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Characterization of Technical Production System of *Kindirmou*, a Fermented Local Milk Product from Cameroon

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A B S T R A C T

The characterization of the technical practices involved in the production of *kindirmou* constitutes a key element in its valorization. Assuming that the quality of the *kindirmou* is based on the specific practices to the territory, an analysis of the technical practices of the *kindirmou* in relation with the quality was carried out in the Adamawa region of Cameroon. The holistic approach of the survey including a technical and socio-economic diagnosis of the production of *kindirmou*, the modes of perception and management of the quality of the products by the actors, the characterization of the technological quality of the product and the orientations of the system was carried out in the five Divisions of Adamaoua Region (Ngaoundéré, Meiganga, Tibati, Banyo and Tignère) from April to October 2016. The mains result show that, 96% of the actors involved in the *kindirmou* production chain are located in town. 97% are Fulani with 70% women. The milk is directly milked for 63% or purchased for 37%. According to the material involve in the production of *kindirmou*, 9% is made of wood, 46.5% of plastic, 43.2% of stainless steel and 1.3% of stainless. The fermentation is spontaneous, according to the starter used, 65.6% is *pendidam*, 30.3% *kindirmou*, 4.1% unwashed lebol. As far as the valorization of *Kindirmou* is concerned, the technical production system has been characterized, but it appears that good hygiene and manufacturing practices are not applied by the actors and the microorganism involved in the fermentation are unowned.

Introduction

Kindirmou is a local dairy product, resulting from the spontaneous fermentation of non-skimmed milk. It was originally produced and consumed by the mainly pastoral Fulani peoples of the northern savannas of Cameroon. This product originates from a need to preserve milk, which cannot be stored for more than 24 hours in a cool place, conditions that these peoples cannot meet.

In addition, fermentation facilitates the conservation of milk, promotes the development of organoleptic and nutritional

characteristics highly appreciated by consumers (Balla, 2011; Libouga, 2002).

However, the valorization of *kindirmou* remains limited by sanitary quality of the product (Edima *et al.*, 2014; Libouga *et al.*, 2005). This variability in quality would come mainly from production conditions.

Indeed, if the control of fermentation implies the control of the bacterial strains involved, it is important to note that the uncontrolled conditions of the peasant practices of fermentation, in terms of body hygiene and the environment, as well as precarious conditions of preservation, encourage the involvement of microbial contamination strains, with the consequence of limiting the sanitary quality of the product, or even its rapid deterioration.

Given that the technical practices of food production and processing are generally associated with a territory, in terms of the functional organization of actors and techniques, as well as networks of relationships for the development of local resources, which is why they are qualified of localized food systems (Muchnik *et al.*, 2007), we can, in the context of *kindirmou* production, consider that it is indeed a localized food system. In addition, the territory would also be a factor of variability in technical practices and therefore in the quality of products. It can therefore be assumed hypothetically that the production practices of *kindirmou* vary from one space to another, in terms of hygienic conditions and risks of contamination, which would justify a variability in the quality of the product (Nduko, 2016; Jans *et al.*, 2017).

Based on this assumption, this aims of this work is to describe the production system of *kindirmou* in the different production spaces of the Adamawa Region.

Material and Methods

Area of study

The study was carried out in the form of a survey in the five Divisions of the Adamawa Region, with focus on markets and production sites of the administrative centers and their suburbs, areas par excellence of convergence of products for consumption (Fig. 1).

Five towns (administrative centers) (Ngaoundéré, Meiganga, Banyo, Tibati, Tignère) and 28 villages/districts surrounding these towns were thus visited.

Approach of the study

The study was conducted using a holistic and integrated approach including (Ndjouenkeu, 2018; Dairou *et al.*, 2014) (Fig. 2):

A technical and socio-economic diagnosis of *kindirmou* production: typology of actors (gender, ethnicity, social and economic levels, etc.) and technical practices (tools, technics, processing organization and management, etc.)

The perception and management modes of product quality by the actors,

The characterization of the technological quality of the product, through their pH measurements. And finally, the orientations for controlling the technical system, on the basis of a link between the perception and management of the quality of the product and its technological attributes.

Implementation of the study

The survey was conducted as an open interview with *kindirmou* producers and

sellers. These actors were identified with the support of local administrative services of agriculture and contacted on the markets from their sale points or in their production workshops.

The visit to the production workshops also allowed the interview to be carried out while identifying the main production tools, as well as the details of the actors' practices and their purpose. All actors were interviewed individually.

Thus, a total of 110 actors were interviewed in the five towns and their surroundings, including: 31 actors in Ngaoundéré, 32 in Meiganga, 23 in Banyo, 16 in Tibati and 8 in Tignère.

The interviews were conducted on a conversational basis, using an interview guide incorporating:

The identification of the people involved in the production (sex, ethnic origin, etc.)

The origin of the milk and / or its method of collection

Any pre-treatment of the milk before its processing into *kindirmou*

The *kindirmou* production process

Indicators of the perception of product quality from the raw material to the final product

Quality constraints during production

The mechanisms put in place by the actors to guarantee the quality of their product or in response to the constraints encountered.

The methods, tools and conditions of *kindirmou* conservation

Evaluation of good hygiene and manufacturing practices of *kindirmou*

In order to evaluate the application of good hygiene practices and good manufacturing practices in the manufacturing process of *kindirmou*, a Check list designed according to the *Alimentarius codex* (FAO / IDF, 2012) was applied on 110 *kindirmou* producers surveyed.

Statistical analyzes

The data collected during the interviews and checklist were translated into modalities of which frequencies were analyzed using Sphinx^{+2} V.5 survey software.

Determination of pH and titrable acidity of the *kindirmou*

Kindirmou samples were randomly collected from the survey sites depending on the type of ferment used for fermentation, and analyzed on site for their pH, the main indicator of the level of fermentation of the product by using method of Siboukeur (2007).

Results and Discussion

Actors involved in the *kindirmou* production

The production of *kindirmou* is characterized by female dominance (≥ 70%), particularly among the Fulani who constitute the majority ethnic group in the activity (Fig. 3). The Fulani socio-cultural group constitutes more than 97% of the actors of the technical production system, with a marginal involvement (<3%) of other ethnic groups (Hausa, Moufou, Dii) constituted mainly of men. The female dominance in the activity could be attributed to the fact that the production of "*kindirmou*" is above all a domestic activity devolved to women (Sow, 2005; Edima *et al.,* 2014), the *kindirmou* produced being

initially intended for family consumption. However, these actresses are also the least educated social fringe, with barely 10% above primary school level (Fig. 3b).

The involvement of men in the activity is observed mainly in urban areas where the activity is economically promising (Fig. 4), which confirms the tendency to masculinization of production activities when they are economically promising (Guétat-Bernard, 2015).The migration of populations and urbanization inherent in the creation, in the eighties, of new administrative units (Regions, Divisions, Sub-divisions), and in the influx of civil servants, have fostered the development of a commercial activity in which local products, like *kindirmou*, are integrated, thus giving housewives the opportunity to sell on these markets, the surpluses of family production. Men, following significant market opportunities, are mainly present in the running of dairy bars. Women, on the contrary, distribute their products on shelves, in the open air or in the shade of trees. The male presence, significant in Ngaoundéré, Meiganga and Banyo (Fig. 4), is mainly due to the predominantly urban status of these localities, which makes them to constitute the point of convergence of the economic activities of the Region and, because of their geographical position, they are the main transit stops on the road linking the northern and southern regions of the country, which generates an attractive commercial activity for men. On the contrary, Tibati and Tignère, relatively isolated, have practically a village status, where the activity is predominantly peasant, the food market being carried by women who market the surpluses of household production.

