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A Review on the Sudanese Traditional Dairy Products and Technology

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ABSTRACT

Sudanese traditional fermented foods represent the main source of nutrition for rural and urban communities. Dairy products participated in enhancement of the economy, finance and business of local societies. Although, many dairy product studies have been conducted in Sudan, information on the microbiology and technology is still sparse. Most of the research conducted has relevance to organisms associated with fermentation and those considered spoilage. Diverse strains of Lactic Acid Bacteria (LAB) were documented as part of many traditional fermented milk products. But knowledge about their specific health benefits and strains properties needs to be revealed. Moreover, publishing is not having much concern compared to the flow of the Sudanese studies. The aim of this review was to figure out the traditional dairy technology used, identity of the isolates as well as presentation of the Sudanese research to the world abroad.

Key words: Rob, gariss, traditional products, dairy, probiotics, fermentation

INTRODUCTION

No other group of bacteria took a considerable attention than Lactic Acid Bacteria (LAB). Its fermentative properties revolutionize the dairy products industry. Its uses as probiotic pave the way of bacteriotherapy era. Its use as natural preservative remains safe for many centuries (Ali, 2011). Milk represents the most important diet for human from infancy to elderly (Elmagli and El-Zubeir, 2006). Milk is fermented by LAB to produce other products varied in their tastes, constitutions and shapes. Dairy products are major source of nutrition and consumed daily throughout the world. In some countries, addition of traditional spices enhances the fermentation process and suppresses the growth of pathogenic organisms (Abdalla and El-Zubeir, 2006). The chemical composition, the hygienic quality and determination of food borne diseases were widely studied in Sudan. But researches issued to laboratory work not actively contribute to industry manufacturing (Warsama *et al.*, 2006). Governments are asked to strength their efforts to advance the measurements of food quality and safety (Yagoub *et al.*, 2006). Many factors are indigenously attributed to the fermentation processes such as the form of the inocula, type of vessels used and the micro flora from the starter/s or from the surrounding environment (Osuntoki *et al.*, 2008).



Fig. 1: Map of Sudan

Sudan in glance: Sudan (Fig. 1) is laid in the heart of Africa between latitude 4° and 22.5° N and extends from longitude 22° to 38° E. It is the largest country in Africa covers area of $2,505,813 \text{ km}^2$ and ranked as the tenth world largest country. River Nile, the world's longest river, divided Sudan into east and west sides (Collins, 2007). Sudan is bordered by Egypt from north, Libya from northwest, Chad from west, Republic of Central Africa and Congo from southwest, Kenya and Uganda from southeast, Eritrea and Ethiopia from east and the Red Sea from the northeast. Sudan is among the wealthiest countries in Africa in terms of the natural resources (Ibnouf, 2009). It is the second largest livestock in Africa. The nomadic pastoral sector accounts more than 90% of the huge animal population (FAO, 2001). Recent census estimates the Sudanese population about 35 million person. Federal Ministry of Animal Resources and Fisheries in 2006 estimated that there were 39.67 million head of cattle, 48.44 million sheep, 42.03 million Goats, 3.50 camel, 7.00 million equines and 50.00 million poultry. The total rate of fresh milk production (Fig. 2) from different animals' sources is 7.095 thousand ton. The consumption as dietary food is 3.969 thousand ton. Cattle, sheep and goats provide an important investment property in terms of meat, milk and leather (FAO, 2005).

Historical background: The introduction of fermented milk products to Human civilization date back many thousands of years (Campbell-Platt, 1994). They may originated in the Middle East and dated back long before the phoenician era. It was proved that Laban Rayeb and Laban Khad (traditional Egyptian fermented milk products) were consumed as early as 7000 Before Christ (Kosikowski and Mistry, 1997).

The Sudanese history of using milk dated back to 5000 years ago. Strong evidence proved that people of Meroe Kingdom (690 BC-D 323) may know how to ferment cow milk

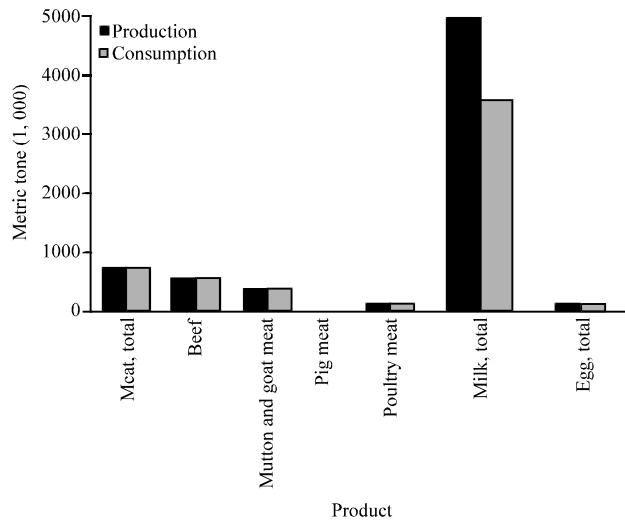


Fig. 2: Production versus consumption for meat, milk and eggs with the year 2002. Source: FAO (2005)

(Abdel Gadir *et al.*, 1998). Milk fermentations provide a way for long-term preservation, enhance the nutritional value, improve the appearance of various products, give the desirable taste, prevent the spoilage and reduce the effort and time required for cooking (Tamime, 2002; Motarjemi, 2002; Floros *et al.*, 2010). The souring of milk into a product or into certain dairy products is a widespread practice. These products are art specific of certain country whereas others are confined to specific geographical locations (Abdel Gadir *et al.*, 1998).

