Isolation and characterization of lactic acid bacteria from *Ititu*: Ethiopian traditional fermented camel milk

Eyassu Seifu*[1], Araya Abraham[2], Mohammed Y. Kurtu[1] and Zelalem Yilma[3]

[1]Department of Animal Sciences, Haramaya University, P.O.Box 287, Haramaya campus, Ethiopia; Tel: (251) 25 553 0370; Fax: (251) 25 553 0325.

[2]Mersa Agricultural, Technical and Vocational Education and Training College, P.O.Box 41, Wollo, Ethiopia.

[3]Holetta Research Center, Ethiopian Institute of Agricultural Research, P.O. Box 2003, Addis Ababa, Ethiopia.

Abstract

This study was aimed at isolation and characterization of lactic acid bacteria from a traditional fermented camel milk called *Ititu*. Twenty samples of traditionally fermented camel milk *Ititu* used for the experiment were obtained from camel herders in *Kereyu* area in Eastern Ethiopia. A total of 146 colonies grown on MRS and M17 agar were subjected to different screening tests and identified as presumptive lactic acid bacteria and classified to the genera *Lactobacillus* (85), *Lactococcus* (36) and *Enterococcus* (25). The isolated species of lactic acid bacteria were *Lactobacillus plantarum* (32%), *Lactobacillus delbrueckii* subsp. *bulgaricus* (17%), *Lactobacillus salivarius* (9%), *Lactococcus lactis* subsp. *lactis* (18%), *Lactococcus lactis* subsp. *cremoris* (7%) and *Enterococcus faecalis* (17%). Among the isolated lactic acid bacteria species, *Lactobacillus salivarius* produced the highest amount of acid at a relatively faster rate than the other isolates. From the present study it can be suggested that with further study on technological properties, the isolated lactic acid bacteria species could be considered as potential candidates for development of starter cultures that can be used for the production of fermented camel milk products under controlled condition.

Keywords: Ethiopia, fermented camel milk, Ititu, lactic acid bacteria, traditional fermented food

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* Corresponding author: eyassu_seifu@yahoo.com

Introduction

Ethiopia has the third largest dromedary camel population in Africa with approximately 2.5 million animals (MAoRD, 2009). Camels are raised by pastoralists in arid and semi-arid lowland areas of the country and are mainly kept for milk production. Camels also produce milk for a longer period of time even during the dry season where other livestock species hardly thrive. Because of their outstanding performance where browse and water are limited, pastoralists rely mainly on camels for their livelihood (Tafesse *et al*., 2002). Pastoralists consume camel milk either in its raw state without heat treatment or after it turns sour (Seifu, 2007). Fermentation appears to be the only means of preserving camel milk under warm conditions (Farah, 1993; Mohamed *et al*., 1990).

There are various traditional fermented camel milk products that are produced by camel herders in different parts of the world (Abdelgadir *et al*., 1998; Abdel Rahman *et al*., 2009; Hassan *et al*., 2008; Lore *et al*., 2005; Yagil, 1982). Fermented milk products such as *suusac* and *garris* are produced from camel milk in Kenya, Somalia and Sudan (Abdelgadir *et al*., 1998; Lore *et al*., 2005). In Ethiopia, pastoralists produce different fermented milk products from camel milk. *Dhaanan* is produced by pastoralists in Somali Region (Seifu, 2007) and *Ititu* is produced in the Kereyu area of the Oromiya Region in the eastern part of the country. *Ititu* is prepared traditionally by letting the raw milk to ferment spontaneously at room temperature.

Microbial fermentation has played an important role to preserve food products, to enhance nutritive value, to destroy undesirable factors, to ensure product safety, and to improve the appearance and taste of food products (Paredes-Lopez, 1992). It also results in desirable biochemical changes such as development of aroma and flavour compounds in food products (Cooke *et al*., 1987). Earlier reports indicate that the bacterial microbiome of traditional fermented camel milk products are dominated by lactic acid bacteria belonging to different genera and species. Understanding the dominant bacteria responsible for traditional fermented camel milk is essential for devising appropriate techniques aimed at improving the quality and safety of fermented dairy products from camel milk.

