Statistical Analysis of Traditional Practices of Fermented Camel Milk in North Kordofan State, Sudan

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Abstract

The present work was conducted to study the preparation process of fermented camel milk (locally named as *gariss*) according to camel herders. A questionnaire was designed to collect information including methods for using starter, daily type of starter used, use of spices as well as duration of the fermentation. In addition, supplementary variables which had a potential effect on the quality of *gariss* were taken in account. The results indicated four types of farms according to gariss preparation process: 1) use of *gariss* without any added spice (27.59%), 2) addition of spices at least once per month and use of previous day *gariss* (41.38%), 3) use of *gariss* and spices with less than 12 h for fermentation (13.79%) and 4) use of a spices for the preparation of the first *gariss* and fermentation time exceeding 12 h (17.24%). The study indicated three types of farmers according to the quantity of camel milk transformed to *gariss*: 1) transformation of almost all milk and a preference for bitter or acidic taste (48.28%), 2) expected consistency of the *gariss* which was a major criterion to judge the quality of gariss (17.24%) and 3) low quantity or variable amount of *gariss* prepared by a single operator (34.48%). The study concluded that *gariss* preparation differs according to method adopted by the camel herders and farms.

Key words: fermented camel milk, gariss, preparation process, traditional practices

Introduction

Globally, 17% of milk consumed by humans comes from species other than cattle. One of these species is camel which is linked to the desert regions. This link contributes to the building of dairy ecosystems including specific dairy species, traditional products, farmer know-how, landscape maintenance, cultural activities, market sector and identity markers. According to the variability of milk composition, nutritional and true or postulated medicinal properties could be potentially an important added value for producers and the dairy sector. Most of non-cattle milk production occurs in developing countries where population growth and protein demand are increasing (Faye and Konuspayeva, 2012).

In the Horn of Africa, where 60% of the world camel population lives, approximately 10% of the total milk produced is of camel origin (Faye and Konuspayeva, 2012). Despite their production potential and ability to survive on marginal resources in extreme conditions, dromedaries have not been exploited as an important food source, due to high individual variation in milk production both within the population and within breeds (Nagy *et al*., 2012). For most of the pastoralists camel milk is superior to the milk

of other species. Camel milk is richer in unsaturated fatty acid (Konuspayeva *et al*., 2008), vitamin C (Farah *et al*., 1994), bioactive compounds like lactoferrin or immunoglobulin (Konuspayeva *et al.*, 2006), and is less allergen (Shabo *et al.*, 2005) than cow milk. Fresh and fermented camel milk were found to provide various potential health benefits including angiotensin I-converting enzyme-inhibitory, hypocholesterolaemic, hypoglycaemic, antimicrobial and hypoallergenicity activities (Alhaj and Alkanhal, 2010). Due to these particularities, unlike cow milk, camel milk has medicinal values and can be used to treat a number of diseases in humans. Fermentation of milk brings about many changes in its chemical constituents which have bearings on its nutritive value so that yoghurt proteins are more digestible than those of fresh milk for the partial hydrolysis of milk constituents in yoghurt, cheese and other cultured dairy food which contribute to their increased digestibility (Dirar, 1993; Konuspayeva *et al*., 2014) .

The presence of many organic compounds in milk helps various types of microorganisms to decompose it and to cause different chemical changes (Omer and Eltinay, 2009). In depth understanding as a result of studying the traditional practices and indigenous knowledge of pastoralists would help to devise appropriate strategies that are applicable to the local situation and would increase camel milk production and improve the quality of camel milk and camel milk products in the study areas, so the development of camel production pattern may enhance those people in this region by increasing their activities through selling milk products, i.e. fermented milk (locally named as *gariss*) and other products . Moreover, due to the tolerant ability of camels to the dry areas making camel milk products would give a great push for the people to stay on these remote places. The objective of the present investigation was to study the indigenous knowledge of the pastoralists in the methods of *gariss* preparation, handling and keeping of camel milk in camel farms of North Kordofan State, Sudan.