SUDANESE TRADITIONAL DAIRY FOODS

The various sources of fresh milk in Sudan shaped the different traditional dairy products (Fig. 3). Dirar (1993) divided the Sudanese fermented dairy products into two major groups: the truly indigenous which include Rob, Gariss, Biruni and Mish and the quasi-indigenous which include Zabadi and Gibna beida. Methods of preparation are different slightly from one part of the country to another. The most important traditional products are Rob (fermented milk product mainly of cow's), Zabadi (local name of yogurt), Gariss (fermented camel's milk product), Gibna Bayda (white cheese), Gibna Mudaffra (White pickled cheese) and Mish (fermented milk product with spices) (Dirar, 1993; Abdel Gadir *et al.*, 1998).

Rob: Rob is produced (Fig. 4) in the rural areas mainly on household levels. It is the popularly known way for surplus milk preservation. There are many spelling Rob, Roub and Robe. The name is varying according to the area produced. For instance, in Butana area called kit, Darfur Berkib and laben-rayeb in urban areas. Rob is made from fermentation of cow, sheep and goat's milk. The bulk is made from cow's milk while a smaller proportion is prepared from either goat's or sheep's milk or a mixture of these two milks (Abdel Gadir *et al.*, 1998; Dirar, 1993). Milk surplus is collected in a container, inoculated with a starter from the previous day and left to ferment overnight. The fermentation process usually starts in the evening when the animals return from grazing and the sour product is churned in the morning when the herd leaves for grazing. Freshly produced Rob has a pleasant taste with a pH of about 4.5. In some parts of the country, churning is done in a

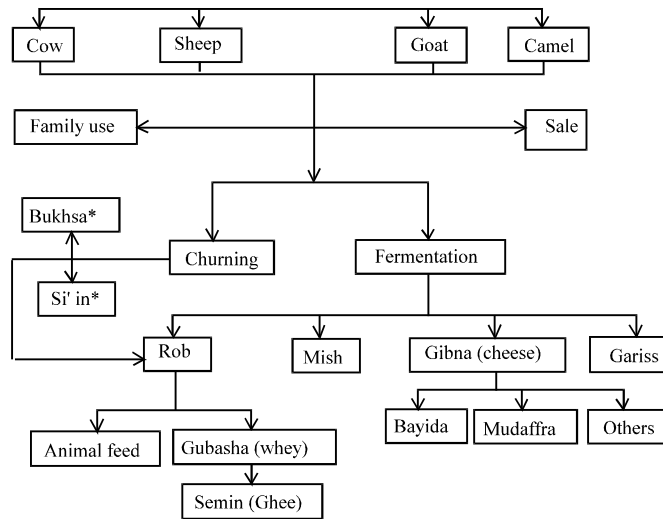


Fig. 3: Flow scheme for processing of various traditional fermented milk products. **Bukhs* and *Si'in* Local churner gourd are used for churning fermented milk, mainly in Darfur State

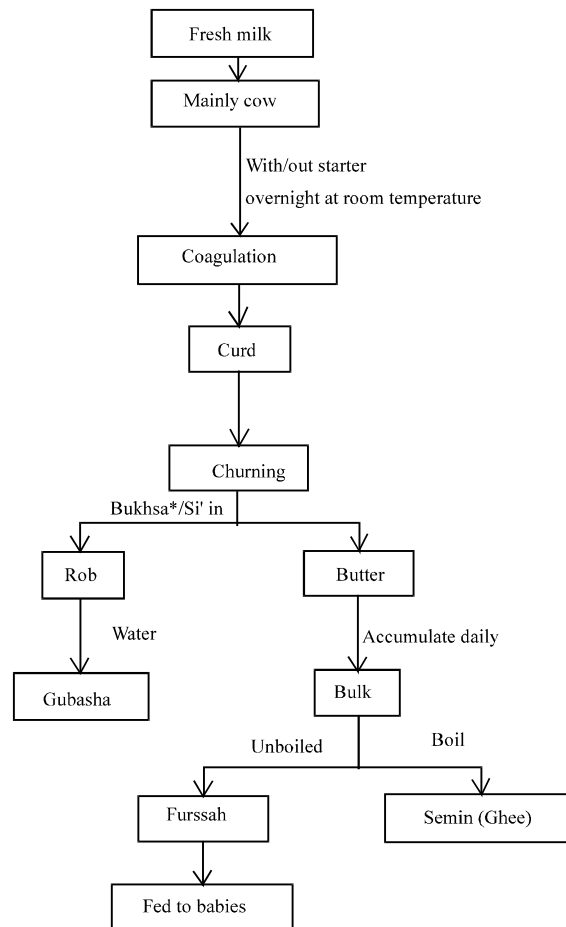


Fig. 4: Rob production in the rural area in Sudan

leather container called *Si'in* made of tanned goatskin (Girrba) and in other parts it is done in a container called Bukhsa. Bukhsa is a gourd made from the dried fruit of the plant *Lagenaria leucantha*. In hot climatic conditions, Rob is diluted with 2 or 3 volumes of water to give Gubasha, a thirst quencher (Abdelgadir *et al.*, 2001; Dirar, 1993).

In urban, Rob is usually refrigerated and consumed with sugar as a desert or eats with wheat bread. Sometimes it is fed to babies and often turned into sauce for Aceda (porridge) or given to young animals as a milk replacer (Dirar, 1993). Most of the developing countries started to search in their indigenous homemade yoghurt for effective antibacterial agents against enteric pathogens (Salih *et al.*, 2011; Osuntoki *et al.*, 2008; Yesillik *et al.*, 2011).

Gibna: Ginba (cheese) production in Sudan has been started in the early eighteenth century by the Greek families who migrated to Sudan. They settled mainly at El Dueim in the White Nile State, El Obeid in North Kordofan state and other localities in the country (El-Tayeb, 1986). Gibna making is the major preservation method for surplus milk in rural areas. The highest production is during the rainy season (Hamid and El Owni, 2007). The major types of cheese are Gibna Bayda and Gibna Mudaffara (El-Sheikh, 1997; Hamid and El Owni, 2007). They are varying in composition, texture, color, taste and flavor. The variation is due to composition of milk, methods of production, microbial flora, type of package, microbial activity during ripening and ripening conditions. Cheese manufacturing is influenced by product composition, processing, packaging and storage conditions. Control of temperature and humidity and transportation are dynamic aspect of health hazards (Nour El-Diam and El-Zubeir, 2006).