Pastoralists in Eastern Ethiopia prepare traditional fermented camel milk by placing fresh camel milk in a clean/smoked container, wrapping the container with a piece of cloth, and keeping it in a warm (ambient temperature ≈ 25-30 °C) place for about 12-24 h to allow spontaneous fermentation to take place (Seifu, 2007). Fermentation is initiated by the natural microorganisms of the milk without using commercial starter cultures or by back sloping technique (adding small amounts of previously fermented milk as a starter into fresh camel milk). Due to spontaneous nature of the fermentation, this traditional method results in a product with varying taste and flavour often of poor hygienic quality. According to Ashenafi (2002), in most households of Ethiopia no attempt is made to control

the fermentation process of milk and products manufactured under traditional systems generally have poor qualities and do not meet the acceptable quality requirements set by various regulatory agencies.

In order to improve the spontaneous traditional fermentation, controlled fermentation using mesophilic lactic acid bacteria starter culture has been suggested (Abu-Tarboush, 1996; Farah *et al*., 1990; Mohamed *et al*., 1990). According to Kenyan researchers the quality of *suusac*, a fermented camel milk, could be improved when manufactured by using selected mesophilic lactic acid bacteria starter cultures as compared to that produced by spontaneous fermentation with the resulting fermented milk product having a uniform taste and a longer shelf life (Farah *et al*., 1990; Lore *et al*., 2005).

Therefore, in order to develop a suitable starter for controlled fermentation, isolation and identification of the dominant bacteria involved in the fermentation of traditional camel milk products and the use of the isolates as starter cultures is essential. However, the microorganisms that bring about the natural fermentation of the traditional camel milk *Ititu* manufactured in Kereyu area of Eastern Ethiopia are neither known nor characterized so far. Therefore, the objective of this study was to isolate and characterize lactic acid bacteria from the traditional fermented camel milk *Ititu*.

Materials and methods

Sample collection

A total of 20 samples of *Ititu* (traditional fermented camel milk) were collected twice from 10 pastoral households of Kereyu area in Eastern Ethiopia. *Ititu* samples were collected using sterile bottles and delivered to Dairy Microbiology Laboratory of Holetta Agricultural Research Center and Sebeta National Animal Health Laboratory in an icebox for the analysis. Aseptic sampling was followed as described by the Health Protection Agency (HPA, 2004) and the Food and Drug Administration (FDA, 2003). After arrival at the laboratories, *Ititu* samples were kept at temperatures below 4°C and analyzed within 48 h of collection (HPA, 2004).

Determination of pH and titratable acidity

The pH of the traditional fermented camel milk *Ititu* was measured using a digital pH-meter (Accument pH-meter, Model number 910, Fisher Scientific). Before use, the pH-meter was calibrated using standard buffer solutions of pH 4.0 and pH 7.0. Titratable acidity expressed as percent lactic acid was determined by titrating *Ititu* samples using 0.1N NaOH solution and phenolphthalein as indicator according to the Association of Official Analytical Chemists (AOAC, 1995).

Isolation and characterization of lactic acid bacteria

Lactic acid bacteria were isolated from the traditional fermented camel milk *Ititu* using de Man, Rogosa and Sharpe (CM0361 Oxoid, England) and

M_{17} agars (CM0785 Oxoid, England) according to the method described by Harrigan and McCance (1976). Serial dilutions (up to 10^{-8}) were prepared and volumes of appropriate dilutions (0.1 ml) were plated on MRS and M17 agars in duplicate using sterile Petri dishes. Plates were incubated anaerobically in an anaerobic jar (BBL, GasPak) at 32°C for 48 h as described by Richardson (1985). Preliminary isolation of lactic acid bacteria was made on the basis of Gram-staining and catalase reaction followed by microscopic examination (Microscope model: XSZ-107BN, Yu Yao Shen Ma Teaching Instrument Whole Set Co. Ltd., China) to observe cell arrangement and morphological characteristics (Table 1) as described by Harrigan and McCance (1976). Gram-positive, catalase-negative, cocci or rod-shaped isolates were considered as presumptive lactic acid bacteria according to Savadogo *et al.* (2004).