Materials and Methods

The Study Area

This study was conducted around Elobeid city in North Kordofan State, Sudan which is characterized by unreliable and erratic rainfall with annual precipitation from 300 to 600 mm per annum, high ambient temperatures (>30 °C), sparsely distributed vegetation dominated by *Cactus* and *Acacia* species, and bushy woodlands (Bekele, 2001). The altitude of these areas ranges from 500 to 1500 m above sea level. The camel herders in these areas are Shanabela, Dar Hamed, Hamar and other groups. Numerically, camel is one of the abundant domestic animals in these areas beside small ruminants.

Framework and Program of Study

The study was conducted from March 1 to April 18, 2009. During this period, 29 camel farmers were interviewed in their farms (n=24) and livestock markets (n=5). A questionnaire was distributed targeting different steps necessary for the fermentation of gariss. In the markets, camel herders who used to prepare the gariss were interviewed. Each of the visits made was concentrated around Elobeid in North Kordofan State, then an additional survey was carried out on the Kerima market Elobeid, where the *gariss* is sold daily by women from surrounding villages. They were also asked about their methods of preparation of *gariss*. Data collected included the following items: (1) method of using starter, (2) daily type of

starter used, (3) use of spices, (4) duration of fermentation (Table 1). In addition, five supplementary variables having potential effects on the quality of *gariss* were taken into account in the multivariate model: (1) organoleptique characteristics of the *gariss*, (2) quantity of milk used, (3) other prepared product, (4) number of processors and (5) storage condition (Table 2).

Statistical Analysis

The statistical procedure included three steps as follows:

1) In order to identify the types of farmers according to their *gariss* preparation practices, a Multiple Factorial Correspondence Analysis (MFCA) was achieved followed by an ascending hierarchical classification (AHC) by analyzing a data table including 29 farmers (rows) and the 4 active variables (columns) describing the process of *gariss* preparation.
2) In order to study the link between these types of preparation of *gariss* and the 5 variables describing the organoleptic properties and the conditions of *gariss* making, the supplementary variables were projected in the factorial plan of the previous analysis and the links were tested by Chi-square test at $P < 0.05$.
3) In order to determine the types of supplementary variable group and the relationships with the former typology, second MFCA and AHC were achieved and the link between the two typologies was tested by Chi-square test.

The statistical analysis software used for data analysis was XLSTAT 2009 (Addinsoft ©).

Table 1 .Coding of main variables used

Variable	Term	Characteristic	Number
	nv-1	No (starter) used	4
New starter	nv-2	Spices	21
	nv-3	*Gariss* added with spices	4
	Quot-1	No (starter) used	4
Starter daily	Quot-2	*Gariss*	22
	Quot-3	*Gariss* added with spices	3
Maintenance	ENT-1	No spices	9
(sourdough)	ENT-2	Spices	20
Time of	TPS-1	Less than 12 h	21
fermentation	TPS-2	12 h and above	8

Table 2. Coding of additional variables

Variable	Term	Characteristic	Number
Sensory Characteristics	org-1	Neither acidic nor bitter	18
	org-2	Slightly acidic	6
	org-3	Consistency than that of milk	5
Quantity of milk processed	qty-1	Is almost full transformed	16
	qty-2	A large quantity	7
	qty-3	Small quantity transformed	6
Other products prepared	pdt-1	Other product prepared	12
	pdt-2	No other product prepared	17
Operator	pre-1	Still the same operator	11
	pre-2	Different people	18
Storage	sto-1	Containing set in the shade, protected in a bag or a net made of grass	21
	sto-2	containing unprotected sun	8

Results and Discussion

Classification of Farms in Terms of the Gariss Preparation Process

The classification by AHC method of the four main variables describing the process of *gariss* preparation allowed identifying similarities and differences in the methods used by farmers. Truncation dendrogram of the AHC defined to minimize intra-class variance by comparison to the inter-class variance considered that four types were convenient explaining around 60% of the total variance (Figures 1 and 2). The four types are described below:

Type 1: Using different types of *gariss* and spices [ENT-1; Quot-2].This included eight of 29 farmers (E01, E02, E03, E04, E13, E15, E18, E29), the main criterion defining this class was the absence of added spice time, use of container and the daily use of the *gariss* of the former day as starter. All individuals constituting the class did not add spice (ENT -1). The daily preparation of *gariss* implied 87.5% (7 out of 8) of the herders used *gariss* as starter (one day old), and stored in container (Quot-2). One breeder (E29) did not add starter or spices for preparation of new *gariss* (Quot-1), thus the milk fermented spontaneously whether the container was new or not. This was the most heterogeneous of the four types, with an intra-class variance of 0.679, and the processes differed among types. On the graphic focus of the ACM (F1, F2) (Figure 1), the breeder E29 was far from the other individuals in this class. The difference in this plan was due to his membership modality (Quot-1). Furthermore, the preparation of the first *gariss* was made with milk only (nv-1) by half of the farmers in this class (E01, E03, E13, E29), while the other half (E02, E04, E15, E18) used spices (nv-2). The time for fermentation of milk was greater than 12 h for three farmers (37.5%) and lower for the other five farmers (62.5%). Eyassu (2007) studied camel herders in eastern Ethiopia and reported that pastoralists prepared fermented milk from fresh camel milk for many reasons, including to prolong shelf life, enable collection of milk over a few days when surplus milk was produced, deliver milk to the market, having high nutritive value, and high demand by urban

dwellers for thirst quenching and consumption.

Type 2: Using spices for the preparation of *gariss* fermented for less than 12 h [Nv-2; ENT-2, GST-1]. This class included 12 individuals (E05, E06, E08, E09, E12, E17, E19, E21, E22, E23, E25, and E26). All individuals grouped in this class added spice to the pudding production of the first *gariss* (nv-2) and adding spices in the *siin* (traditional container made from young goat or sheep leathers) occasionally (ENT-2). A part from 19 farmers was similar to that of class 1 farmers because no spices was added (ENT-1). The fermentation time of *gariss* was less than 12 h for all farmers which was a homogeneous group (intra-class variance of 0.288). Heterogeneity was due to the daily preparation of *gariss*. Every day, nine of them (75%) used *gariss* on the type (Quot-2). Three farmers (E17, E19, and E23) used fresh milk daily to prepare *gariss* (Quot-1). This heterogeneity was observed in factorial plans (F1, F2) and (F1, F3) (Figures 1and 3) of the CMA.

Ashmaig and Elgaali (2009) reported that for preparation of fermented camel milk, container of calabash, clay pots, plant fiber vessels or hollowed wood vessels are smoked by burning chips of Olea Africa or *Acacia busia*. The daily residual fresh milk is poured into the milk container. No starters are used and acidification develops after a few days, either from natural flora of milk when it is not boiled, or from the bacteria growing on the sides of the vessel. The milk is left in a quiet place, often in a covered container sheltered from dust from usually 24 to 48 h until it becomes sour. Due to spontaneous nature of fermentation, this traditional method results in a product with varying taste and flavor and often of poor hygienic quality. To improve the spontaneous traditional fermentation, controlled fermentation using mesophilic lactic acid bacteria starter culture is a very important strategy for camel milk processing (Abutarboush, 1998).

Type 3: Using the previous *gariss* and spices to prepare the first *gariss* maintenance by the addition of spices and fermentation time less than 12 h [nv-3, ENT-2; GST-1]. Four farmers made up this class (E07, E24, E27, E28). They were distinguished by preparation of the first *gariss*, which was associated with previous spices. They maintained the starter by adding spices and left to ferment for 12 h. The low heterogeneity (intra-class variance of 0.333) of this class revolved around a single variable. Fifty percent of farmers in this class (E24, E28) used *gariss* of the day only (Quot-2) and 50% used the same spices added to *gariss* (E07, E27) (Quot-3).

Type 4: Using spices for the preparation of the first *gariss*, adding spice to at least once per month, fermentation time exceeds 12 h and use of *gariss* the former day. [nv-2; ENT-2, GST-2]. This included five farmers (E10, E11, E14, E16, and E20). These breeders differentiated Breeders Class 2 only by the duration of fermentation of milk greater than 12 h (GST-2). The first *gariss* was prepared with spices (nv-2), then the gariss of the day was used alone daily (Quot-2) except for breeder 20 (E20; Quot-3) which combined spices. This *gariss* was maintained by adding spices more or less frequent (ENT-2). This was the class most homogeneous (within class variance of 0.200). These breeders differed from those in class 2 of the F3 axis of the ACM (Figure 2). The F3 axis of the ACM explained only 4.5% of the variance.