Gibna bayda: Sudanese Gibna Bayda is unique in containing high concentrations of salt (Sodium Chloride) which is added to the milk before processing. High salting preserve cheese from rapid deteriorating before ripens (Taormina, 2010; Osman, 1987). The procedure (Fig. 5) for making Gibna Bayda includes heating of the fresh milk to 35°C followed by salt addition to give 6-10% solution in milk. The lactic acid bacteria naturally present in the raw milk carry out the fermentation process, no starter is used (Abdel Gadir *et al.*, 1998; El-Owni and Hamid, 2008).

Gibna mudaffara: Gibna Mudaffara is similar to Gibna bayda but high percentage of salt is added to milk (Fig. 5). Rennet or rennet extract is added to obtain a firm coagulum which develops in 4 to 6 h. Ripening takes place while the cheese is submerged in whey. The purpose of coagulant is the conversion of liquid milk into a gel catalyzed by different proteases (Green, 1984). There are two main phases in the mechanism of milk clotting: the primary (enzymatic) phase and the secondary (coagulation) phase (Dalglish, 1993; Payne *et al.*, 1993). The coagulum is then transferred to wooden moulds lined with cheese cloth muslin and the whey is allowed to drain overnight. The drained whey collected into a clean pan, boiled for 15 min, followed by removal of the fats and coagulated whey proteins, then starter from previous fermented milk is added and left overnight to ferment. Next day the cheese is removed from the molds and the curd is cut into 10 cm cubes. Gibna Mudaffara preserved for long time by immersion in the whey. For marketing it packed in tins or other suitable sealed containers (Dirar, 1993; Abdel Gadir *et al.*, 1998; El-Tayeb, 1986).

Gariss: Gariss is unique Sudanese traditionally fermented camel's milk product. It made by a semi-continuous fermentation process. The word Gariss means pinching or stinging, denoting a

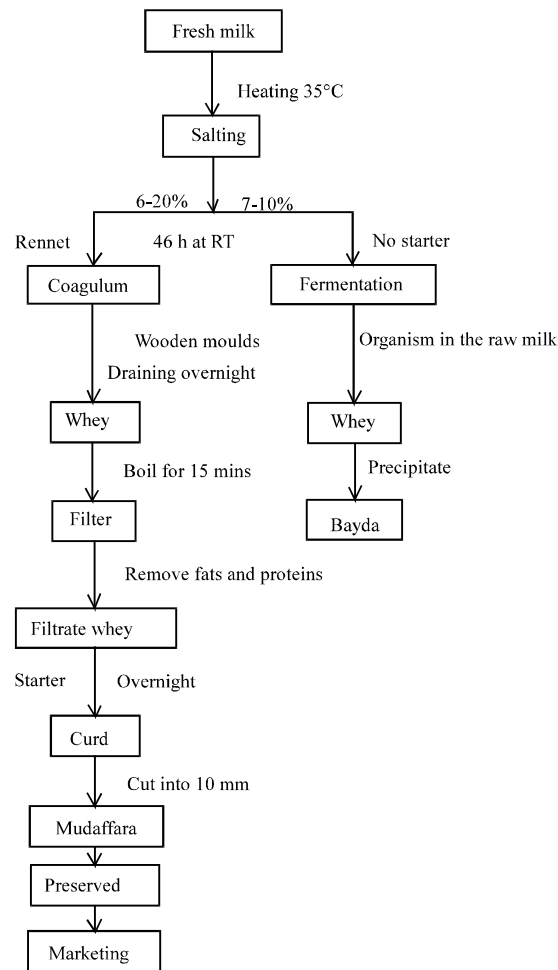


Fig. 5: Cheese production in Sudan

high degree of sourness (Dirar, 1993). Fermentation is carried out in two leather bags of tanned goat skin embedded in green or wet grass carried on the back of camels. Milk is subjected to continuous shaking by the jerky walk inherent to camels. Whenever part of the product is withdrawn for consumption, a part of fresh camel's milk is added to make up the volume and this continues for months (Dirar, 1993; Abdel Gadir *et al.*, 1998). Camel milk is the main dietary of nomadic tribes in the East and West of Sudan. It also consumed by pastoralists living in the arid and semi-arid regions. Pasteurization reduces the chemical composition (total solids, fat, protein, ash and acidity) of Gariss. Pasteurized and non pasteurized Gariss equally withstand the storage conditions (Hassan *et al.*, 2007).

Suusac is similar to Garris and widely consumed by the pastoralist communities living in Kenya and Somalia. It is prepared by fermenting fresh camel milk in a pre-smoked gourd at ambient temperature (26-29°C) for 1-2 days (Lore *et al.*, 2005).

Mish: Mish is famous fermented milk product recently introduced from Egypt (El-Mardi, 1988). Mish is produced by boiling milk, cooling and inoculation with small quantity of the previous batch or Rob. After souring, seeds of black cumin (*Nigella sativa*), seeds of fenugreek (*Trigonella foenum*

graecum) and perhaps a few pods of green or red pepper are added. The product is fermented for 2 or more days before consumption (Dirar, 1993). Black cumin played a remarkable inhibitory effect on the growth of *Staph aureus*. This may be due to the fact that volatile oil inhibits the growth of some pathogenic bacteria (Abdalla and El-Zubeir, 2006). The intensity of spicing may differ from region to another and from family to family within the same district. Variation depends on spices availability and the taste of the people (El-Mardi, 1988).

Other Sudanese dairy products

Biruni: Biruni is similar to Mish. Its manufacturing was limited to Nuba Mountains area but recently spread into the area inhabited by pastoralists who named it Laban-gadim (aged milk). Biruni is stored at least for one year and may extend to more than ten years. The main purpose of making Biruni remain secret as it consumed years after fermentation (Dirar, 1993).