The ethnic distribution of the actors in the different production areas (Fig. 4) shows that the *Fulani* are dominant in all the production areas. However, production areas such as Meiganga, Tignère and Tibati are represented exclusively by the Peuls, as opposed to Ngaoundéré and Banyo, which represents an ethnic heterogeneity. This suggests the strategic influence of these two areas in the trading system of the Adamawa region. Indeed, Ngaoundéré is the regional capital of the Region and therefore constitutes the point of convergence of the economic activities of the Region. Besides, Banyo because of its geographical position connecting the northern regions to the southern regions of the country.

Good hygiene and manufacturing practices of *kindirmou*

The *kindirmou* producers use milk from manual milking regardless of its origin (direct milking or purchase) with a break in the cold chain. 100% producers do not master hygiene of the *kindirmou* processing and assessment of *kindirmou* processing. 90% of producers are non-compliant to the reglementation by using wooden, plastics and enamel material. These observations show the non-compliant nature of the implementation of good hygienic manufacturing practices for *kindirmou* in the Adamoua region according to the recommendations of the Codex Alimentarius which can have a consequence on the microbiological and technological aspect of *kindirmou* (Table 1).

This result shows that personnel can be a source of product contamination. This had already been presented in the literature, resulting in the appearance of food poisoning (FAO, 2007; Libouga *et al.,* 2005; Edima *et al.,* 2014).

These observations show that 90% of the materials used are non-regulatory. These materials can interact with the *kindirmou* and

promote its contamination (Gaquerel and Costes, 2004). The use of plastic containers is the result of recycling of packaging mineral water, cooking oil and hydrocarbon products.

However, this container can be source of chemical contamination of milk due the exchange and the transfer of chemical into the milk, and also a biological contamination due to the structure of the container which cannot be easily cleaned and disinfected (Edima *et al.,* 2014).

Enamel materials when they are crumbled, the metal compounds can react with the acids present in the *kindirmou*, causing the formation of hydrogen gas and metal ions which will lead to a phenomenon of corrosion with the appearance of a metallic taste as well than perforation of the material (Martinez, 2002).

Wooden materials have a porous structure, are fragile and easily cracked. They are materials of questionable hygienic qualities, favorable to physical contamination and proliferation of microorganisms in the *kindirmou* (Gran *et al.,* 2002).

Evaluation of the hygiene of *kindirmou* processing milieu shows a lack of a production area, presence of wastes that can be liquid or solid that can constitute potential sources of food contamination, namely flies which are truly formidable agents. Evaluation of the *kindirmou* transformation method reveal the use of an undefined starter composition would be a source of contamination of *kindirmou,* because they are not produced under hygienic conditions according to the literature (Edima *et al.,* 2014). In addition, failure on fermentation time and temperature could be a consequence of variation in organoleptic quality of *kindimou* depending on the production areas.

Technical practices of *kindirmou* production

Milk supply and processing level

Kindirmou actors value chain are found in the three links of the chain (production, processing and distribution). The milk used in the manufacture of *kindirmou* comes either from direct milk milking (63%) or by purchase (37%). In this distribution of supply, the Fulani derive more than 61% of their raw material from trafficking compared to 1.6% for other ethnic groups (Fig 8). The small number of Hausa (0.8%) and Dii (0.8%) involved in the production of *kindirmou* (0.8%), are exceptionally because they have become breeders and therefore derive their raw material from milking. of their cows. Purchase milk could be an initiative by stakeholders to meet growing demand for *kindirmou*. However, purchasing is not always obvious. Indeed, the low availability of farmer's milk, inherent in the difficulties of acquiring milk with regard to the breeds involved, which are generally lactating and non-dairy, accentuated by the difficulties of access to farms due to poor road conditions. This would better explain the financial and production constraints of local dairy products noted by Edima *et al.,* (2013). Seen on this aspect, these constraints would minimize the market opportunities for *kindirmou,* a product however sought after by consumers (Libouga, 2005, Libouga *et al.,* 2010). However, it should be noted that the purchase of milk under peasant conditions where the cold chain is not controlled remains a risky initiative for controlling the microbiological quality of milk (Colloque ocha, 2010).

The production of *kindirmou* for the market is the priority destination of milk, since the response to consumer demand and the profit function constitute, for nearly 70% of the actors, the justification for the acquisition of

milk, irrespective of its personal milking or purchase origin. This destination is valid regardless of the ethnic origin of the actors. However, we note among the Fulani that the transformation of milk into *kindirmou*, in addition to having economic assets, constitutes a cultural identity. In addition, the ethnic groups (Hausa, Moufou and Dii) do it only for marketing. This confirms the cultural dimension of the uses of milk in Fulani communities (Duteurtre, 2019).

The transformation of milk into *kindirmou* seems ethno-specific, as the Fulani are the ethnic group most involved in the activity. The milk intended for the processing of *kindirmou* is transported to the manufacturing workshop by imprinting either a vehicle (car / motorcycle / bicycle) (28.8%), or walking (71.2%) over more kilometers or less important. However, according to Edima *et al.,* (2012), these modes of transport at room temperature in the absence of a cold chain compromise the hygienic quality of the milk. It should be noted that, women transport the milk on the head and by foot, from the milking place to the processing workshop. These findings help to strengthen the artisanal nature of the *kindirmou* production activity.

The processing of milk into *kindirmou*

Usually, milk is processed within 2 hours after acquisition. This period can be spread out according to the collateral occupations of the actors, in particular women, involved in various household tasks which are likely to delay the processing of milk.

For all stakeholders, the conditions for transporting milk to the processing plant, as well as the constraints imposed by the relationship with the supplier (order confirmation, delivery time, etc.) can also be factors in processing delays.

The transformation of milk into *kindirmou* follows a process in four major steps (Fig. 5) integrating: the filtration of the milk, its heat treatment, its cooling and its fermentation.

The processing tools are of the household type (calabash, plastic bucket, enamel or stainless-steel bowl) and serve as both fermentation reactors and *kindirmou* conditioning and distribution equipment, with variable volumes depending on the production level. For this purpose, the calabash is only used by women and regulatory stainless-steel equipment, particularly by men. This could be associated with the level of education of men and their involvement in the implementation of different governmental milk projects and programs, which trained the actors of the local milk system and strongly contributed to the emergence of dairy bars in the cities (Ndjouenkeu *et al.,* 2003). In general, plastic and enamel materials are mainly used because of their affordable cost on the markets, followed by the calabash. All these materials are very often, sources of chemical, microbiological and physical contamination (Gaquerel et Costes, 2004, Gran *et al.,* 2002;), due to the risk of their constituent elements being diffused into the dairy matrix and their ability to concentrate milk microorganisms on their surface.