Individuals of classes 2 and 4 were considered to be closed. Farah *et al.* (1990) stated that traditional fermented camel milk from Kenya (*susa*) prepared by spontaneous fermentation has good character and uniform fresher taste than that prepared by starter cultures. The traditional *susa* can be improved by using selected mesophilic lactic

acid cultures. Similar approach was developed in Central Asia with local fermented camel milk (locally named as *shuba)* (Akhmetsadykova *et al*., 2014).

Links Between the Supplementary Variables with the Types of Gariss

This analysis was carried out to see if the supplementary variables were dependent on one or more of the main variables used for determining the type of *gariss* preparation. It appeared that the sensory variables as well as the other retained parameters were independent of the types of *gariss* preparation. The typology of Figure 2 farms based on the five supplementary variables (step 3 of the statistical analysis) was conducted in order to know: 1) whether there were associations of additional variables able to describe the four types of *gariss* preparation, 2) if the farmers described by these variables were grouped in similar classes than above.

According to the obtained dendrogram and factorial plan, three types of farmers were described (Figures 3 and 4).

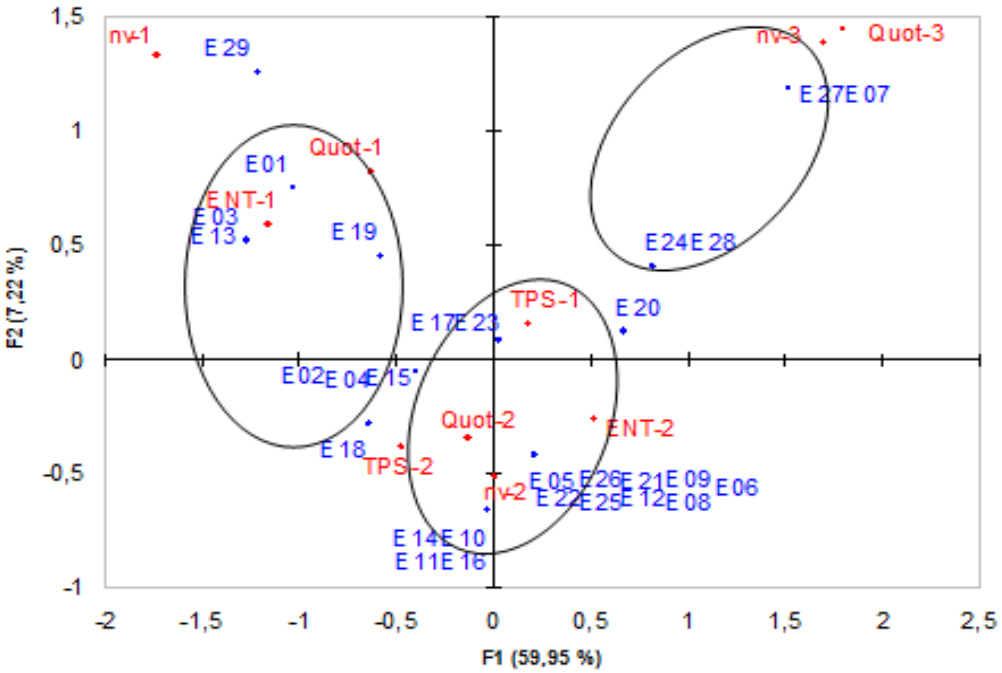

Figure 1. Representation of the main variables and observations (farmers, E), axes (F1, F2).

