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Review on the Dual Functions of Camel Milk Processing and Marketing for Unmet Demand

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Abstract: Camel milk makes a direct economic contribution to the pastoral system of Ethiopia. A booming trade and growing international interest for camel milk consumption to its dual functions (nutritional and therapeutic); the urbanized population is looking for more diversified products. Nutritionally, the milk contains lower protein, fat and lactose, higher levels of iron, zinc, copper, potassium, sodium and calcium, low cholesterol, higher vitamin C and protective proteins. Fresh or fermented camel milk contains high concentration of bioactive substances, has a potential therapeutic functions such as a treatment for gastritis, asthmatics, stomach discomfort, HIV, tuberculosis, fever, urinary problems, hepatitis, jaundice, common cold, diarrhea, nausea and diabetics. Raw camel milk has longer shelf life and it is more heat stable while it is pasteurized than that of cow milk. Thus, it is possible to transport and sale camel milk from remote areas to processing unite further can be traded to urban consumers nationally and internationally. Vitamin C, insulin and antibacterial factors in camel milk at significantly greater concentrations are more heat inactivated during pasteurization at 63°C for 30 minutes. Presence of starter cultures and stabilizers, yoghurt can be produced from pasteurized camel milk with high acceptability for colour, flavour and taste. Camel milk cheese can be prepared effectively by pasteurizing the milk using rennet and vegetable extracts as coagulating agent and starter cultures for fermentation. Ultra-filtration technology can also be applied to enhance the cheese yield of camel milk. Seasonality camel milk production, post-harvest losses due to spoilage, lack of milk collecting facilities and processing and poor hygienic standards are major challenges in raw camel marketing. However, production potential for camel milk, presence of enabling policy that encourages investments, high unmet demand for dual functions of camel milk and camel milk products at local or national and export market in neighbouring countries and Gulf States are major opportunities for processing and marketing the milk in Ethiopia. Hence, it is high time to introduction for processing and marketing camel milk at national and international trade.

Key words: Camel milk cheese · Export market · Fermented camel milk · Heat stable · Post-harvest losses

INTRODUCTION

The majority of camel population in Ethiopia is kept by pastoralists, Somali, Afar and Oromia (Borena and Guji Zones) Regions, lowland parts of the country. Camels are the most adapted domestic animals in arid lands for a sustainable development and desertification combats [1]. Although camels provide different products and services, their milk is a commodity that makes a direct economic contribution to the pastoral system and the various value chain actors involved in marketing of the milk [2]. A booming trade and growing international interest for camel milk consumption to its dual functions (nutritional and therapeutic), the urbanized population is looking for more diversified products and the consumption of raw camel milk in this context is decreasing [3]. A bulk is sold informally under uncontrolled hygienic conditions in local market of Ethiopian pastoralist area and smuggled through borders to the neighbouring countries such as Kenya, Somali, Somaliland and Gulf States [4].

Camel milk production is facing high post-harvest quality deterioration due to spoilage and quantity losses [5]; surplus milk is wasted during the rainy seasons when production is high [6]. Post-harvest quality deteriorations due to spoilages may pose a threat to public health as chances of consuming unsafe milk are very high. In reducing post-harvest and surplus milk losses through provision of a steady outlet for the camel milk produced

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is vital. Hence, introduction of proper collection, transportation, processing, packaging and distribution should be in place to improve quality of camel milk. Long shelf-life camel milk products such as pasteurized fresh and fermented milk could guarantee returns to producers, processors and consumers for the substitution of the currently imported milk products with high foreign currency exchange rate. This will also induce reduction of wastage and helps in camel milk product diversification to make camel milk and camel milk products available at affordable prices; and has an additional advantage in providing safe and quality milk to the consumers. The aim of this paper is to review the available innovative information for camel milk processing in Ethiopia and marketing at national and international trade.

Camel Production

Camel Production in Ethiopia: African countries like Somalia, Sudan, Ethiopia, Kenya, Djibouti and Eritrea had 58% of the total camel population in the World [3]. Ethiopia ranks third by the number of camel population after Somalia and Sudan [8] and second by camel milk production from the globe [7]. It is widely recognized that dromedary camels produce more milk of high nutritional quality for a longer period of time than other species in an environment that may be rightly termed as hostile in terms of extreme temperature, drought and lack of pasture [9]. Camel sustain its productivity in difficult conditions and comparatively lesser affected by the adverse factors like lack of feed, water, season and length of lactation [10]. Due to prevailing droughts and decreasing production trend of other animals, the camel has gained much attention to a bridge the gap of demand and supply. In this regard [11] reported that cattle population is decreasing from time to time, while camel population is increasing trend in arid and semi-arid areas. Milk production was reported to be the primary purpose of camel production in Borana Zone of Southern Oromia, Ethiopia [12].