The milk can be heated over a wood fire, an oil stove or a gas hob depending on the social level of the actors. Women mainly use wood fires (68% of actresses), unlike men who use kerosene and gas hobs. This could be justified by the fact that men produce *kindirmou* in urban dairy bars, while women generally do it at the domestic level in their kitchen (Sow, 2005; Edima *et al.,* 2014).

Filtration of milk before processing is seen as a classic and common operation intended to

rid the milk of physical contaminants (flies, cow fur, etc.), particularly for milk directly from milking.

The majority of actors (>90%) heat the milk to boiling, with objectives to sanitize it and to obtain a good quality *kindirmou*. Such a practice is liable to degrade milk proteins with foreseeable consequences on the nutritional and functional quality of the final product. It should be noted that boiling heating is practiced overwhelmingly (>70% of citations) by women who, perhaps due to their low level of education, have not benefited from government training projects and programs.

After heating, the milk is allowed to cool at room temperature. To speed up the cooling which, in a steady situation can last up to 2 hours, some actors stir by repeated transfers, with sufficient spacing between the transfer basins, thus allowing ventilation of the product. While this operation actually speeds up the cooling of the milk, it exposes it, on the other hand, to a risk of microbial recontamination by the ambient air, which may justify previous findings on the doubtful microbiological quality of milk and its products sold on the markets of the region (Libouga *et al.*, 2005; Edima *et al.*, 2014).

Fermentation, a central and critical unit operation in the production of *kindirmou*

Fermentation, the operation of acidifying milk to transform it into *kindirmou*, consists either in letting the milk ferment spontaneously, or in inoculating it with *kindirmou* from a previous production, in particular from the day before (*old-kindirmou*), *pendidam*, or unwashed *lebol* (partially dehydrated fat, obtained by churning milk cream), and to let it stand at room temperature for about 3 to 24 hours. These different ferments are all products derived from *kindirmou* with the fundamental difference being their degree of acidity (Fig. 6). They are made by the actresses of the production of *kindirmou*, in the dynamic of artisanal production of dairy products. *Pendidam* is the product of further fermentation of skimmed or non-skimmed *kindirmou*, and is the most conservable form of fermented milk, due to its higher acidity, a characteristic inherent in the presence of acidophilic lactic acid bacteria that seems not to exist in *kindirmou* (Jiwoua and Millière, 1990). When *kindirmou* is skimmed (by scraping off the cream covering its surface), it provides *bourwadam* (skimmed and stirred fermented milk), another product from the range of local fermented dairy products, which is then stirred and fermented to result in *pendidam*. *Lebol*, an aggregate of fat considered in popular language as traditional butter, results from churning cream, the buttermilk of which is fermented into *pendidam*. The use of unwashed *lebol* as a ferment is due to the fact that at this stage, it would contain residual strains capable of initiating fermentation. The ferments are inoculated at a rate between 0.5 and 1.75 ml of ferment per litter of milk. Milk is inoculated, either in bulk or in small pots or cups of volume corresponding to individual consumption portions. The temperature and fermentation time are managed in an intuitive and personalized way by the actors, due to the lack of suitable control tools. The temperature is evaluated by appreciating the touch of the milk which must be, in the words of the actors, "*lukewarm like water exposed to the sun, or like the child's porridge*". Failure to control the temperature induces a variability in the duration of the fermentation (3-24 hours), especially since the process takes place at room temperature, which is itself susceptible to variation. The term of fermentation is defined according to the operator's perception of the *kindirmou* quality.

The quality of *kindirmou*: perception, management and technological value

The quality attributes sought by those involved in the production of *kindirmou* mainly relate to the color, texture and taste of the product (Fig. 7). Good quality *kindirmou* should have a whitish color ("matt white"), a homogeneous gel and should not be acid. These attributes are perceived in equivalent proportions regardless of the production site, which may be indicative of a relative homogeneity in the perception of the quality of *kindirmou* throughout its cultural space. In addition, the "non-acid" taste of *kindirmou* is the characteristic that differentiates this product from other traditional fermented milks, *pendidam* in this case. The “homogeneous gel” or “heavy” character of its texture is in fact representative of the translation of the term *kindirmou* (heavy milk) into the *Fulani* language (Libouga *et al.*, 2005; Essomba *et al.*, 2002). The matt white (or whitish, even yellowish) color of *kindirmou* is related to to the β-carotenoid content in the milk fat, which depends on the cow's diet. Indeed, at the end of fermentation, the fat in the milk forms a thin shiny layer on the surface of the product, in particular when the fermentation has been undergone without previous mixing of milk, giving it a yellowish appearance. Stirring the product when it is packaged or at the time of consumption, gives the matt white color. The fat, combined with the firm texture of *kindirmou*, gives the product its softness when consumed, which actors and consumers translate as the "*oily sensation in the mouth*". This quality characteristic justifies the operation of mixing *kindirmou* which, in order to both homogenize the product and reduce the size of the fat globules, changes its appearance and promotes the sensation of softness in the mouth.

The non-occurrence of the above attributes reflects a poor quality of *kindirmou*, which is characterized by a foamy appearance, phase separation and above all, an acid taste (Fig. 8). These non-conformities reflect a technical malfunction in production practice, in particular in terms of management of hygiene, heating temperature and fermentation parameters of the milk. Indeed, poor hygienic conditions (environmental and bodily) are likely to favor the development of hetero-fermentative contamination germs, often non-lactic, of fecal or telluric origin (Mahaut *et al.*, 2005; Federighi *et al.*, 2005), resulting in the foamy appearance and phase separation (whey exudation) of the product. The uncontrolled fermentation inherent in the coupling between the contamination germs and endogenous bacteria of technological interest, will result in high acidification of the product (Laithier *et al.*, 2004).

Table.1A Application of good hygienic and good manufacturing practices by actors

Requirements	Conform	Non conform
Hand washing before and after handling		✔
Wearing clean and suitable clothing		✔
Wearing jewelry during handling		✔
Wearing a mouth-nasal mask		✔
Medical visit every 6 months		✔
Total of scores		**100%**

Table.1B Evaluation of the hygiene of the *kindirmou* processing equipment

Requirements	Conform	Non conform
Use of wooden materials		✔
Use of plastic materials		✔
Use of enamel material		✔
Use of stainless steel materials	✔	
Washing and disinfection of equipment before and after		✔
Use of materials only for production		✔
Total of scors	10%	90%

Table.1C Evaluation of the hygiene of *kindirmou* processing milieu

Requirements	Conform	Non conform
Existence of a production area		✔
Respect for forward movement		✔
Presence of pests		✔
Presence of a waste disposal system		✔
Cleaning and disinfection of production areas		✔
Easily washable premises, materials and surface		✔
Total of scors		100%

Table.1D Evaluation of the *kindirmou* transformation method

Requirements	Conform	Non conform
Heat treatment of milk	✔	
Respect of the time / temperature of heating the milk		✔
Rapid cooling of heat-treated milk		✔
Control of fermentation temperature		✔
Use of controlled ferments		✔
Respect of the storage temperature		✔
Total of scores	10%	90%

