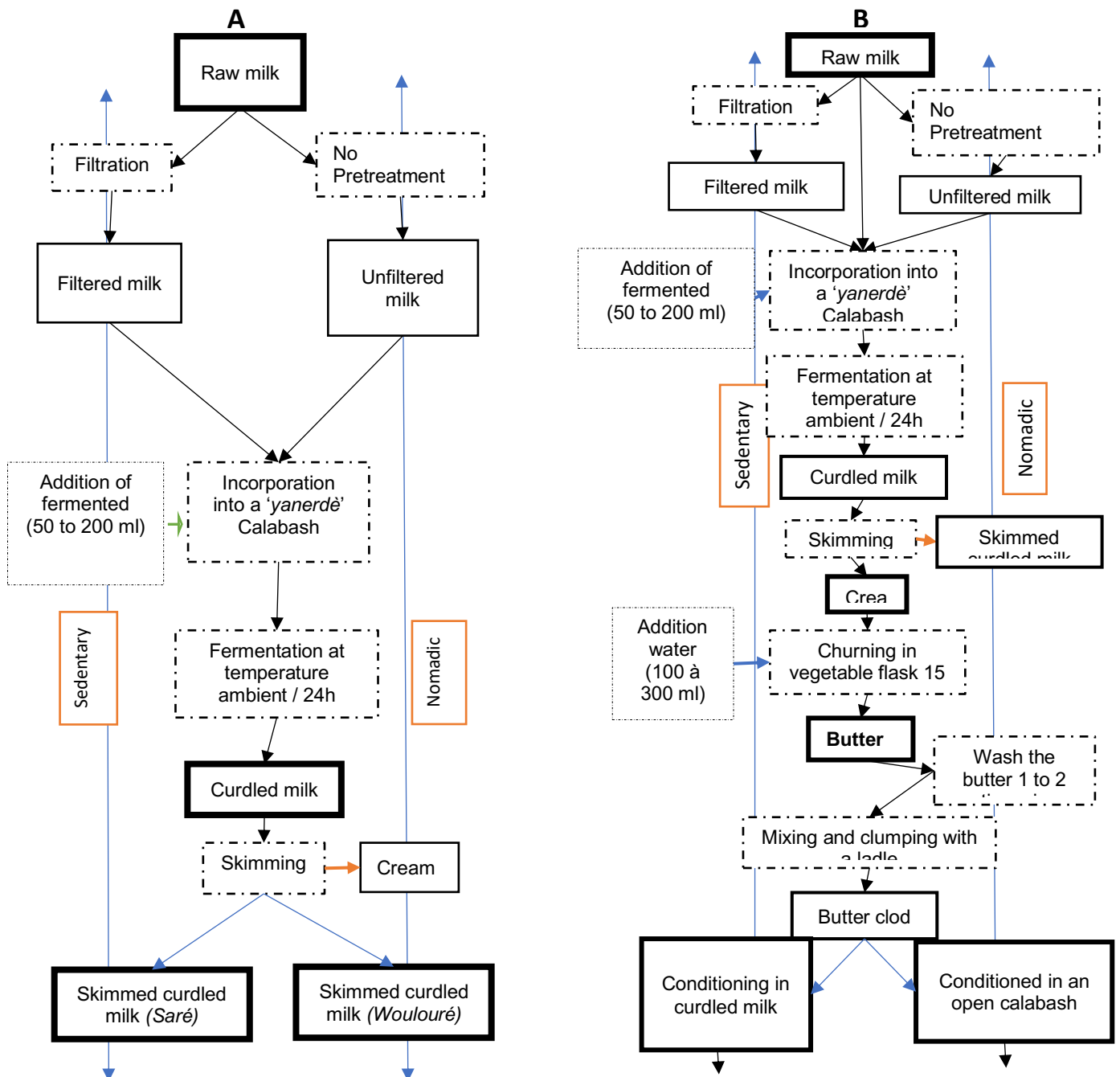


Figure 5: Sedentary and nomadic production diagram for curdled milk (A) and butter (B)

Characterization of dairy products in the study area

The results of this study reveal two types of fermented milk and butter. These are:

(i) Skimmed curdled milk, locally called 'Saré' or 'Woulouré' in the PZ and 'Nono' in the APZ: this is obtained after skimming the cream from the surface.