Producers, collectors and transporters, vendors and some consumers performing camel milk handling operations are illiterate in Eastern Ethiopia [13]. Thus, camel milk production is still faced high post-harvest quality deterioration and quantity losses [5]. This situation poses a potential threat to public health as chances of consuming unsafe milk are very high. Complains were reported on the absence of milk and milk product processing and cooling infrastructures to safeguard milk from spoiling and to further elongate its shelf life [14]. On the other hand, seasonal variation in camel milk production in pastoral production systems is great and it is believed that surplus milk is wasted during the rainy seasons when production is high [6].

Camel Milk Yield and Lactation Length: The proportion of camel milk has reported to the total milk production by all dairy species is almost 10% in Eastern Africa in spite of the significant cattle population in those regions [3]. Several authors [15-18] have been reported the overall average daily volume of camel (*Camelus dromedarius*) milk throughout the entire lactation period was 3.75, 4.14, 3.22 and 2.92 litters, respectively, in different arid and semi-arid regions of Ethiopian. In the country camels, no significant reduction in milk production was reported until the ninth month of lactation [15] due to the high persistency observed in camel. However, higher average daily milk off take (yield/day), 6 litres was reported from Northeast Ethiopia [19]. This variation in camel milk yield might be attributed to the high genetic variation between individuals, breed, feeding and management conditions, type of work, milking frequency, age of animal, persistency of lactation, lactation number and stage of lactation [2].The average lactation length of camel (*Camelus dromedarius*) 12, 13.38, 13 and 13.76 months was reported [12, 16-18] for arid and semi-arid regions of Ethiopia, respectively.

Dual Functions of Camel Milk

Nutritional Function: Camel milk is main food especially for those who live in arid zones and also it can be produced in large amount in dry area than other livestock [20]. Its composition varies due to difference of geographical origin but other factors such as the physiological stage, feeding conditions, seasonal or physiological variations, genetic or health status of camel have also a paramount importance [21]. Camel milk contains lower protein, fat and lactose, high levels of iron, zinc, copper, potassium, sodium and calcium [22, 23]. Camel milk, differs from other mammals milk as its chemical composition is low cholesterol and sugar, high minerals, vitamin C and protective proteins like Lactoferrin, Peptidoglycan recognition protein, N-acetyl-glucosaminidase, Lysozyme and Immunoglobulin and lacks β-lactoglobulin [7, 24]. The low pH due to vitamin C content stabilizes the milk and can be kept for relatively longer period [24]; giving the milk its sour taste, which can be masked if the animal eats salty or bitter vegetation [22]. Various camel milk products could be prepared and commercialized [25]. Unlike cow milk, camel milk can be

preserved for a longer time at same temperature. This is vital and possible to transport and sale camel milk from remote areas to processing unite further can be traded to urban consumers nationally and as an internationally. Camel milk that handled with good hygiene has high antimicrobial effect and its chemical composition is better when compared with other livestock, besides to this in some countries societies use camel milk for therapeutic purpose [20].

Therapeutic Function: Camel milk has been used for centuries as a medicinal drink in Middle Eastern, Asian and African cultures [26]. Truly, apart from the essential nutrients available from cow milk, fresh or fermented camel milk contains high concentration of bioactive substances [27], which have great therapeutically virtues for health benefit in different patients [28, 29]. Camel milk has potential therapeutic characteristics, such as anti-hypertensive, anti-diabetic and anti-carcinogenic [24]. Due to low quantity of β-casein and the lack of β-lactoglobulin in camel milk; it is recommended to be consumed by individuals intolerant to lactose and children who are allergic to bovine milk [21, 22]. Camel milk has the ability to inhabit the growth of pathogenic microorganisms because it contains number of enzymes with anti-bacterial and anti-viral properties [24].