Table.2 pH of the *kindirmou* depending on the manufacturing site and the type of ferment used

Localities	Type of ferment		
	Old kindirmou	***Pendidam***	**Unwashed *Lebol***
Tignère	4.80 ± 0.08^{aA}	4.91 ± 0.17^{aA}	-
Banyo	4.56 ± 0.03^{aB}	4.60 ± 0.22^{aA}	-
Tibati	4.93 ± 0.06^{aA}	4.54 ± 0.08^{bB}	-
Meiganga	4.49 ± 0.12^{aB}	4.54 ± 0.04^{aB}	**4.65 ± 0.16^{a}**
Ngaoundéré	**4.77 ± 0.16^{aA}**	**4.84 ± 0.05^{aA}**	-

a, b: the means showing the same lowercase letters on the same line are not significantly different at p = 0.05
A, B: the means showing the same letters in upper case in the same column are not significantly different at p = 0.05

Fig.1 Area of study

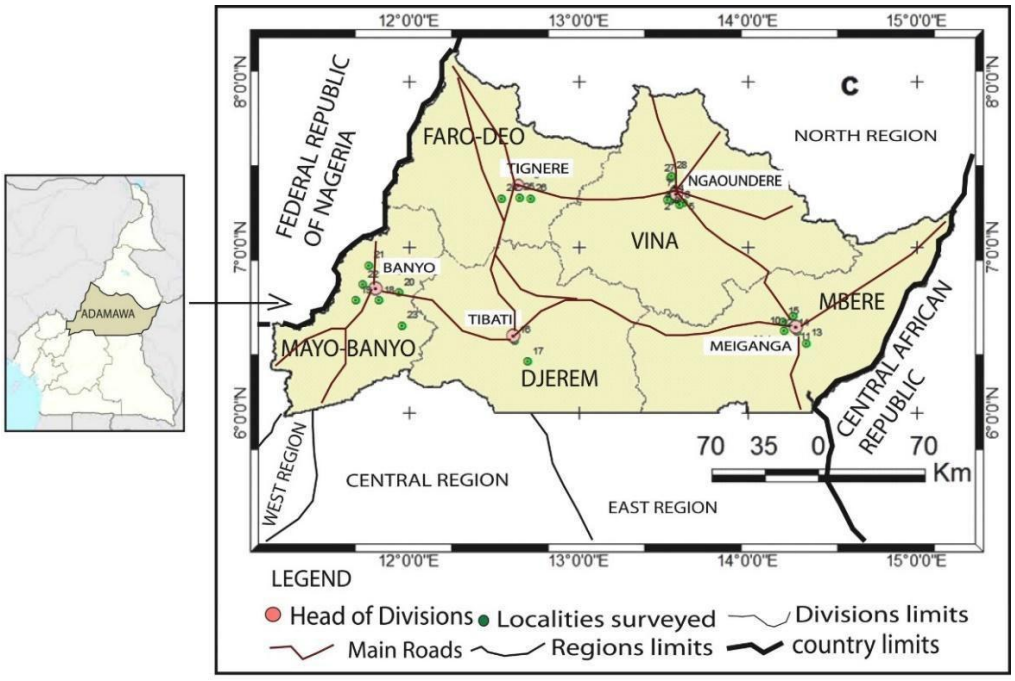


Fig.2 Integrated approach for the study of production practices and quality

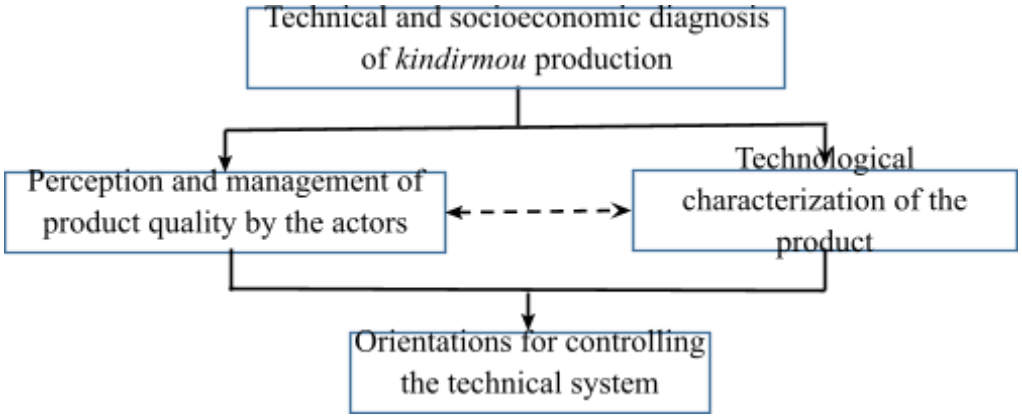


Fig.3 Gender distribution of actors in the production of *kindirmou* by ethnic groups (**a**) and by level of education (**b**) in the Adamawa Region of Cameroon.

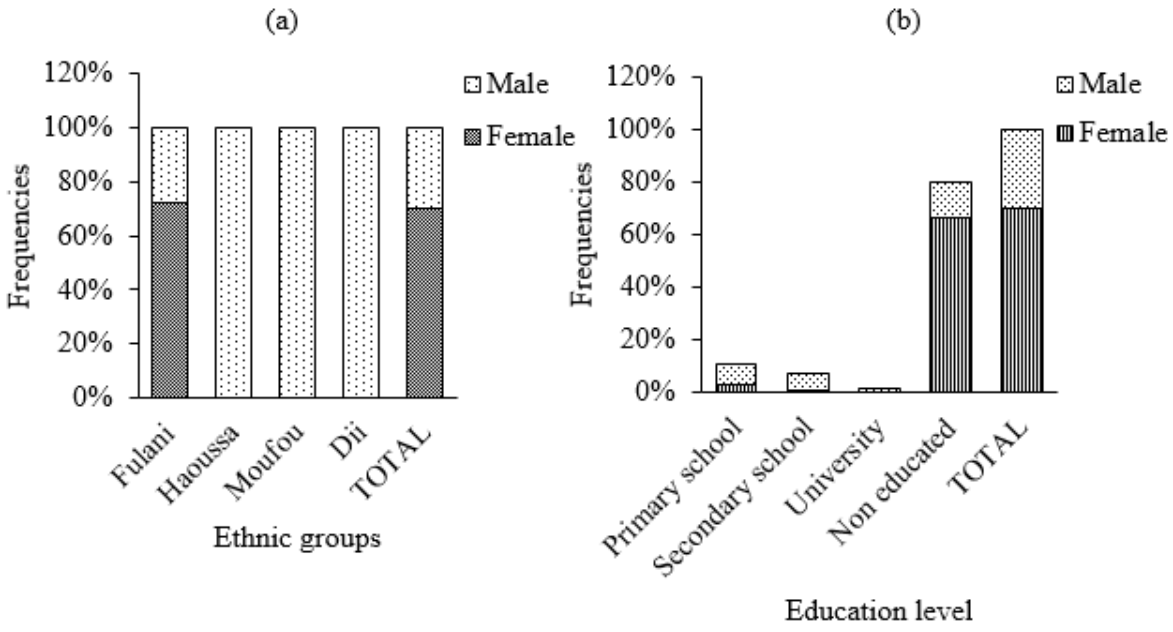


Fig.4 Spatial distribution of actors in the production of *kindirmou* by ethnic group