Identification to genus level

Isolates (10%) from each of MRS and M_{17} agar plates that showed the general characteristics of lactic acid bacteria and had different cellular morphology were selected randomly and subjected to various tests that include gas production from glucose, growth at 10°C and 45 °C and growth at different concentrations (%w/v) of NaCl (2%, 3%, 4%, 6.5% and 10%). Identification of the isolates to genus level was made on the basis of the criteria described by Harrigan and McCance (1976) and Wood and Holzapfel (1995).

Identification to species level

The isolates were first subjected to carbohydrate fermentation tests according to the method described by Schillinger and Lucke (1987). Based on the results, the isolates were then identified to species level using the species identification procedure of Bergey's Manual of Determinative Bacteriology (Holt *et al.* 1994) and by comparing the results with previously published scientific works (Wood and Holzapfel, 1995; Beukes *et al.*, 2001).

Acidification activity of the isolates

The acid production by the isolated lactic acid bacteria species was determined after inoculating the isolates into sterile reconstituted skim milk powder (10% w/v) at a rate of 1-2% inoculum/100 ml milk in sterile bottles of 200 ml capacity according to the method described by Attia *et al*. (2001). The inoculated skim milk medium was incubated at 30°C for mesophilic and at 38°C for thermophilic lactic acid bacteria (Farah *et al.*, 1990; De Vuyst and Degeest, 1999; Attia *et al*., 2001). Change in pH was monitored at different intervals by taking samples at 0 h (initial), 12 h, 24 h, 48 h and 72 h until the pH of the medium reached 4.6 (iso-electric point) as suggested by Patrignani *et al*. (2007). The isolated lactic acid bacteria species were characterized as fast acid producers (less than 12 h to reach pH 4.6), medium acid producers (12-48 h to reach pH 4.6) or slow acid producers (more than 48 h to reach pH 4.6) based on their acid production potential. Samples for determination of the titratable acidity were taken from the inoculated medium at similar intervals as that for pH.

Table 1. Morphological, biochemical and physiological characteristics of lactic acid bacteria isolated from traditional fermented camel milk (*Ititu*)

Characteristics		***Groups***									
		Lactic Acid Bacteria isolated on MRS agar					***Lactic Acid Bacteria isolated on M_{17} agar***				
		FTD-04	***FTD-06***	***FTD-07***	***FTD-08***	***FTD-05***	***FTD-11***	***FTD-13***	***FTD-17***	***FTD-14***	***FTD-18***
Morphological tests											
Cell morphology		R & ML	R & MR	R & ML	R & TS	RL & R	C	C	C	C	C
Cell arrangement		Ch & P	Ch & P	Ch & P	Ch & P	Ch & P	P & Ch	P	Ch & P	P & SCh	P
Biochemical tests											
Gram stain		+	+	+	+	+	+	+	+	+	+
Catalase test		−	−	−	−	−	−	−	−	−	−
Physiological tests											
CO_2 from glucose		−	−	−	+	+	−	−	−	−	−
ADH		−	−	−	−	−	+	−	+	+	+
Growth at	10°C	−	−	−	−	−	+	+	+	+	+
	45°C	+	+	+	+	+	+	−	−	+	−
Growth in NaCl	2%	+	−	−	+	+	+	ND	ND	+	ND
	3%	−	−	−	−	−	+	−	+	+	+
	4%	−	−	−	−	−	+	−	+	+	+
	6.5%	−	−	−	−	−	+	−	−	+	−
Identified genera		Lb	Lb	Lb	Lb	Lb	Ec	Lc	Ec	Lc	Lc

ADH = arginine hydrolysis; R and ML = rod and medium long; R and MR = rod and medium rounded end; R and TS = rod, thin and short, RL and R = rod long and rounded end; C = cocci; P and Ch = pairs and chains; P = pairs; P and SCh = pairs and short chains; ND = not determined due to invisible growth; FTD-04, FTD-05, FTD-06, FTD-07 and FTD-08 represent genus *Lactobacillus* (Lb); FTD-11 and FTD-14 represent genus *Enterococci* (Ec) and FTD-13, FTD-17 and FTD-18 represent genus *Lactococcus* (Lc)

Statistical analysis

Difference in acid production potential between the isolated lactic acid bacteria was determined by the analysis of variance technique using SPSS software (version 10) and Duncan Multiple Range test was used for mean separation when ANOVA showed statistical difference between means. Statistical differences were declared at 5% ($P< 0.05$) significance level (Steel and Torrie, 1980).