Samin: Samin (ghee) like in many African countries is produced from butter (Sserunjogi *et al.*, 1998). The process involves a gradual heating of butter, during which water is driven off and protein is dehydrated and precipitated. Then oil is extracted in a closed tight container. Samin is home-made product and mainly add to Rob sauce and for bakery.

MICROBIOLOGICAL OVERVIEW OF THE DAIRY PRODUCTS

Milk fermentation process depended on the microbial biological activity to produce a range of metabolites. These metabolites have preservative and antagonistic effects so prevent the spoilage and/or pathogenic food microbes. Fermentation produces aromatic compounds such as diacetyl and acetaldehyde which flavor the foods, as well as vitamins and antioxidants (Ross *et al.*, 2002; Ray and Daeschel, 1992). The nature of fermented products is different from one region to another. Differences depend on the local indigenous microflora and the climatic condition of the area. Thus, traditional fermented milk in cold region contained mesophilic bacteria such as *Lactococcus* and *Leuconostoc* spp while thermophilic bacteria which include mostly *Lactobacillus* and *Sterptococcus* prevailed in subtropical or tropical regions (Savadogo *et al.*, 2004). The metabolic pathways of each strain ended with different byproducts as organic acids, alcohol and carbon dioxide. The microorganisms present in milk may originate from the animal itself, milking equipment and environment, personnel or from the previous batch if back-slopping is used (Narvhus and Gadaga, 2003). It is clear that the microbiology of these products is so variable. The variation is due to the method of processing, salting time and method of whey treatment. It is of great value to carry out extensive and comprehensive studies to elucidate and identify the Sudanese normal dairy flora. Research must focus on which is which microbe and/or its products is predominated or confined in each country part.

LACTIC ACID BACTERIA (LAB)

Lactic Acid Bacteria (LAB) are widespread in most ecosystems. They are famous starter cultures for food fermentation, as well as commonly found in non-fermented foods such as fruits, vegetables, cereals, sewage. LAB also inhibits the genital, intestinal and respiratory tracts of humans and animals. LAB has an excellent employment in foods industry, due to their contributions to flavor, aroma and increase shelf life of fermented products (Stiles and Holzapfel, 1997; Leisner *et al.*, 1999). It bears many responsibilities as in dairy to make yoghurt and cheese, in meat to produce sausages, in fish to manufacturing tuna, in cereals for bread bakery and beverages to make beer,

in fruit (malolactic fermentation processes in wine production), and in vegetables to prepare sauerkraut, kimchi and silage (Calo-Mata *et al.*, 2008).

LAB are Gram-positive microorganisms, non-sporulating, cocci or rods, negative to catalase test, devoid of cytochromes, preferring anaerobic conditions but are aerotolerant, fastidious, acid-tolerant and strictly fermentative. LAB produces lactic acid as main product of glucose degradation (Stiles and Holzapfel, 1997). The most important genera are *Lactobacillus*, *Lactococcus*, *Enterococcus*, *Streptococcus*, *Pediococcus*, *Leuconostoc* and *Bifidobacterium*. The isolation and characterization of LAB aimed to provide starters that allow standardization without changing the fundamental properties of the product (Herero *et al.*, 1996). Tentative identification of new strains may attract the attention of the dairy industry for development of starter cultures, new products and tastes. Great efforts were made to investigate and manipulate its role in these symbiotic processes (Reid, 2008). Current researches focused on the use of LAB as probiotic (Ouwehand *et al.*, 2002). Sudanese researchers still want to know the starters, the common microbes present and the chemical composition of the fermented dairy products. Little research (Abdullah and Osman, 2010; Ali, 2011; Salih *et al.*, 2011) intended to constitute a bank of LAB strains isolated from Khartoum state. They aimed to use the selected strains, one hand, in manufacturing fermented dairy products suitable to local conditions and on the other hand, to introduce national functional products into the Sudanese and international markets.

In general practice, although the method used for characterization and identification of LAB species was still traditional phenotypic characterization, few studies used the recently advanced molecular techniques.

RESEARCHES AREA REVIEW

The capital city (Khartoum) is the most studied area and nomads in the surrounding (Saeed, 1981; Mahjoub, 1998; Abdelgadir *et al.*, 2001; El-Mardi, 1988). Few studies were conducted in White Nile State, central of Sudan (Abdalla and Ahmed, 2010), Darfur (Abdel Moneim *et al.*, 2006; Hamid and El Owni, 2007) and Gezira states (Sulieman *et al.*, 2009) west and center of Sudan, respectively. The researches were either for microbial screening or for isolating the common types of bacteria in the samples. Samples studied were varied according to the dairy products.

The microflora of Sudanese dairy products: The microbiology of the spontaneous souring of milk in Sudan is complex and diverse (Table 1). Most of the dairy products are prepared by spontaneous fermentation, either using the previous fermented batch back slop or using the same instrument (Gonfa *et al.*, 2001). The predominant microbiota in animal's milk (cows, goats, camels and ewes) contains variable strains of different genera and species (Elgadi *et al.*, 2008). Homofermentative lactobacilli from cows and camel milk were tentatively identified as *Lactobacillus plantarum* and *Lb. acidophilus*, whereas the Heterofermentative ones from cows, goats and ewes milk were found to be *Lactobacillus fermentum*. The Homofermentative *Streptococci* isolated from all milk were tentatively *Streptococcus cremoris* and *Streptococcus lactis*, whereas the only Heterofermentative strain isolated from camel milk is *Leuconostoc lactis* (Elgadi *et al.*, 2008).

Dirar (1975) noticed that milk soured by *Enterobacter aerogenes* to produce a frothy product or by *Lactococcus* sp. to produce a smooth-set product. *Coliform* bacteria and LAB are both involved in the souring of milk, especially in the hot summer.