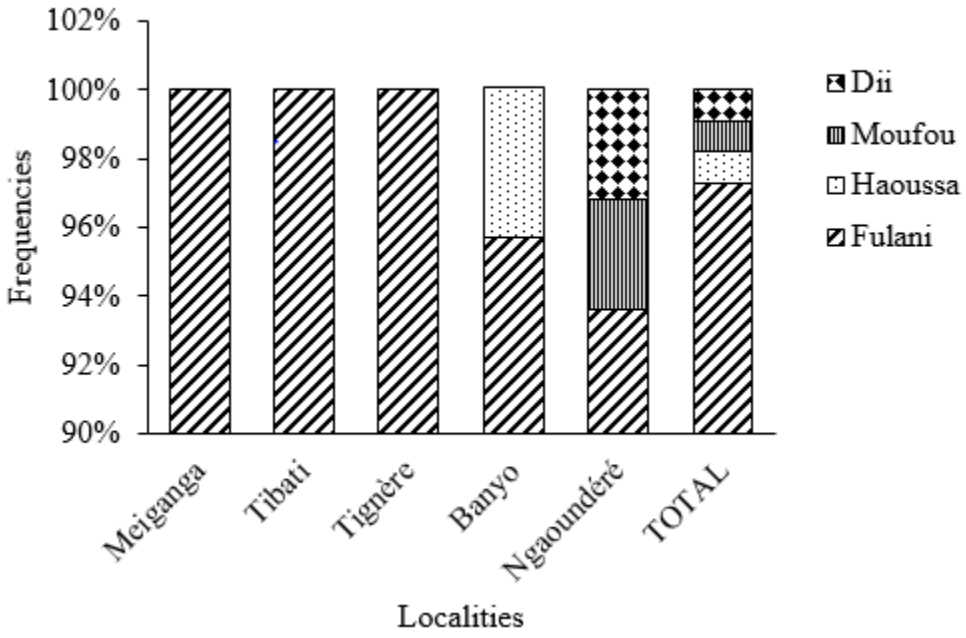


Fig.5 Artisanal process diagram of *kindirmou* production

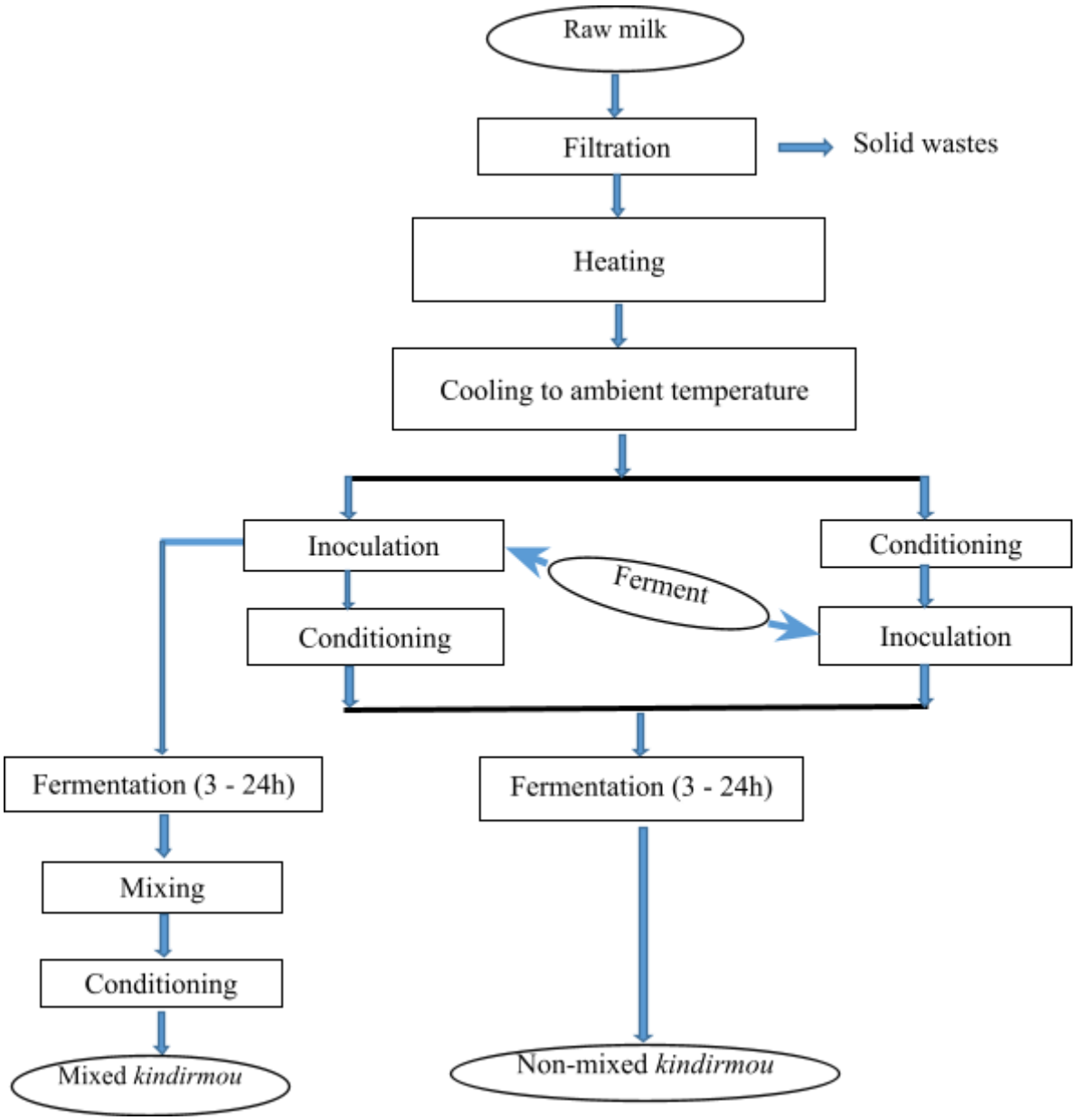


Fig.6 Methods of preparing the ferments used in the production of *kindirmou*

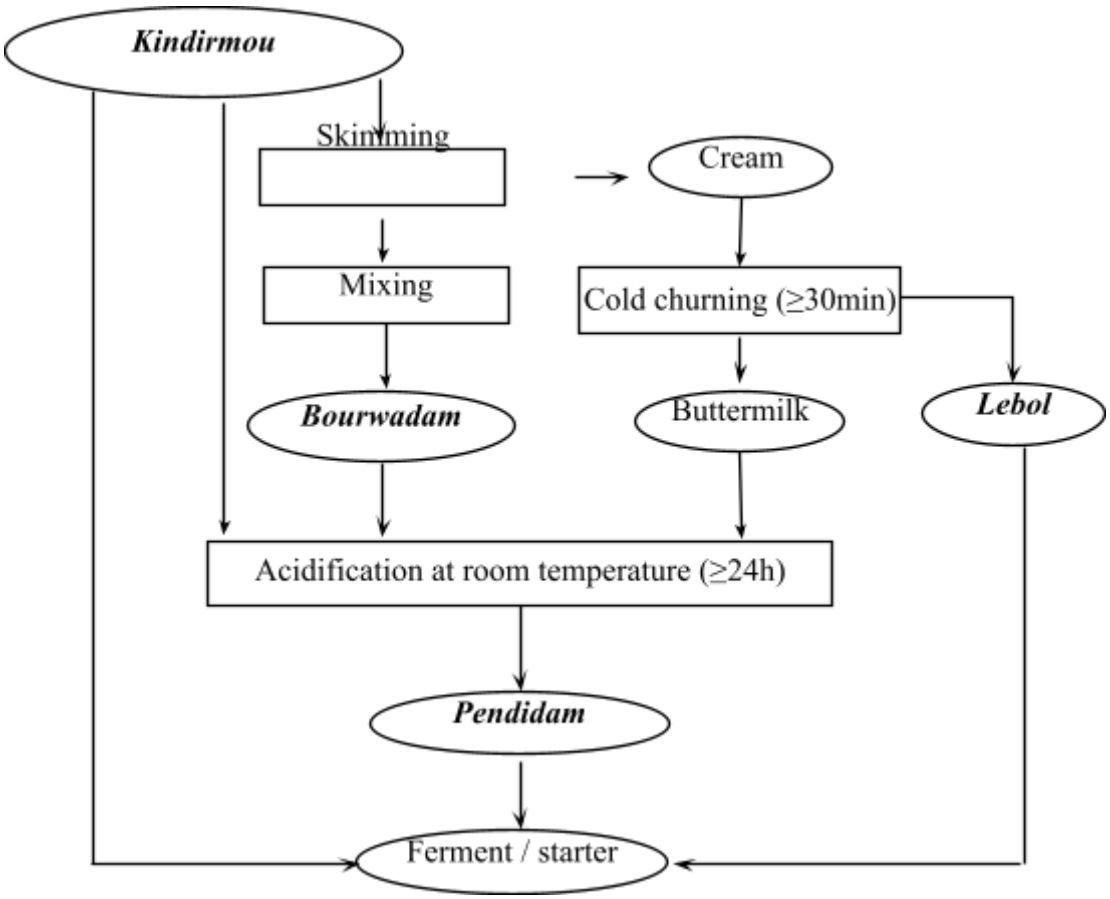


Fig.7 Quality attributes of *kindirmou* in production localities

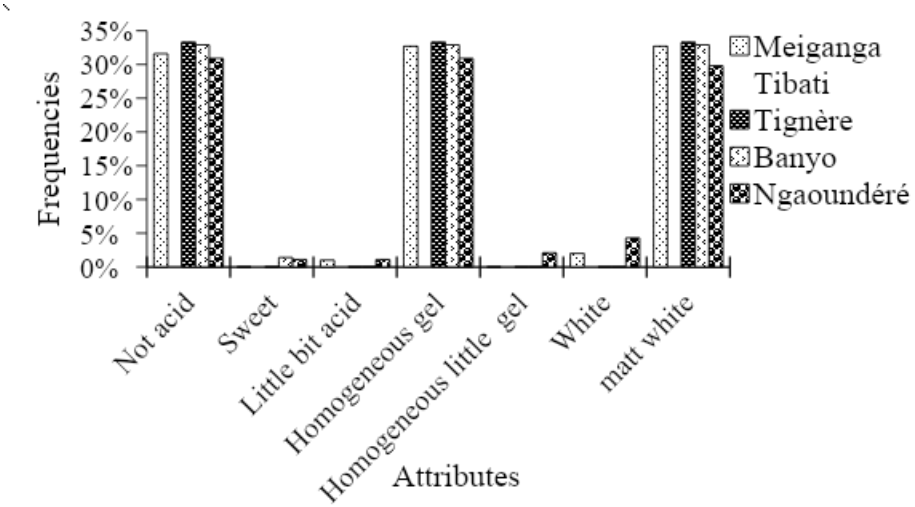


Fig.8 Characteristics of poor-quality *kindirmou*

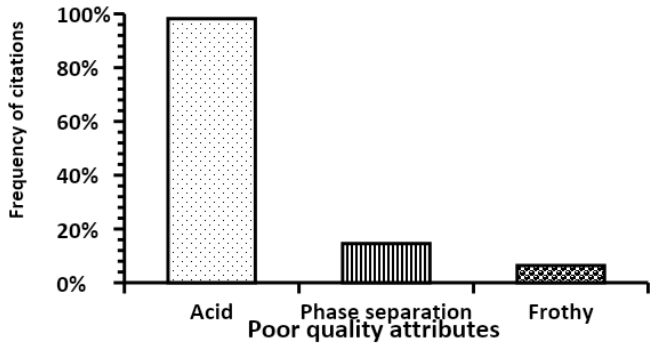
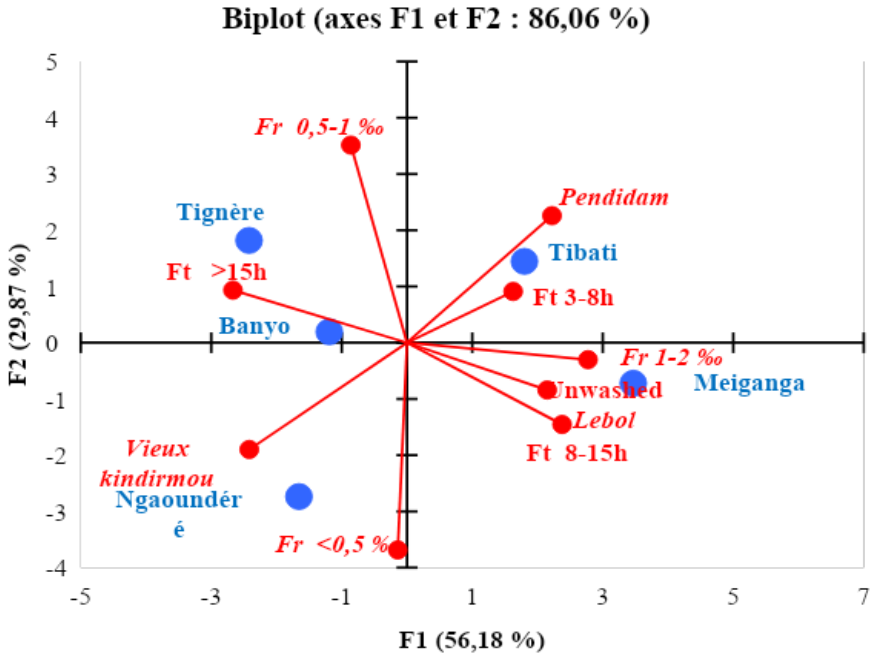


Fig.9 Comparative analysis of the fermentation management mode (type of ferment [ ], inoculation rate [ ], fermentation time [ ]) in the different production localities [ ] of kindirmou in the Adamawa Region (Ft: fermentation time; Fr: fermentation rate)



Heating the milk before processing and the relative attention paid to the dosage of ferments and the fermentation time can be considered, from the point of view of the actors, as forms of management of the risks of non-compliance of *kindirmou*. In this regard, if the systematic heating of milk is perceived by more than 90% of the actors as a constructive element of the quality of the product, in terms of the firmness of *kindirmou*, it nevertheless constitutes a factor of sanitation, although the temperature and the treatment times are excessive in some cases.