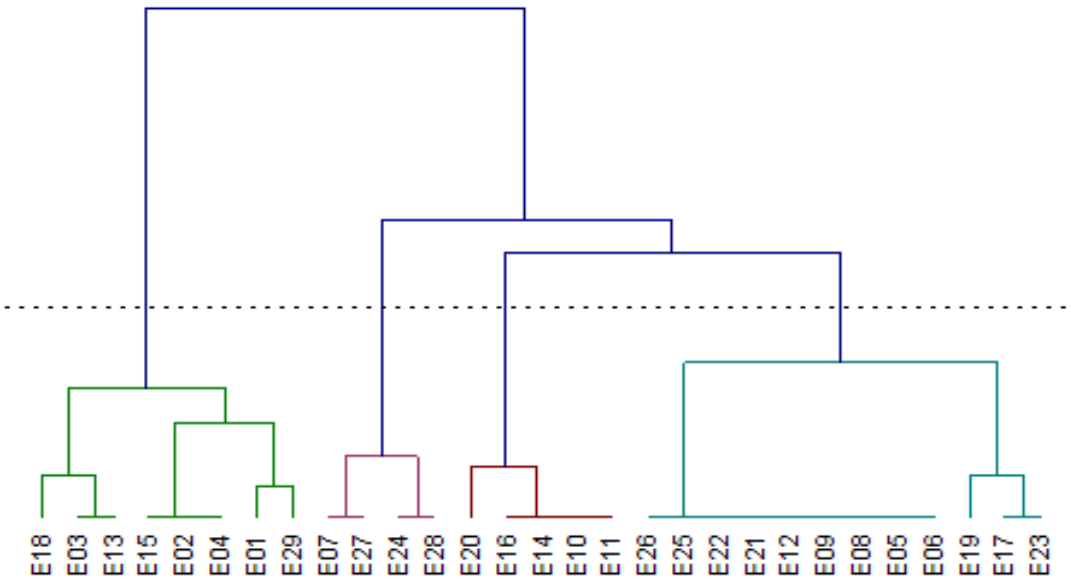

Figure 2. Dendrogram representing the classification of camel herders in the light of the *gariss* preparation process (dendrogram with dissimilarity)

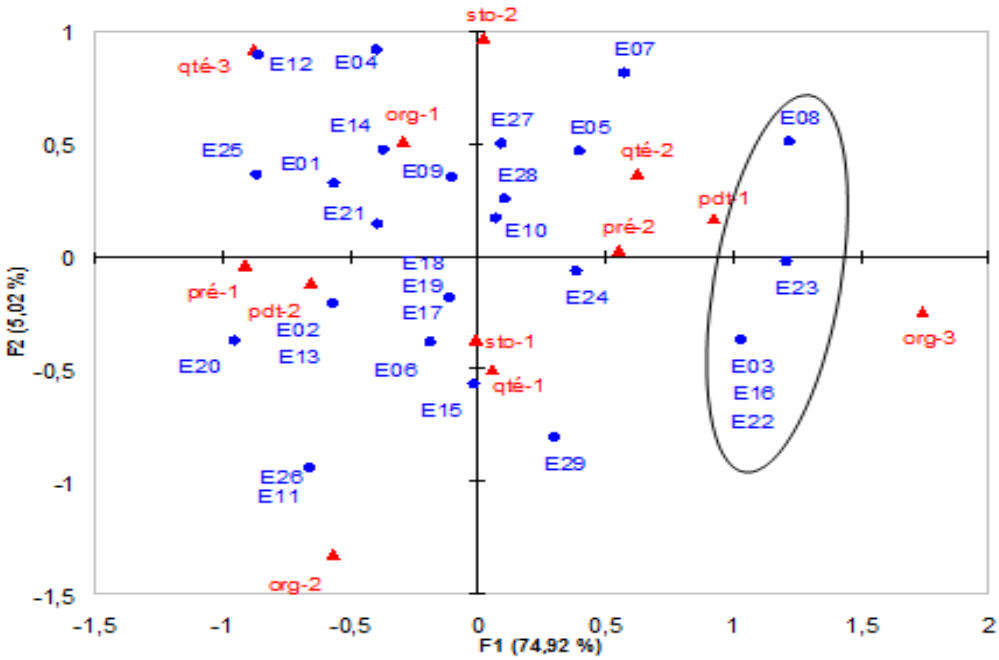

Figure 3. Representation of farmers in relation to the additional variables on axes F1 and F2.