Fresh or fermented camel milk products are recognized in Ethiopia particularly in Ethiopian Somali Regional State in providing various therapeutic value such as a treatment for gastritis, asthmatics, stomach discomfort, HIV, *hamot (kar),* tuberculosis, fever, urinary problems, hepatitis, jaundice, common cold, *dearbeh* ("diarrhea"), *daarta* ("nausea") and diabetics, for corresponding diseases, there are traditional ways of treatment and for some diseases even dosages [30]. Presence of insulin-like and protective protein in camel milk used for the treatment of many ailments like diabetes, autism and diarrhea and possesses anti-tumours properties [31]. Other authors also reported low prevalence of diabetes [6]; autistic [32, 33] and diarrhoeas [32] are acknowledged by communities consuming camel milk. All these medicinal properties make this milk attractive to some consumers and its production is gradually increasing [34].

Heat Stability and Processed Products of Camel Milk

Pasteurization and Heat Stability of Camel Milk: Potential pathogenic microorganisms, *Salmonella species* [35] from Eastern Ethiopia and *Staphylococcus aureus* and *Escherichia coli* [36] from Northeast Ethiopia were detected in raw camel milk. The authors also reported generally poor and microbial contamination of camel milk occurs along the value chain while it is transported from the production site to the market. Hence, the purpose of heat treatment of milk is either the partial destruction of micro-organism or the complete sterilization of milk to prolong its shelf life [37]. Although raw camel milk has longer shelf life than that of cow milk [38], longer shelf life can be further extended when heat treatment is applied, which is advantageous in commercial production of camel milk products. As report shown [39] pasteurization of camel milk before its fermentation improved the microbiological content and increasing the shelf life of the product. The author has observed a decrease in the means values of microbial measurements (total bacteria, coliforms, total yeast and mould, psychrotrophic bacteria and thermoduric bacteria) after heat treatment of camel milk samples. Study [40] revealed that the shelf life or the keeping quality of *Gariss* (fermented camel milk in Sudan) from non-pasteurized milk (10 days) was less than those obtained for *Gariss* made after pasteurization of milk (17 days) when stored at refrigeration temperature. Recent studies on pasteurized camel milk shelf life [41] indicated that camel milk has shown stability in total desirable acidity level until 46 days of storage at 4°C, while goat and cow milk took less than one month to reach undesirable acidity levels.

Camel milk is more heat resistant than those in cow milk [42]. Especially vitamin C, the most heat sensitive vitamin and insulin are only affected by 5 to 8 % reduction of the value found in raw milk when heated at 72°C for 5 minute [43]. Recently recommended [39], heating of camel milk at 63°C for 30 minutes, in order to preserve vitamin C, as low temperature long time heating is much better for its conservation. The presence of antibacterial factors such as lysozymes, lactoferrin, immunoglobulin in camel milk at significantly greater concentrations are more heat stable compared with those in cows [44]. Whey protein in camel's milk is more heat resistant than those of cow's milk, as the degree of denaturation varied in camel's milk from 32 to 35% at 80°C for 5 minutes and pasteurization at 72°C for 5min revealed no losses in camel's milk whereas, in cow milk 70-75% of whey proteins are denatured at 80°C for 5 minute [42]. It is concluded that higher keeping quality of longer shelf fermented milk product can be produced from camel milk using heat treatment and stored at refrigeration. Milk enzymes play an important role in the keeping quality of camel milk. Gamma glutamyl transferase (γ-GT) can be used as an indicator for the proper heat inactivation of

camel milk [43] since it is destroyed between 10 to 20 minutes at 72°C. It is concluded that heat treatment would improve camel milk quality and extended its shelf life, hence it is high time for private sectors to establish camel milk processing unit in Ethiopia for marketing at national and international trade.

Yoghurt and Fermented Camel Milk: In Ethiopia, pastoralists produce different fermented camel milk products such as *Dhanaan* which is produced by pastoralists in Somali Region [45] and *Ititu* is produced in the Kereyu area of the Oromia Region in the eastern part of Ethiopia [46]. In East and South East part of Ethiopia, fermented camel milk is widely consumed [47]. Fermentation of *Dhanaan* and *Ititu* is carried out by mesophilic lactic acid bacteria used as starter cultures [48]. Lactic acid bacteria play a significant role in food fermentation and they have also antagonistic effects against food borne pathogenic microorganisms and help to improve biochemical features of fermented foods [47].