In addition, 70% of the actors claim to process the milk within 2 - 3 hours after milking, which is relatively comparable to

the recommendations of the Codex Alimentarius (FAO, 2012), indicating a relative consideration, by the actors, of the need to avoid any risk of occurrence of negative attributes of product quality. In addition, the limited dosage of the ferment (0.5 to 1.75 ml per liter of milk), in conjunction with the management of the fermentation time, meets the requirement of a non-acidic taste of *kindirmou*. The evaluation of the pH of *kindirmou*, a technological indicator of the perception of the acidity of the product, shows that all the products sampled from producers in the region have a value between 4.5 and 4.9 (Tab. 1) and confirms the values initially reported by Libouga *et al.,* (2005) and Ngassam (2007). This range of pH values is compatible with those of firm fermented milks without whey exudation or phase separation (Bourdichon, 2012; Croguennec *et al.,* 2008), as well as with the preferences of consumers of low-acid yogurts (Tamime et Robinson, 2007b; Loones, 1994). It should be noted that this pH of *kindirmou* is obtained with a ferment inoculation rate between 0.5 and 1.75 ml / liter of milk, *i.e*. 0.5 to 1.75 ‰, which is relatively low compared to the range of 2-5% recommended for obtaining a bacterial population of the order of 107 CFU/mL (Clark et Plotka, 2004), values considered effective for obtaining fermented milk in 3 hours (Benbadis *et al.,* 1998). The weak or non-acidic taste of *kindirmou* preferred by those involved in production and certainly by consumers, justifies the low inoculation rate applied by *kindirmou* producers which, however, has the effect of lengthening the latency time of the milk acidification process (Jones *et al.,* 1992), a strategy adopted by producers to overcome the problems of management of fermentation time in relation to the quality of the product without refrigeration means.

For a given production locality, no significant difference appears in the pH of the *kindirmou* whatever the ferment used, whereas from one locality to another, the same ferment can lead to different pH values (Tab. 1). This influence of the locality of production on the acidity of *kindirmou* can be attributed to a variability in the management methods of the production process in the different localities, in this case the conditions of heat treatment (Temperature-time) and of fermentation (type of ferment, inoculation rate and fermentation time) of milk, or even the product's storage conditions (Luquet et Corrieu, 2005; Mahaut *et al.,* 2005; Alonso-Calleja *et al.,* 2002; Beal *et al.,* 1999). Given that 90% of those involved in the production of *kindirmou* boil the milk before fermentation and that the nature of the ferment is not a factor in the variation of the pH, the inoculation rate and the fermentation times seem to be considered as factors of construction of the quality of the product at the local level. In this regard, the comparative analysis of the fermentation management mode (nature of the ferment, inoculation rate, fermentation time) in the different localities (Fig. 9), makes it possible to group together the production areas according to two modes of management of fermentation practice:

The producers of Tignère, Ngaoundéré and Banyo are characterized by a majority use of *old-kindirmou* (generally from the production of the day before, therefore of relatively low acidity), at a relatively low inoculation dose (0.5 - 1‰), but a long fermentation time (>15H);

On the other hand, the producers of Tibati and Meiganga mainly use *pendidam*, a more acidic ferment, at an inoculation rate of 1-2 ‰, and a relatively shorter fermentation time (≤15H). Note a particularity for Meiganga where, in addition, unwashed *lebol* is used.

The characterization of the *kindirmou* production system has shown that, the application of Good Hygiene and Manufacturing Practices is not effective in all structures and fermentation conditions are not mastered. It therefore appears necessary to support the actors in this sector in the application of Good Hygiene and Manufacturing Practices and to formulate a ferment in order to control fermentation. Ultimately, *kindirmou* is a local dairy product with strong economic and nutritional potential that needs to be developed for the financial empowerment of stakeholders

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Conflict of interest

The authors have not stated any conflict of interest

References

Alonso-Calleja C., Carballo J., Capita R., Bernardo A. & Garcia-Lopez M. L., 2002. Changes in the microflora of Valdeteja raw goats milk cheese throughout manufacturing and ripening. *LWT* 35, 222-232. https://doi.org/10.1006/fstl.2001.0842.

Balla A., 2011. Effets de quelques cryoprotecteurs sur la conservation d'une souche d'intérêt isolée à partir du lait camelin. Thème de Magistère. Université d'Ouargla, Algérie.

Beal C., Skokanova J., Latrille E., Martin N. & Corrieu G., 1999. Combined effects of culture conditions and storage time on acidification and viscosity of stirred yogurt. *Journal.of Dairy Science*. 82, 673–681. https://doi.org/10.3168/jds.S0022-0302(99)75283-5.

Benbadis L., Oudot E. & De Villeroche J., 1996, *Streptococus thermophilus* strain, fermentation process using such strain and product obtained. Gervais Danone, assignee. European Patent NO WO 96/10627.

Bourdichon F., Casaregola S., Forrokh C., Frisva J. C., Gerds M. L., Hammes W. P., Harnett J.,

Boutrais J., 2006. Pastoralisme et aires protégées en Afrique de l'Ouest et de l'Est. In : Aubertin, C., F. Pinton & E. Rodary (eds), *Les aires protégées, zones d'expérimentation du développement durable : recueil des contributions*. ATI seminar - Queyras Regional Natura Park France, 28-30. November 2006 https://www.documentation.ird.fr/hor/fdi:010043935#.

Chatellier V., 2019. La planète laitière et la place de l'Afrique de l'Ouest dans la consommation, la production et les échanges de produits laitiers. In 3èmes rencontres internationales sur « *Le lait, vecteur de développement* », 12-13 June 2019, Dakar, Sénégal. *Accessed December* 10, 2020. https://www6.inrae.fr/lait-vecteur developpement/Editions/2019

Clark S. & Plotka V. C., 2004. Yoghurt and sour cream: operational procedures and processing equipment, pp 159-182. In Hui, Y. H., Meunier-Goddik, L., Åse Solvejg, H., Josephsen, J., Wai-Kit Nip, Stanfield, P.S., and Toldrà, F. (eds), *Handbook of food and beverage fermentation technology*. Marcel Dekker Inc. New York Basel.

Croguennec T., Jeantet R. & Brulé G., 2008. *Les Fondements Physico-chimiques de la Technologie Laitière. Technologie et Documentation*. Lavoisier, Paris, 135 p.

Dairou S., Biyanzi P., Pallet D. & Ndjouenkeu R., 2014. Traditional Production, Processing and Quality Attributes of *Ziziphus mauritiana* in Savannah Region of Cameroon. *Journal of Scientific Research & Reports*, 3(5) : 686-699.

Duteurtre G., 2019. Les produits laitiers africains à l'épreuve de la libéralisation : Des traditions laitières en danger, un

patrimoine à valoriser. In 3èmes rencontres internationales sur «*Le lait, vecteur de développement*», 12-13 June 2019, Dakar, Sénégal. *Accessed December* 10, 2020. https://www6.inrae.fr/lait-vecteur-developpement/Editions/2019.