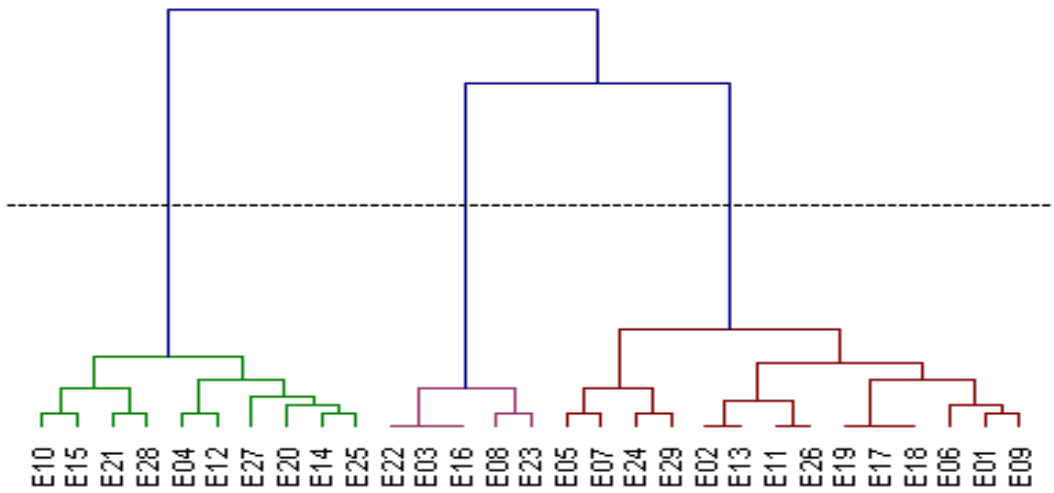

Figure 4. Classification of farmers according to their husbandry practices may influence the process of preparing the *gariss* (dendrogram in dissimilar)

Type A: Transformation of almost all milk and a preference for bitter in taste of *gariss*, and acid [qty-1; pre-2, org-1; pdt-2]. Fourteen farmers in this class (E01, E02, E05, E06, E07, E09, E11, E13, E17, E18, E19, E24, E26, E29) converted almost all their raw milk in *gariss* (qty-1) except E07, and a large majority (78%) liked *gariss* when it was neither acidic nor bitter (org-1). In addition, ten farmers (71%) did not prepare any other milk products (TDP-2) and nearly 65% protected the containers containing *gariss* from the sun (sto-1). In 65% of these farms, different people prepared the *gariss* (pre-2). The three main criteria on which most breeders gathered in this type were (1) the amount of *gariss* prepared, (2) their assessment's criteria and (3) the fact that they did not prepare any other dairy product.

Type B: Expected consistency of the *gariss* [org-3; pdt-1, pre-2]. This type included five farmers (E03, E08, E16, E22, and E23) where the major criterion to judge quality of *gariss* was its higher consistency compared to fresh milk (org-3). In each farm, different persons might prepare *gariss* (pre-2) and they also prepared another product (locally named as *semin*) based on camel milk (pdt-1). These three characteristics [org-3; pdt-1, pre-2] were common to all the farms of this group. In addition, 80% (4 of 5) of them protected the container of the *gariss* from the sun during storage. The highest variability was the quantity prepared, almost all milk (qty-1) for 60% of them (n = 3) and a variable quantity (qty-2) for 40% of them (n = 2).

Type C: Low quantity or variable amount of *gariss* prepared by a single operator [qty-3 or qty-2, pre-1, org-1; pdt-2]. The ten individuals grouped in this class (E04, E10, E12, E14, E15, E20, E21, E25, E27, E28) differed from type A by the quantity of *gariss* prepared, namely a small amount for 60% of them (qty-3) and a variable amount for 40% (qty-2) and by the operator in charge of preparing the *gariss* (only 60% of individuals included in this class (pre-1)). As for Class 1, 80% considered a good *gariss* which was neither acidic nor bitter in taste (org-1), the majority of farmers (80%) prevented the *gariss* from

the sun (sto-1) and 70% did not prepare another camel milk product (pdt-2).This type was more heterogeneous, with an intra-class variance of 1.122, than the inter-class variance. These results were not in agreement with those reported by Eyassu (2007) in low land of Ethiopia where 12% of camel pastoralists prepared other camel milk products rather than fermented camel milk (locally named as *dhanaan* or sour milk).

Study of the Existence of a Link between the Two Types

According to the observed results (Figures 2 and 3), none of the farmers could be classified according to the previous analysis. The different types of transformation process of milk into *gariss* did not seem to be explained by the five variables used above (amount of milk transformed, main sensory characteristic, producing another product, processor, storage). The confusion matrix (Kohavi and Provost, 1998) established to evaluate the relationship between these two typologies, showed no significant difference ($P > 0.05$) between the two distributions (Table 3). We can then conclude that there was independence between additional variables and the preparation of *gariss*.