The early studies of Saeed (1981) and El-Mardi (1988) revealed *Streptococcus thermophilus*, *Lactobacillus bulgaricus* (or the closely related *L. jugurti*), *Lactobacillus helveticus*, *Lactobacillus*

Table 1: Frequency of the common isolates in Sudanese dairy products

Group	Isolate
Highly constitutive	<i>Lactobacillus plantarum</i> and <i>Lactococcus</i> spp., <i>Lactobacillus fermentum</i>
Constitutive	<i>Lactobacillus paracasei</i> , <i>Lactobacillus bulgaricus</i> , <i>Leuconostoc</i> , <i>Lactobacillus paracasei</i> ssp. <i>paracasei</i> , <i>Streptococcus lactis</i> , <i>Enterococcus</i> spp.
Semi-constitutive	<i>Streptococcus thermophilus</i> , <i>Lactobacillus brevis</i> , <i>Enterococcus faecium</i> , <i>Lactobacillus acidophilus</i> , <i>Lactobacillus delbreuckii</i> , <i>Lactobacillus casei</i>
Rare	<i>Pediococcus</i> , <i>Lactobacillus helveticus</i> , <i>Corynebacteria</i> spp. <i>Staphylococcus</i> , <i>Streptococcus infantarius</i> subsp. <i>infantarius</i> , <i>Streptococcus uberis</i>

fermentum and *Lactococcus lactis* as the common microbial species in Rob. All studies used the conventional methods of identification. In the new millennium recent advanced methods were used for bacterial identification. Hamza *et al.* (2009) identified *Lactobacillus delbreuckii* sub sp. *bulgaricus*, *Lactobacillus rhamnosus*, *Lactobacillus plantarum*, *Lactobacillus casei*, *Lactobacillus pentosus* using API 50 CHL. *Aerococcus viridians*, *Enterococcus faecium*, *Enterococcus gallinarum*, *Lactococcus lactis* sub sp. *lactis*, *Leuconostoc* sp. *Streptococcus acidominimus* and *Streptococcus bovis* were added to the list by API 20 STREP identification. Random Amplified Polymorphic DNA (RAPD) was used as molecular identification technique to confirm the results (Hamza *et al.*, 2009). Gram negative bacteria may not associate with the aerobic bacteria in Rob. This may due to the acidity of the product (Mahjoub, 1998). Some of the bacterial species were not frequency reported in dairy products such as *Corynebacteria pseudodiphtherium* isolated from Rob (Mahjoub, 1998). Other unfavorable bacterial species may present in high amount such as *Staphylococcus saprophyticus*, *Staph. epidermidus*, *Staph. arlettae*, *Staph. hyicus*, *Streptococcus uberis*, *Micrococcus luteus*, *M. kristinae* and *Coliform* (Mahjoub, 1998). It seems that some pathogenic bacteria may be a part of the normal dairy biota such as *Streptococcus infantarius* sub sp. *infantarius* in Gariss (Abdelgadir *et al.*, 2008).

Studies on Gariss revealed that the most dominant LAB were *Lactobacillus paracasei* sub sp. *paracasei*, *Lactobacillus fermentum*, *Lactobacillus plantarum* and *Lactococcus raffinolactis*. The dominant were *Lactococcus lactis*, *Enterococcus* spp., *Leuconostoc* spp., *Lactobacillus animalis*, *Lactobacillus gasseri*, *Lactobacillus brevis*, *Lactobacillus divergens*, *Lactobacillus rhamnosus* and *Lactococcus alimentarium*. Whereas the less frequently isolates from Gariss were *Streptococcus lactis* sub spp *diacetylactis*, *Lactobacillus brevis*, *Lactobacillus casei*, *Lactobacillus leichmanii*, *Lactobacillus acidophilus* (Suliaman *et al.*, 2006; Abdel Moneim *et al.*, 2006; Hassan *et al.*, 2008; Ashmaig *et al.*, 2009).

The presence of *Salmonella* spp. and *Clostridia* spp. is not documented in Gibna Bayda collected in Zalingei Area, west Darfur State (Hamid and El Owni, 2007) but *Salmonella* spp. present in considerable amount in Gibna from Khartoum State (Yagoub *et al.*, 2006). There are significant variations between color, texture, flavor and saltiness in Gibna from Zalingei. The common microorganisms in Gibna bayda were *Streptococcus mutans*, *Lactobacillus bulgaricus*, *Lactobacillus casei* and *Lactococcus plantarum* (Ahmed, 1997).

There is no significant difference in the microbial counts of Gariss from transhumance and nomadic camel. But *Streptococcus lactis* is the most predominant in the Nomadic herders, while *Str.lactis* sub sp *diacetylactis* is predominate in transhumance herders (Hassan *et al.*, 2008). The microbiota of Gariss is different from area to another. In Butana area high count of *Lactobacilli* ($8.22 \pm 0.28 \log_{10}$ cfu mL⁻¹), Kordufan area higher counts ($7.85 \pm 0.45 \log_{10}$ cfu mL⁻¹) of yeasts than Butana (Suliaman *et al.*, 2007). *Lactobacillus plantarum*, *Lactobacillus paracasei* are major

Table 2: Chemical composition of fresh milk in %

pH	Moisture	Ash	Protein	Fat	Lactose	TSS	TA
6.7±0.05	88.5±1.3	1.2±0.03	3.47±0.07	3.3±0.01	3.7±0.01	11.8±1.2	0.14±0.08

TSS: Total soluble solids, TS: Titrable acidity. Modified from Sulieman *et al.* (2007)