Edima H. C., Awono E. T. & Ndjouenkeu R., 2013. An Analysis of the Milk Quality in Cameroon. A Study in Adamawa Region. *Journal of Scientific Research & Reports* 2(1), 337-346.

Edima H. C., Awono E. T., Biloa D. M., Tchoumkeu H. B. & Etoa F-X., 2014. Evaluation of good hygienic practices on the production of *kindirmou* and *lebol. International Journal of Current Microbiology and Applied Sciences* 3(9): 249-253.

Essomba J. M., Dury S., Mbonji Edjenguèlè & Bricas N., 2002. Permanences et changements dans la consommation des produits laitiers ; la « success story » des petites entreprises de transformation à Ngaoundéré, Cameroun, Pages 1-10. In "*Food resources and food choices in the Lake Chad basin"*. XIth International Colloquium Mega-Tchad, CNRS/University of Paris X-Nanterre (France).

FAO (Food agricultural Organization).et IDF (International Dairy Federation). 2012. Guide de bonnes pratiques en production laitière Directives FAO : Production et santé animales. 51pp.

FAO. (2007). Les bonnes pratiques d'hygiène dans la préparation et la vente des aliments de rue en Afrique.188 pages

Federighi M. *Bactériologie alimentaire compendium d'hygiène des aliments.* 2nd Ed. *Economica* Paris, pp 224-233.

Gran H. M., Mutukumira A. N., Weltlesen A., & Narvhus J. A., 2002. Small holder dairy processing in Zimbabwe: the production of fermented milk products with particular emphasis on sanitation and microbiological quality. *Food Control*, 13, 161-168.

Guétat-Bernard H., 2015. Travail des femmes et rapport de genre dans les agricultures familiales : analyse des similitudes entre la France et le Cameroun. *Revue Tiers Monde*, 1(221), 89-106. https://www.cairn.info/revue-tiers-monde-2015-1-page-89.htm.

Huys G., Laulund S., Ouwehand A., Powell I. B, Prajapati J. B., Seto Y., Schure E. T., Van Boven A., Vankerckhoven V., Zgoda A., Tuijtelaars S. & Hansen E. B., 2012. Food fermentations : microorganisms with technological beneficial use. *International. Journal. of Food Microbiology.*, 154(3), 87-97. https://doi.org/10.1016/j.ijfoodmicro.2011.12.030.

Jans C., Meile L., Kaindi D. W. M., Kogi-Makau W., Lamuka, P., Renault P., Bonfoh,B., 2017. African fermented dairy products– Overview of predominant technologically important micro or-ganisms focusing on African *Streptococcus infantarius* variants and potential future applications for enhanced food safety and security. *International Journal of Food Microbiology*, 250, 27–36. https://doi.org/10.1016/j.ijfoodmicro.2017.03.012.

Jiwoua C. & Millière J. B., 1990. Lactic flora and *Enterococci* in cultured milk (*Pendidam*) manufactured in Adamaoua (Cameroon). *Lait*, 70, 475–486. https://doi.org/10.1051/lait:19905-637

Jones B. A., Satter L. D. & Muck R. E., 1992. Influence of bacterial inoculant and substrate addition to lucerne and ensiled at different dry matter contents. *Grass Forage Science*, 47, 19-27. https://doi.org/10.1111/j.1365-2494.1992.tb02243.x.

Laithier C., Chatelin Y. M., David V., Tormo H., Lefrileux Y. & Gauzere, Y., 2004, Facteurs de maîtrise de l'acidification dans les technologies fromagères fermières (caillé lactique) utilisant du lactosérum comme ferment. *Rencontres Recherche Ruminants*, 11, 95-98.

Libouga D. G., Essia Ngang J. J. & Halilou H., 2005. Qualité de quelques laits fermentés camerounais. *Sciences des aliments* 25, 53-56.

Libouga D. G., Womeni H. M. & Bitjoka, L., 2002. Extrait des écorces de l'*Ongokea gore*: protéolyse et conservation. *Journal of the Cameroon Academy of Sciences.* 2, 89-150.

Loones A., 1994. Laits fermentés par les bactéries lactiques. In De roissart H. & Luquet F. M. (eds), *Bactéries lactiques : Aspects fondamentaux et technologique* Vol 2, pp 135-154. Uriage Lorica, France.

Luquet F. M. & Corrieu G., 2005. *Bactéries lactiques et probiotiques*. *Technologie & Documentation*, Lavoisier. Paris 307p.

Mahaut M., Jeantet R., Brule G. & Schuck P., 2005. *Produits laitiers industriels*, pp 1-40. *Technology & Documentation* Lavoisier. France.

Metzger R., Centres J.M., Thomas L. & Lambert J.C., 1995. Approvisionnement laitier des villes africaines. FAO, Rome, GRET, France. http://www.fao.org/3/V4870F/V4870F00.htm#Contents.

Ndjouenkeu R. & Cerdan C., 2003. Impact de l'innovation technologique sur l'amélioration des systèmes alimentaires du Nord Cameroun. In Brouwer, I. D., Traoré A. S. & Trèche S. (eds), Voies alimentaires d'amélioration des situations nutritionnelles en Afrique de l'Ouest, pp 633-646. Proceedings of the 2nd International workshop, Ouagadougou, Burkina Faso, 23 – 28 November 2003, 1134 p.

Ndjouenkeu R., 2018. Cassava in Central and Western Africa: Postharvest Constraints and Prospects for Research and Market Development, pp 199–217. In Waisundara, V. (ed), *Cassava*. *Intech Open Science*, 304 p. http://dx.doi.org/10.5772/intechopen.71507

Nduko J. M., Matofari J. W., & Nandi Z. O., 2017. Spontaneously fermented kenyan milk products: A review of the current state and future perspectives. *African Journal of Food Science*, 11(1),1 11. https://doi.org/10.5897/AJFS2016.1516

Ngassam T.C., 2007. Contribution à l'étude des caractéristiques microbiologiques des laits fermentés artisanaux au Sénégal : cas de la zone des Niayes. Veterinary Medicine Thesis, Dakar, 109 pages.

Redlingshofer B. & Soyeux A., 2010. Cultures des laits du monde. *Le Courrier de l'environnement de l'INRA*, 59(59), 93-96. **(**2010). https://hal.archives-ouvertes.fr/hal-01211502.

Sow S. A., 2005. Le lait, patrimoine des Peuls pasteurs du Niger : pratiques alimentaires, représentations et usages non alimentaires chez les Gaawoo'be du Gourma, pp 419-442. In Cormier-Salem M. C., Juhé-Beaulaton D., Boutrais J. & Roussel B. (eds), *Patrimoines naturels au Sud : Territoires, identités et stratégies locales*. IRD éditions Colloques et Séminaires, Paris, France, 551 p.

Tamime A. Y. & Robinson R. K., 2007. Processing plants and equipment. In *Tamime and Robinson's Yoghurt, Science and technology* (Third edition), pp 162-283. Wood head Publishing.

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