Table 3. Confusion matrix between the typology on the fermentation process of *gariss* (process-i) and the one established by variables characterizing additional farms (type- x)

Process	Type A	Type B	Type C	Total
Process-1	5	1	2	8
Process-2	6	3	3	12
Process-3	2	0	2	4
Process-4	1	1	3	5
Total	14	5	10	29

Using Spices in Starter or Maintenance of Starter

The farmers used a variety of condiments, in association or not, when changing container for the fermentation of camel milk. All farmers had described the practice as necessary from a sensory standpoint, for obtaining a flavor and/or desired odors and not for technological aspect such as fermentation time and texture. The various associated ingredients used and the number of farmers using each ingredient are shown in Table 4. The most commonly used ingredients were in descending order: fenugreek, onion and black cumin seeds. These condiments were added either "bulk" in the *siin* or other container or in a "piece of clean cloth". Sometimes only the fenugreek was added wrapped in tissue and others were added in bulk. Of the 25 farmers adding various ingredients to the composition of first starter, 68% of them (n = 17) used a piece of clean cloth for all or a part of the mixture of spices, 16% (n = 4) mixed them in milk, and for 16% (n = 4) gave no response. Biochemical characteristics of the final products should be achieved for a better understanding of the observed variability as it was done on cow milk (Baron *et al*., 2000).

Table 4. Number of farmers using different groups of ingredients and those using each ingredient in the preparation of *gariss* in a new container.

No. of farmers using ingredients	Fenugrec[1]	Oignon[2]	Black cumin[3]	Citron[4]	Garlic[5]	Others	No ingredient
8	■	■	■				
5	■	■					
4							■
3	■		■				
2	■						
2	■			■			
1	■	■	■		■		
1	■	■				■	
1	■			■			
1		■	■				
1			■				
Number of farmers using each ingredient	23	17	14	3	1	1	4

[1]Fenugrec(*Trigonella foenum graecum),* [2]Oignon (*Allium cepa),* [3]Seeds of black cumin (*Nigella sativa),* [4]Citron (*Citrus limon),* [5]Garlic (*Allium sativum)*

Conclusion

In conclusion we can assume that *gariss* preparation methods differ according to the farms and there was link between some of them, but there is no link between organoleptic character, starter used and *gariss* fermentation time according to the farmer's point of view. Other husbandry practices need to be used to explore their effect in *gariss* preparation methods. According to indigenous knowledge, common diseases can be treated by *gariss* and camel milk. The preparation methods could play a role in these health benefits. However, the study of better shelf life conditions of camel milk in remote areas should be of concern.

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References

Abu-Tarboush, H., Al-Dagal, M. and Al-Royli, M.1998. Growth, viability and proteolytic activity of bifidobacteria in whole camel milk. Journal of Dairy Science. 81: 354-361. http://download.journals.elsevierhealth.com/pdfs/journals/00220302/PIIS0022030298755845.pdf

Akhmetsadykova, S., Baubekova, A., Konuspayeva, G., Akhmetsadykov, N. and Loiseau, G. 2014. Microflora identification of fresh and fermented camel milk from Kazakhstan. Emir. J. Food Agric. 26 (4): 327-332. http://ejfa.info/index.php/ejfa/article/view/17641/9108.

Al haj, O. A. and Al Kanhal, H.A. 2010. Compositional, technological and nutritional aspects of dromedary camel milk a review: International Dairy Journal. 20 (12): 811-821. http://www.sciencedirect.com/science/article/pii/S0958694610001196

Ashmaig, A. and Elgaali, A. 2009. Identification of lactic acid bacteria isolated from traditional Sudanese fermented camel milk (gariss). African Journal of Microbiology Research. 3(8): 451- 457.