Table 3: Amino acid composition of Fresh Milk (FM) and Rob samples

Amino acid	Barakat		Darweesh		El-Mekki		Mean±SD	
	FM	Rob	FM	Rob	FM	Rob	FM	Rob
Alanine	Bql	Bql	Bql	Bql	Bql	Bql	Bql	Bql
Arginine	0.18	0.24	0.16	0.26	0.21	0.26	0.18±0.02	0.20±0.01
Asp acid	0.22	0.5	0.18	0.5	0.17	0.7	0.19±0.02	0.56±0.10
Cysteine	0.08	0.1	0.1	0.14	0.13	0.24	0.10±0.02	0.16±0.05
Glutamic acid	1.4	3.4	1.2	2.8	1.6	2.8	1.40±0.16	3.00±0.20
Glycine	0.05	0.3	0.06	0.3	0.08	0.36	0.06±0.01	0.32±0.02
Histidine	Bql	Bql	Bql	Bql	Bql	Bql	Bql	Bql
Isoleucine	Bql	0.07	Bql	0.09	Bql	0.12	Bql	0.10±0.03
Leucine	1.5	3.1	1.3	1.8	1.5	2.1	1.40±0.09	2.30±0.50
Lysine	0.4	0.5	0.4	0.6	0.3	0.7	0.36±0.04	0.60±0.08
Methionine	Bql	0.12	Bql	0.13	Bql	0.12	Bql	0.12±0.004
Phenylalanine	0.3	0.5	0.4	0.8	0.4	0.9	0.36±0.1	0.73±0.17
Proline	0.5	0.9	0.3	0.8	0.3	0.7	0.36±0.1	0.80±0.08
Serine	1.1	4.0	0.8	3.0	0.9	4.1	0.90±0.12	2.30±1.40
Threonine	0.14	0.17	0.15	0.18	0.16	0.2	1.50±0.008	1.80±0.01
Tryptophan	ND	ND	ND	ND	ND	ND	ND	ND
Tyrosine	0.4	0.6	0.2	0.3	0.3	0.5	0.30±0.1	4.60±0.1
Valine	0.33	1.1	0.16	0.93	0.42	1.2	0.30±0.1	1.070±0.1

Bql: Below quantifiable limit of 0.11 m mole amino acid/100 g, ND: Not detected with the procedure utilized.. Sucrose: Sulieman *et al.* (2009)

bacteria in Kordufan, whereas the major in Butana is *Lactobacillus paracasei* sub sp. *paracasei* (Sulieman *et al.*, 2007).

Changes in fermentation of the dairy products: The development of food industry depends entirely on the use of defined strain starters. The mixed undefined starters used traditionally require more efforts to be elucidated. The quality of culture performance, product quality and consistency need more improvement. Unsatisfactory strain performance in manufacturing can results from intensively use of specific starters (Klaenhammer and Fitzgerald, 1994). Moreover, Change in sensory is critical to the overall quality of the product. Deterioration of sensory is indicated by rapid end of shelf life (Gacula, 2004). The direct antimicrobial effects of lactic and acetic acids (present in the fermented products) play a significant role in improving the shelf-life (Davidson, 1997). Their antagonistic action on the bacterial cytoplasmic membrane, interfere with the maintenance of membrane potential and inhibit the active transport (Blom and Mortvedt, 1991).

Proximate chemical composition of fresh milk was profiled to study the changes due to fermentation (Table 2). Changes following Rob fermentation increased the availability of some free amino acids, particularly *Methionine*, *Histidine* and *Isoleucine* (Sulieman *et al.*, 2009). There is doubling in the concentrations of most amino acids of Rob than that of fresh milk (Table 3). Fermentation also increases the contents of most macro-and micro elements with decreased in

Table 4: Comparison of chemical composition of Gariss samples collected from transhumance and nomadic herders

Contents	Transhumance samples	Nomadic samples	Significant level
Total solids (%)	11.29±1.40	9.81±2.32	0.569
Fat (%)	4.85±0.66	3.46±1.18	0.413
Protein (%)	2.32±0.59	2.58±0.69	0.082
Ash (%)	1.30±0.17	0.87±0.13	0.167
pH	3.41±1.12	3.82±0.49	0.01**
Acidity (%)	2.29±1.25	2.24±0.68	0.01**

Values are Means±SD. *Significant differences at (p<0.05). **Significant at (p<0.01)

sodium and manganese content. Minerals analysis revealed that the concentration of most macro- and micro elements is increased. However, in general, the concentrations of micro-elements are very low and hardly detectable in the analyzed sample (Sulieman *et al.*, 2009). Rob present in the Sudanese market regardless of the source i.e., from powder or fresh milk showed variable chemical composition. But it contains high amount of coliform, yeast and mould (Mohammad and El-Zubeir, 2011). Sudan standards should establish strict sanitary standards to control milk production and marketing and to improve the hygienic processing situations.

Sulieman *et al.* (2006) suggested the relatively high amounts of ethanol detected in Gariss (average 1.40±0.03%) together with the high yeasts counts (6.0±0.53 log₁₀cfu mL⁻¹) indicated that the fermentation process is a yeast-lactic fermentation. Gariss from transhumance and nomadic camel Herds in Sudan showed differences in mean levels of total solids, ash and protein content (Table 4). In an experiment (El Hadi Sulieman and Tsenkova, 2007) to prepare fermented milk products in High Temperature Short Time (HTST) pasteurized cow's milk was used. The LAB strains were already isolated from Gariss and yeast strains were isolated from Rob. LAB included *Lactobacillus plantarum*, *Lactobacillus paracasei* sub sp *paracasei* and *Lactobacillus fermentum* while the yeast strains were *Pichia membranefaciens* and *Candida famata*. The strains were inoculated into HSTS milk and incubated at 25°C. Mixture of LAB and yeast showed sufficient growth at 25°C for 24 h. Therefore, resulted in stable fermented milk with high nutritive value. At the end of the experiment, the chemical profile of organic acids during fermentation was studied (Table 5). The organic acids concentrations increased in all fermented milk samples but were more or less similar in all fermented milk products. Other experiment (Abdel Rahman *et al.*, 2009) combined two bacteria (*Lactobacillus bulgaricus* plus *Streptococcus thermophilus*) as starters for Garris. The mixture gave most acceptable sensory than Gariss fermented by one strain e.g., *Lactococcus lactis*. It also showed increase in the total viable count, acidity and proteolytic activity.