(ii) Buttermilk, known as 'Tordeh' or 'Nono kadadde', is obtained by churning the cream. It is sold mainly in pastoral areas.

In addition, the results of this study concluded that there are two types of butter: washed butter and unwashed butter.

'Woulouré' or 'Nono' curdled milks are technologically similar to Raib in Algeria [24] and Rouaba or Rayeb in Chad [25], the difference lies in the skimming process for woulouré. Fermented buttermilk, 'nono kadadde' in Hausa or 'tordeh' in Fulani, is technologically similar to 'Lben' in Algeria [24], 'katch' (Wolof) or 'kossam kaadam' (Fulani) in Senegal, 'rouaba' (Arabic) or 'pendidam' (Fulani) in Chad, or 'arera' (Amharic) in Ethiopia [25]. The only difference is that in the case of 'tordeh', it is the cream that is churned rather than the whole curd.

Packaging and transport of dairy products in the study area

In sedentary households, curdled milk is packaged in a calabash (Figure 6A) and butter is stored in the curdled milk (Figure 6A). In the case of nomads, the curdled milk is packaged in cans (Figure 6B) and the butter in small calabashes or in cups (Figure 6D).



Figure 6: Type of packaging for curdled milk and butter, curdled milk and lumps of unwashed butter in APZ(A), curdled milk among nomads in PZ(B), washed butter in APZ(C), washed butter in PZ(D)

In addition, there is a statistically significant difference ($P=0.0001$) between the means of transport to the market used in the different zones. Producers in the ZAP (84%) transport their dairy products on foot, while those in the ZP (76.7%) transport their products on a donkey's back. Packaging butter in fermented milk could have an influence on the microbiological quality of the milk or butter. Nevertheless, the

degree of oxidation of butter packaged in milk would be lower than that of washed butter, packaged in open containers under the effect of light and oxygen.

Traditional methods of preserving curdled milk and butter

Two methods of preserving curdled milk and butter have been identified: preservation by adding vegetable products and preservation by lowering the temperature.

Preservation Using Vegetable Products

A factorial correspondence analysis (FCA) was used to categorize the different ingredients used to preserve curdled milk and butter according to the type of farming ($P = 0.0001$, axis1=65.58%, axis2=34.42%). The results were analyzed on the two axes that explained 100% of the variation in the data for the three stakeholder classes:

- Nomads, who make extensive use of guinea pepper (*Xylopia aethiopica*) to preserve curdled milk and no ingredients in butter.
- Sedentary people in agropastoral areas, who make little use of cowpea seeds (*Vigna unguiculata*) and ginger (*Zingiber officinale*) to preserve curdled milk, but also use Guinea pepper fruit and fermented milk to preserve butter.
- And finally, sedentary farmers in pastoral areas make extensive use of cassava tubers (*Manihot esculenta*) to preserve curdled milk and, to a lesser extent, ginger (*Zingiber officinale*), but no ingredients are added to preserve butter.

These results are shown in Figure 7. In practice, 3 to 4 cloves of guinea pepper are added to a calabash of curdled milk. Cowpea seeds are added when the milk is poured into 5 L or 25 L (airtight) cans, at a rate of 8 to 10 seeds, in association or not with 14 to 20 g of dried ginger. A 100–200g piece of moist cassava tuber is added to the milk calabash, together with guinea pepper. Under normal circumstances, the use of these preservatives depends on their availability to producers.

The vast majority of producers used vegetable products to increase the stability of curdled milk and butter. However, there are no studies demonstrating the bioactive activity of these plant products in the preservation of curdled milk and/or butter, following the example of those used in the ZAP and ZP of Niger. Nevertheless, it should be noted that the bioavailability of bioactive compounds, principally, the antioxidant activity of polyphenols in different plants, has long been known and used to increase the shelf life of foods [26]. They are bioavailable in all plants and have antibacterial properties [27], which may explain the use of plant products for dairy product preservation in both zones.