There are different fermented camel milk products, for instance, *Gariss* (in Sudan), *Suusac* (popular in East Africa of Kenya and Somalia), *Chal* (in Turkey) and *'Shubat'* (in Kazakhstan) as reported by [49]. Research that has been done in Kenya showed that the quality of *Suusac*, fermented camel milk, improved using selected mesophilic lactic starter cultures rather than spontaneous fermentation; the resulting fermented milk had a uniform taste and a longer shelf life [50]. *Lactobacillus* spp. and *Streptococcus* spp. were the main fermentative organisms for making yoghurt [51]. Since *S. lactis, S. cremoris* and *L. acidophilus* strains produced maximum acidity during first five hours, they could be selected for maximum ability to use lactose and convert it into lactic acid [52]. Moreover, microflora in fermented products plays also a therapeutic role on improvement of digestion properties and is responsible for antimicrobials properties [53].

The camel milk fermented by yoghurt starter culture and fortified by different concentration of *Depis* (date palm syrup) is the most acceptable, so that addition of 5% *Depis* provided camel milk yoghurt with desired sensory properties [54]. The sensory evaluation of the yoghurt produced from camel milk revealed high acceptability for colour, flavour and taste in comparison to powder milk yoghurt; however, the panellists noticed that the yoghurt made from camel milk is watery in texture [55]. To overcome watery in texture, hydrocolloid stabilizers can be used in camel milk yoghurt to prevent serum separation and to adjust the viscosity at a level up to 1.5% [56]. Addition of stabilizers significantly decreased the syneresis and increased viscosity and water holding capacity of camel milk yoghurt, also enhanced its sensory acceptability [56].

For substitution of commercial hydrocolloid stabilizers, supplementation of dromedary milk with ginger powder at concentration ranged from 0.6 to 1% weight per volume complements its healthy characteristics, produced acceptable yogurt and allows energy and time saving in the manufacturing process [57]. The addition of ginger powder to dromedary yogurt increased significantly the water holding capacity [57]. Ginger has a considerable amount of starch (up to 40%, dry basis), which is long recognized as an important source of energy [58]. It is one of the most frequently used thickening agents in yogurt production [56]. So the addition of this plant could be a good source of growth factors for inoculated lactic acid bacteria and may offer the possibility of improving the texture of fermented dromedary milk. Contamination by yeasts and moulds during processing of yogurt may occur; however, *Staphylococcus aureus*, *Salmonella* and coliforms were absent in fresh camel yogurt and also throughout the storage period [51].

Camel Milk Cheese: Camel milk cheese can be prepared successfully from camel milk and better results can be obtained by coagulating milk with starter culture [52]. Camel milk supported the growth of lactic acid bacteria, which are isolated and identified for making starter culture of fermented milk products like cheese. Mostly, lactic acid producing bacteria that grow in camel milk are *Lactobacilli (Lactobacillus acidophilus*) and *Streptococci* (*S.cremoris* and *S. lactis*), *which* are used as starters in dairy products [52]. The sensory properties of camel cheese could be improved by using more adapted starters from natural camel milk microflora [59].

Fresh soft white cheeses could be made with good flavour, texture and overall acceptability: 1.5% fat and 3% salt in milk with yogurt or lactic fermentation starter culture [60]. However [61] suggested that the level of salting should be reduced when adding calcium chloride ($CaCl_2$) or further drying and storage of cheese should be done as some of panellists, reported that level of salting is more than they like. Recently [62] indicated that soft cheese of an acceptable quality and an adjusted cheese yield of 14.57% could be produced by adjusting the fat content of camel milk to 1.82%, total solid level to 14% and using rennet powder at a ratio of 1.5mg $(100g)^{-1}$. Many challenges are faced when processing such as coagulation time, rennet concentration, temperature, $CaCl_2$ concentration and selection of culture [34]. Camel milk

cheese can be prepared effectively by pasteurizing the milk at 65°C for 30 minute and changing the pH to 5.5 and addition of $CaCl_2$ to 0.06 % [63]. Addition of $CaCl_2$ increases the firmness and elasticity in camel milk, cheese and yogurt [64].

Hansen™ (Denmark) invented and marketed recently new coagulant agent named of Chymax-M1000®, Ch. Hansen© or Chy-Max M containing camel chymosine, recombinant specific camel rennet as coagulating agent at 50 µL//L concentration [65]. Using at rate of 50 µL/L of rennet, Chy-Max M, acidification was faster at 36°C without starter during 10 hours and pH reduced to 5.08 [66]. Thus, the availability of this curd Chy-Max M, camel milk coagulation is no longer camel milk cheese making a constraint. The addition of yoghurt culture or other lactic acid bacteria with rennet to camel milk is reported to facilitate camel milk coagulation by increasing the lactic acid content and improving curd firmness [60, 67].