Baron, M., Roy, D. and Vuillemard, C. 2000. Biochemical characteristics of fermented milk produced by mixed-cultures of lactic starters and bifidobacteria. Lait, 80: 465-478. http://www.academicjournals.org/ajmr/PDF/Pdf2009/Aug/Ashmaig%20et%20al.pdf

Bekele, T., Zeleke, M. and Baars, R.M.T. 2002. Milk production performance of the one-humped camel (*Camelus dromedarius*) under pastoral management in semi-arid eastern Ethiopia. Livestock Production Science. 76: 37-44. http://www.sciencedirect.com/science/article/pii/S0301622601003335

Dirar, H. A. 1993. The Indigenous Fermented Foods of the Sudan. A Study in African Food and Nutrition. CABIinternational, England.

FAO. 2008. Camel milk. Retrieved from http:www.fao.org/ag/againfo/themes/en/dairy/camel.html.

Farah, Z., Streiff, T. and Bachmann, M. 1990. Preparation and consumer acceptability tests of fermented camel milk in Kenya. Journal of Dairy Research. 57:281-283. http://dx.doi.org/10.1017/S002202990002690X

Farah, Z., Mollet, M., Younan, M. and Dahir, R. 2007. Camel dairy in Somalia: Limiting factors and development potential. Livestock Science. 100: 187-191. http://www.sciencedirect.com/science/article/pii/S187114130600463X

Farah, Z., Rettenmaier, R. and Atkins, D. 1992. Vitamin content of camel milk. International Journal of Vitamin Nutrition and Research, 62: 30-33. http://www.camelmilkforhealth.com/admin/uploads/pubs/journal_for_vitamin_and_nutrition_research_62_1994_30.pdf

Faye, B. and Konuspayeva, G. 2012. The sustainability challenge to the dairy sector; the growing importance of non-cattle milk production worldwide, International Dairy Journal, 24:50-56. http://www.sciencedirect.com/science/article/pii/S0958694612000210.

Kohavi, R. and Provost, F. 1998. Glossary of terms. Editorial of the Special issue on applications of machine learning and the knowledge discovery process. Machine Learning, 30, 271-274. http://ai.stanford.edu/~ronnyk/glossary.html

Konuspayeva, G., Faye, B., Loiseau, G. and Levieux, D. 2006. Lactoferrin and immunoglobin content in camel milk from Kazakhstan, Journal of Dairy Science, 90: 38-46. http://download.journals.elsevierhealth.com/pdfs/journals/00220302/PIIS0022030207726061.pdf.

Konuspayeva, G., Lemarie, E., Faye, B., Loiseau, G. and Montet, D. 2008. Fatty acid and cholesterol composition of camel's (Camelus bactrianus, Camelus dromedarius and hybrids) milk in Kazakhstan, Dairy Science Technology, 88: 327-340. http://www.dairy-journal.org/index.php?option=com_article&access=standard&Itemid=129&url=/articles/dst/pdf/2008/03/dst0732.pdf

Konuspayeva, G., Camier, B., Gaucheron, F. and Faye, B. 2014. Some parameters to process camel milk into cheese. Emir. J. Food Agric. 26(4): 354-358. http://ejfa.info/index.php/ejfa/article/view/17277/9112

Nagy, P., Skidmore, J.A. and Juhasz, J. 2013. Use of assisted reproduction for the improvement of milk production in dairy camels (*Camelus dromedarius*). Animal Reproduction Science. 136 (3): 205-210. http://dx.doi.org/10.1016/j.anireprosci.2012.10.011

Omer, R.H. and Eltinay, A.H. 2009. Changes in chemical composition of camel's raw milk during storage. Pakistan Journal of Nutrition. 8 (5): 607-610. http://www.pjbs.org/pjnonline/fin1208.pdf

Seifu, E. 2007. Handling, preservation and utilization of camel milk and camel milk products in Shinile and Jijiga Zones, eastern Ethiopia. Livestock Research for Rural Development. 19 (6): 1-16. http://www.lrrd.org/lrrd19/6/seif19086.htm

Shabo, Y., Barzel, R., Margoulis, M. and Yagil, R. 2005. Camel milk for food allergies in children. Immunology and Allergy. 7: 796-798. http://www.camelmilkforhealth.com/admin/uploads/pubs/ar05dec-12.pdf

Sukar, S.A., Majid, A.M., Bakheit, S.A. and Ibrahim, A.A. 2002. The socioeconomic of camel's herders in Kordofan region, ACSAD/ CARDN Damascus, Syria.