According to El-Owni and Hamid (2007) Gibna bayda was affected by the period of storage. But usually affect by some of the microbial hazards such as *E. coli*, *Salmonella* spp. and *Staph. aureus* (Warsama *et al.*, 2006). The weight loss, crude proteins, total solids and ash contents significantly increased in the beginning of storage then decreased after 120 days. The total bacterial count, *Coliform*, *E. coli*, *Staph. aureus* and psychrotrophic bacterial count decreased during storage while yeasts and mould increased with improvement in the texture, flavor and colour of the cheese (El-Owni and Hamid, 2008). Mish has less shelf-life and could be up to 21 days (Table 6) (Abdalla and Ahmed, 2010). Traditionally added spices may be have a good role in extending to this period (Abdalla and El-Zubeir, 2006).

Table 5: Organic acids (ppm) of various fermented milk products after 48 h fermentation at 26°C (El Hadi Sulieman and Tsenkova, 2007)

Parameters	PM	A	B	C
Citric acid	78.4	90.2	88	86
Orotic acid	77.6	88.5	92	84
Pyruvic acid	3.2	5.5	5.2	5.3
Succinic acid	389	450	430	480
Lactic acid	ND	9020	9445	9178
Formic acid	ND	41	78.6	68.5
Uric acid	ND	10.8	16	14.3
Acetic acid	542	1285	1355	1358

ND: Not detected

Table 6: Microbiological quality of Mish from each plant during storage (Log₁₀ cfu g⁻¹) (Mean±SE) (Abdellah and Ahmed, 2010)

Parameter	Storage period (days)				
	1	7	14	21	28
P1					
Total viable bacteria	9.99±0.196	7.53±0.196	8.70±0.196	9.97±0.196	10.07±0.196
Coliform bacteria	5.77±0.155	6.38±0.155	6.37±0.155	6.38±0.155	5.80±0.155
<i>Staphylococcus aureus</i>	6.85±0.155	7.90±0.155	6.66±0.155	7.99±0.155	6.70±0.155
Psychrotrophic bacteria	7.87±0.117	8.40±0.117	8.60±0.117	8.54±0.117	8.10±0.117
Yeasts and molds	4.77±0.101	4.67±0.101	5.09±0.101	5.30±0.101	5.23±0.101
Titntable acidity (% lactic acid)	3.63±0.079	3.72±0.079	3.48±0.079	4.20±0.079	4.75±0.079
P2					
Total viable bacteria	9.64±0.196	8.24±0.206	8.96±0.196	8.90±0.196	9.57±0.196
Coliform bacteria	6.78±0.155	6.75±0.164	6.25±0.155	5.96±0.155	5.94±0.155
<i>Staphylococcus aureus</i>	6.04±0.155	7.60±0.164	7.37±0.155	7.93±0.155	8.52±0.155
Psychrotrophic bacteria	9.67±0.117	9.66±0.123	9.99±0.117	8.67±0.117	8.56±0.117
Yeasts and molds	4.97±0.101	4.95±0.106	4.94±0.101	5.37±0.101	5.59±0.101
Titntable acidity (% lactic acid)	1.93±0.079	2.26±0.079	2.58±0.079	2.66±0.079	2.97±0.079
P3					
Total viable bacteria	8.79±0.235	8.31±0.196	10.12±0.196	7.78±0.196	10.09±0.196
Coliform bacteria	6.15±0.155	5.94±0.155	6.05±0.155	5.62±0.155	7.42±0.155
<i>Staphylococcus aureus</i>	5.77±0.187	6.50±0.155	5.69±0.155	6.83±0.155	5.76±0.155
Psychrotrophic bacteria	8.23±0.140	9.14±0.117	9.31±0.117	9.17±0.117	9.17±0.117
Yeasts and molds	4.14±0.101	4.91±0.101	5.11±0.101	5.20±0.101	5.20±0.101
Titntable acidity (% lactic acid)	2.53±0.079	3.16±0.079	3.38±0.079	3.30±0.079	3.79±0.079

Molecular characterization of the isolates: Enumeration of LAB species in the dairy products is important to study their dynamics role. The Culture-dependent technique widely used is still problematic (Dave and Shah, 1996). The appropriate rapid quantification approaches are dot blot rRNA hybridization and whole-cell in situ fluorescent hybridization techniques (Furet *et al.*, 2004). They are much suitable tools for the rapid identification and quantification of LAB species in complex microbial ecosystems without their prior isolation (Matsuki *et al.*, 1999, 2002). But when the threshold of the target population is lower than 1%, Polymerase Chain Reaction (PCR) is much more suitable means (Furet *et al.*, 2004).

Currently, there is a wide variety of molecular techniques used for microbial identification such as PCR with specific primers, DGGE, RAPD, PFGE, FISH, RFLP and PCR-ARDRA (Morris *et al.*, 2002). In Sudanese dairy products literature there are few studies applied PCR and

RAPD for housekeeping genes (rpoB, sodA), 16S rRNA and gtf (Abdelgadir *et al.*, 2001; Hamza *et al.*, 2009; Ashmaig *et al.*, 2009). Strains genes sequencing is not far from application in Sudan (Abdelgadir *et al.*, 2001, 2008). But traditional PCR for genus species of LAB is the most common application. Some research used multiplex PCR for group and species specification of *Lactobacillus*, other designed primers form nucleotide sequence of the 16S-23S rRNA intergenic spacer region (Sulieman *et al.*, 2007; Abdelgadir *et al.*, 2008).