Report [67] has suggested that importance of ultra-filtration (UF) technology for making Domiati-type cheese (the most popular cheese in Egypt and other Middle East countries) with better yield as compared to conventional Domiati-type cheese. The author has found cheese yield of 20.2% by using UF technique whereas the conventional one was 13.9%. This revealed that an increase of 45% in cheese yield achieved by UF process, since increased recovery of protein, fat and milk total solid. Thus, the UF process has the potential for developing a camel milk cheese with high yield and good acceptability. Various coagulation agents were proposed: plant extracts such as ginger (*Zingiber officinale*) [68]. Coagulation of camel milk using ginger rhizome crude extract improved firm curd could be achieved and obtained at a pH value of 5.0, a temperature of 65°C and crude ginger extract concentration of 10% by volume [69].

Marketing of Camel Milk

Market Constraints for Camel Milk: Lack of quality control of milk, lack of cooling and storage facilities at milk vending sites, poor quality of milk supplied from rural areas, sale of raw milk, inappropriate milk handling and storage vessels and spoilage of milk due to lack of preservation and processing facilities are constraints related to milk marketing [70]. Similarly [71] reported that seasonality of milk production, milk spoilage, lack of milk collecting facilities and processing, poor hygienic standards are major challenges in raw milk marketing. Seasonal variation in camel milk production in pastoral production systems is great and it is believed that some surplus milk is wasted during the rainy seasons when production is high [6]. Despite some awareness of the risks, unhygienic practices along the chain frequently lead to spoilage of milk, rejected by traders and consumers [71]. To overcome this constraint use of sisal foil wrapped milk containers, since it has an advantage in maintaining the quality of milk transported long distance exposing to sun light [72]. Wrapped containers have a great contribution in minimizing microbial load and lactic acid production as of the fermentation; it has stayed negative for both alcohol and clot-on-boiling test at the terminal market [72].

Market Opportunities for Camel Milk: Elsewhere in the Horn of Africa, valued for its medicinal properties camel milk has been transformed from a food produced and consumed by pastoralist communities, to a highly valued commodity around which there is a booming trade and growing international interest [3]. In Ethiopia, the milk price is set by producers and buyers negotiation [70]. Surplus milk is sold in urban centres and the derived cash contributes to the total household cash income, which is used to purchase cereals, oil, sugar, drugs and other household requirements [71]. Pastoralist's sale camel milk implies that camel milk has high demand in the market [45]. There was unmet demand for camel milk in Dire Dawa, Jijiga and Harar markets; every day it also goes to Addis Ababa and neighbouring countries Somaliland (Hargessa) and Somalia (Mogadishu) [17], which is produced in Eastern Ethiopia. It is sold both as fresh whole milk and fermented milk, with the former in greater demand [17]. The market is expected to expand because of the real content or the myth of its medicinal benefit. According to [4] four camel milk trading routes were identified: the Finchawa-Moyalle route to Kenyan boarder, Boqol-manyo to Suftu route to Mandera town of Kenya, Awsah to Addis Ababa serving mainly Somali refugees in Addis and Babile to Tog-wachale route passing through Jigjiga links to the markets in Somaliland and the Gulf states. In India, Kenya, Mauritania and U.A.E endeavours have been made to market such camel milk after collection and pasteurization in central processing unit/factory [10].

Camel's milk is more heat resistant than cow's milk which is advantageous in commercial production of camel milk products [42]. The major opportunities in camel milk production and marketing are high potential for local and international market and increased number of pastoralists interested in keeping camels as a business [3]. The unmet demand for camel milk at local and export market; the current initiation of the Ethiopian Government in developing fundamental infrastructural facilities for dairy

development and the existence of relatively many actors involved are the opportunities which could enhance the competitiveness of camel milk production, processing and marketing. Introduction of processing and marketing of camel milk products in Ethiopia such as pasteurized fresh and fermented products could guarantee returns to camel milk producers, processors and consumers.

CONCLUSION

Exploiting of camel milk production potential with its particular nutritional, therapeutic and heat inactivation properties, heat treatment would improve camel milk quality and extended its shelf life. Potential of camel milk production, various camel milk products reported to be produced successfully, high unmet demand in local and export market and presence of enabling policy that encourages investments are opportunities. It is high time in Ethiopia to invest on camel milk processing and marketing for national and international trade. Further study is needed to determine the amount of camel milk produced in camel production potential areas, the volume of traded and prices along local and export trade routes.

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