The use of plant products for preservation is not mastered by processors or can be inefficient, as losses linked to the deterioration of curdled milk and butter are frequent, mainly in the pastoral zone (among nomads). There are no scientific studies in the literature on the preservation capacity of these products, so surveys should be carried out to assess the effectiveness of these methods. Cowpea seeds are better at stabilizing the pH of raw milk during the first three days of storage at +4 °C, but on the fourth day onwards, ginger is better suited. However, at room temperature, Guinea pepper is better at stabilizing milk pH [28]. This shows that these products have antimicrobial and/or acidity regulating activities. The difference in effect time observed by the authors may be due to the soaking time of the products, as they are incorporated into the milk in a dry state.

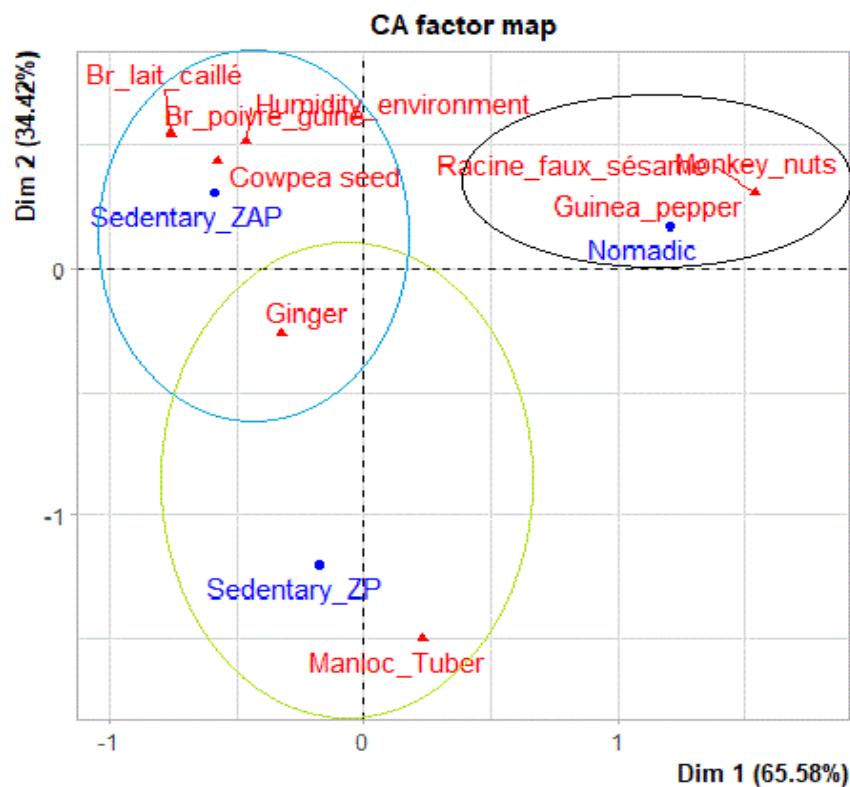


Figure 7: Factorial analysis of correspondences on ingredients used to preserve curdled milk and butter, by type of farm

Preservation by lowering the soil temperature

This method of preservation is done in the shade and involves making a hollow in the ground (the size of a calabash) half-filled with cow dung and topped up with water. Once the water has infiltrated, the calabash of curdled milk covered with a damp cloth is placed in the hollow. Preservation by lowering the temperature of the soil used by nomads corroborates those reported by Loutan [12] in the Tahoua Region. However, this practice is not very effective, as in all cases the temperature

cannot reach that of refrigeration, and there is also a risk of contamination of the product of the soil.