PROBIOTICS

FAO/WHO (2002) defined probiotic as live microorganisms which when administered in adequate amounts confer a health benefit on the host. A wide variety of species and genera of bacteria could be considered potential probiotics, the most potential strains are LAB. Industrial applications are relying on six main beneficial and nonpathogenic species isolated from natural sources: *Lactococcus* (milk), *Lactobacillus* (milk, meat, vegetables, cereal), *Leuconostoc* (vegetables, milk), *Pediococcus* (vegetables, meat), *Oenococcus oeni* (wine) and *Streptococcus thermophilus* (milk). *Lactobacilli*, occupy important niches in the gastrointestinal tracts of humans and animals and offer a number of probiotic benefits to general health. These benefits include a positive influence on the normal microflora, competitive exclusion of pathogens and stimulation/modulation of mucosal immunity (Klaenhammer *et al.*, 2005). The use of probiotic bacteria is not documented in the Sudanese literature. There is no published study carried out in Sudan to isolate this type of bacteria, study the therapeutic or functional role. However, Salih *et al.* (2011) studied the antibacterial activity of selected probiotic bacteria isolated from Rob. The results paved a way to use those strains as therapeutic agents. A delightful study used Gariss (G) and Gariss supplemented with *Bifidobacterium lactis* Bb-12 (G+Bb-12) to investigate their hypocholesterolaemic effect in rats. Rats were fed on a cholesterol enriched diet for one week. Then the levels of cholesterol and triglyceride were measured in rats' plasma. Rats fed on (G) and (G+Bb-12) diet showed significant low levels of plasma VLDL+LDL-cholesterol. The (G+Bb-12) diets were more effective in lowering plasma VLDL+LDL-cholesterol levels than (G). Also, both of the diets (G) and (G+Bb-12) were remarkably lower the levels of plasma triglycerides in rats (Elayan *et al.*, 2008).

Outside of dairy products, probiotic of Malaysian origin, *Bifidobacterium longum*, was used to ferment malted brown rice flour to produce a nutritious Medida (Sudanese cereal thin porridge) (Kabeir *et al.*, 2004).

Sudanese dairy products were used traditionally for therapy. In Butana area Kit (ferment product from goat's milk) is used to cure patients complaining from some enteric ailments (Abdel Gadir *et al.*, 1998). Gariss is used to cure *Leishmaniasis* or kala-azar (Dirar, 1993). The addition of spices (Black cumin, fenugreek and garlic) and salt to Rob and Mish acted as antimicrobial agents against *Enteropathogens* and *Staph. aureus* (Abdalla and El-Zubeir, 2006).

ECONOMICAL VIEW

Human progression has been catalyzed by evolution of food industry. Food manufacturing promotes the population's health and helps the societies to prosper and flourish. There is a pressing need for a re-evaluation of livestock policy in Sudan. Many problems hinder the development of the dairy industry. To be overcome; comprehensive plans, regulations and economical policy must be introduced. Most of the animal wealth owned by the nomads and represent a part of their own traditions and customs which are handed down throughout generations. This shed negative effect

on the quality of the animals breeding and dairy products. Although, the government developed several policies and projects to promote the crop production; it had quantitatively bordered the livestock and pastoralism. Despite the merit reproductivity of Sudanese cattle, research is influential to increase the awareness of the role of livestock, their genetic diversity and for the implementation of sustainable breeding programmes (Lutfi *et al.*, 2005). Most of the dairy products are traditionally made, either part of their livelihood, daily dietary needs, or as part of a small enterprise scale. Modern, large-scale production of fermented foods is dependent entirely on the use of defined strain starters which have replaced the undefined strain mixture traditionally used for the manufacture of the products. This switch to defined strains has meant that both culture performance and product quality and consistency have been dramatically improved.

The first dairy factory is established in the early 19th in Khartoum North by the British colonization. The main purpose of the factory is to supply the governmental employees with dairy needs. In 1963 the first equipped milk factory established in Hela-Koko (Khartoum North). Since then only few small factories are added into the industrial sector.

Civil wars in Sudan have great negative effects on Sudan economy. The past efforts devoted to develop the dairy products are apparent in today's violent conflicts, massive population displacements and extensive food insecurity. In the natural pastures and throughout the last centuries, the style of the grazing depends on two things; continuous searching for water sources and landing on the seasonal green pastures. Environmental and social conflicts are raised from desert encroachment and utilization of the animal welfare. All these factors led to civil wars, tribes' conflicts and scarcity of resources. The issues of overgrazing and desertification have been inadequately studied. Because episodic drought, the southward drift of isohyets, fires and deforestation are cited as causes but pastoralism is often singled out for blame.

CONCLUSION

Sudan has one of the largest and most species diverse livestock populations in Africa. It greatly contributes to national economy and export revenue. The importance of traditional dairy products is not of economical only but also represents a cultural heritage for the production area. The knowledge of microbial communities may improve the understanding of specification and characterization of these products. Only little research was carried out on the Sudanese dairy food. Most of the researchers focused on the isolation of the LAB presented in the traditional dairy products. Conventional methods used for microbial detection are based on samples dilution and pour-plating or spreading the highest dilution on selective media. However, this method might not isolate the species present in small number. Gap exists in our knowledge of the mechanisms of fermentation, role of the different isolates and characterization of probiotic bacteria. More additional studies on isolation, classification and molecular characterization of the strain in milk and dairy products are particularly needed. For the hygienic quality of market raw milk in Khartoum State during the two seasons (summer and winter) some important procedures must be considered (Mohamed and El-Zubeir, 2007):

- Immediate cooling of milk after milking [in the absence of cooling facilities, Lactoperoxidase System (LPS) is efficient means for preservation (El Zubeir *et al.*, 2006)
- Heat treatment to control bacteriological quality (it was noticed that *Brucella* is more common in winter than in summer)
- Milk commission must staff the production, distribution and marketing

- Sanitary inspector and veterinarian have to implement the standards methods
- Screening laboratory tests to the entire employees from farms to shops must be inspecting periodically
- More studies are needed to identify bacterial toxins produced by harmful bacteria

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