Results and Discussion

Genera of lactic acid bacteria isolated

A total of 267 colonies were selected, of which 154 and 113 colonies were obtained from MRS and M17 agar medium, respectively. A total of 85 isolates picked from MRS agar plates were found to belong to the genus *Lactobacillus*. These isolates were unable to hydrolyse arginine, unable to grow at 10°C but grew at 45°C, able to produce gas from glucose and able to grow in a medium containing 2% NaCl (Table 1). The growth of the isolates in a medium containing 2% NaCl observed in the present study is similar to the findings of Hutkins *et al*. (1987).

Thirty six isolates picked from M17 agar plates were found to belong to the genus *Lactococcus* and they were unable to produce gas from glucose, able to produce ammonia from arginine, all were able to grow at 10°C and at 45°C, and able to grow in a medium containing 3% and 4% NaCl (Table 1). Similar observation was reported by Togo *et al*. (2002) who indicated that *Lactococcus* isolates were able to grow at higher NaCl concentrations (4% and 6.5%). Twenty five isolates picked from M_{17} agar plates were identified as *Enterococcus* and they were able to hydrolyse arginine, unable to produce gas from glucose, and able to grow at 10 and 45°C and in a medium containing 3, 4 and 6.5% NaCl (Table 1). *Enterococcus* was observed to be the only genera that showed growth in a high NaCl concentration (6.5%) which is in agreement with an earlier finding. As indicated by El-Hadi Sulieman *et al*. (2006), Gram-positive and catalase negative bacteria that are capable of growing at 10 and 45°C and in a medium containing 6.5% NaCl were considered as enterococci.

Lactobacillus species isolated on MRS agar was the dominant genus and comprised of 58% of the total lactic acid bacteria isolates (Table 2). El-Hadi Sulieman *et al*. (2006) reported that the majority of lactic acid bacteria isolated from Garris (Sudanese traditional fermented camel milk) belong to the genus *Lactobacillus* (74%). Similar observations in composition and diversity of lactic acid bacteria isolated from traditional fermented milk of cows and ewes were reported by Gonfa *et al*. (1999) from Ethiopia, Savadogo *et al*. (2004) from Burkina Faso,

Table 2. Lactic acid bacteria species isolated from the traditional fermented camel milk *Ititu*

Species	*Number of isolates*	*% of total isolates*
Lactobacillus salivarius	47	32.3
Lactobacillus plantarum	13	8.9
Lactobacillus delbrueckii subspecies *bulgaricus*	25	17
Lactococcus lactis subspecies *cremoris*	10	6.8
Lactococcus lactis subspecies *lactis*	26	17.8
Enterococcus faecalis	25	17
Total	146	100

Ayad *et al*. (2004) from Egypt and Abdelgadir *et al*. (2001) from Sudan which comprised mainly of lactobacilli and lactococci.

Species of lactic acid bacteria isolated

The isolated lactic acid bacteria groups (genera) were identified to species level based on their carbohydrate fermentation profiles (Tables 3 and 4). The results revealed that the isolated lactic acid bacteria that belong to the genus *Lactobacillus* fermented the majority of the substrates (sugars) except dolcitol. The isolates that were weak to ferment trehalose, sorbitol and raffinose were identified as *Lactobacillus plantarum* (Table 3). The sugar fermentation profile of *Lactobacillus plantarum* observed in the present study was also reported by El-Hadi Sulieman *et al*. (2006) and Isono *et al*. (1994) for isolates from naturally fermented milk in Northern Tanzania and from cultured milk in Cameroon. The lactic acid bacteria isolates that fermented majority of the substrates except dolcitol and trehalose and that were weak to ferment raffinose were identified *as Lactobacillus salivarius* (Table 3). *Lactobacillus* isolates that fermented only maltose, salicin, glucose, mannose and fructose, on the other hand, were identified as *Lactobacillus delbrueckii* subspecies *bulgaricus*. Mourad and Nour-Eddine (2006) isolated *Lactobacillus plantarum* and *Lactobacillus delbrueckii* subspecies *bulgaricus* from traditional butter made from camel milk based on their sugar fermentation profiles.