SOCIOCULTURAL CONSIDERATIONS OF CURDLED MILK AND BUTTER

The results of the focus group discussion revealed that among the sedentary people of the APZ, curdled milk is perceived as the food supplement par excellence, mainly during work in the fields. It accompanies the boule and sometimes the porridge. It is seen as 'a food that improves health and gives greater physical strength.' Among the sedentary (Fulani) and nomadic (Tuareg) populations, fermented 'Tordeh' milk is considered to be of poor quality, and its consumption is reserved for domestic animals, mainly goats.

The focus group also highlighted two types of use for butter, food use and non-food use. For food use, after cooking, butter is eaten as an appetizing ingredient in dishes and for non-food use, butter is used as an ingredient in the formulation of phytotherapy products in association with other plant extracts. Butter is fed to infants in its raw form to treat colds and flu. It is combined with *Cassia italica* (MILL) extracts ('hilisko' in Fulani) to treat wounds and skin ailments. However, this type of use requires a butter made without the addition of water during the churning of the fermented cream. In later years, the Fulani used butter for hair and body care, a practice increasingly abandoned in view of the profits to be made from butter.

CONCLUSION AND RECOMMENDATIONS FOR DEVELOPMENT

The manufacturing processes for curdled milk and butter have retained their traditional characteristics of pastoral and agro-pastoral areas, both in terms of equipment and techniques used. Producers are faced with technological problems that can cause health and nutritional risks for consumers. The traditional processes used to make curdled milk and butter are linked to the type of livestock reared: sedentary and nomadic. Two types of fermented milk and butter have been identified: partially skimmed curdled milk (Nono, Woulouré or saré) and buttermilk (Tordeh or nono kadaddé); washed butter produced by nomads and unwashed butter produced by sedentary people. The milk is fermented either spontaneously or by adding ferment (curdled milk from the previous day), and the cream that rises to the surface after fermentation is used to make butter.

Pastoralists and agro-pastoralists have limited access to drinking water, and most use water from swamps during the rainy season. Packaging and storage equipment for dairy products is unsuitable, as it encourages translucency and oxidation. Traditional preservation techniques are promising, but require further scientific investigation. Improvements to these traditional processes are needed to guarantee consumer health safety and increase producers' incomes.



Authors' contributions

Conceptualization NOUHOU MB, OUMAROU HD and A BALLA. Methodology NOUHOU MB and ABDOU RS. Software NOUHOU MB. Validation NOUHOU MB, OUMAROU HD, ABDOU RS and A BALLA. Formal analysis NOUHOU MB. Investigation NOUHOU MB. Resources NOUHOU MB. Data retention NOUHOU MB. Drafting - Preparation of original draft NOUHOU MB. Writing NOUHOU MB. Revision and editing NOUHOU MB, OUMAROU HD and ABDOU RS. Visualization NOUHOU MB. Project administration NOUHOU MB, A BALLA and OUMAROU HD. Funding acquisition NOUHOU MB, A BALLA and OUMAROU HD.

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Conflict of interest

The authors declare no conflict of interest.



Table 1: Socio-demographic characteristics of milk handlers

		Number (N=98)	Percentage (%)
Gender	Female	86	87.8
	Male	12	12.2
Marital status	Single	1	1.02
	Divorced	1	1.02
	Married	89	90.8
	Widowed	7	7.2
Age	Average	47.1	
	Minimum	20	
	Maximum	70	
	Standard deviation	12.1	
Main activity	Milk processing	55	56.1
	Milk producers/breeders	18	18.3
	Dairy product sellers	25	25.5
Level of education	None	86	87.7
	Primary	3	3.1
	Quran school	9	9.3
Ethnic origin	Hausa	23	23.3
	Fulani	58	59.6
	Tuareg	17	17.1

Table 2: Relationship between source of water supply and zone

Zone	Swamp water	Water from well	Tap water	Total	Pearson's chi-square	ddl	P-value
Agro-pastoral zone	12 (28.6%)	10 (23.8%)	20 (47.6%)	42 (42.9%)	6.604	2	0.037
Pastoral zone	30 (53.6%)	17 (30.4%)	9 (16.1%)	56 (57.1%)			
Total			98 (100%)				

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