Lactic acid bacteria groups that fermented maltose, mannitol, lactose, arabinose salicin, glucose, mannose and fructose were classified as *Lactococcus lactis* subspecies *lactis* (Table 4). This result is in agreement with Cheriguene *et al*. (2006) who reported *Lactococcus lactis* subspecies *lactis* to be unable to ferment raffinose, sorbitol and arabinose.

Other groups of lactococci that fermented maltose, lactose, sucrose, salicin, glucose, fructose and mannose were identified as *Lactococcus lactis* subspecies *cremoris* (Table 4) which is in agreement with the findings of Cheriguene *et al*. (2006) who reported *Lactococcus lactis* subspecies *cremoris* to be non raffinose, sorbitol and arabinose fermenter. In the present study, *Lactococcus lactis* subspecies *lactis* was more frequently isolated from *Ititu* as compared to *Lactococcus lactis* subspecies *cremoris*. Padmanabha-Reddy *et al*. (1994) also reported *Lactococcus lactis* subspecies *lactis* to be more frequently isolated from raw milk samples and from Dahi and butter samples in India as compared to *Lactococcus lactis* subspecies *cremoris*.

Isolates that fermented the majority of the substrates tested except arabinose and dolcitol and that were too weak to ferment sorbitol and raffinose were identified as *Enterococcus faecalis* (Table 3). The present observation is inline with the findings of Benkerroum *et al*. (2003) who reported that *Enterococcus faecalis* isolated from raw camel milk was able to metabolize the majority of the sugars tested. The lactic acid bacteria species identified in the current study are more diverse as compared to those reported by El-Hadi Sulieman *et al*. (2006) who isolated only two *Lactobacillus* species (*Lactobacillus plantarum and Lactobacillus paracasei*) from fermented camel milk (*Garris*). Such variation in the diversity of lactic acid bacteria species observed between *Garris* and *Ititu* might be attributed to the inherent characteristics of the fermented camel milk used and the specific fermentation condition followed.

Acidification activity of the isolated lactic acid bacteria

The results of acid production of the isolated lactic acid bacteria species indicated that none of the species was found to be fast acid producer (Figure 1). All the isolates examined took more than 12 h to reduce the pH of the growth medium to a final pH value of 4.6. *Lactobacillus* species reduced the pH of the medium relatively faster and attained the target pH value of 4.6 within 48 h as compared to the other lactic acid bacteria species (Figure 1). Among *Lactobacillus* species, only *Lactobacillus salivarius* could reduce the pH of the skim milk medium (from an initial value of 6.78 to a final pH value of 4.38) within 48 h of incubation (Figure 1) and attained a final titratable acidity value of 1.25% within 48 h (Figure 2).

Kandler and Weiss (1986) measured the acid production potential of *Lactobacillus salivarius* and reported its strong acidifying activity. On the other hand, *Lactobacillus plantarum* and *Lactobacillus delbrueckii* subspecies *bulgaricus*, showed medium acidification activity and reduced the pH of the skim milk powder from initial values of 6.77 and 6.76 to final pH values of 4.57 and 4.58, respectively at about 48 h of incubation (Figure 1).

Table 3. Carbohydrate fermentation profile of lactic acid bacteria isolated using MRS agar from traditionally fermented camel milk (*Ititu*)

Type and number of species	*Types of sugar used*															
	Malt	*mani*	*treh*	*sor*	*lact*	*sou*	*raff*	*arb*	*sali*	*dolc*	*escu*	*glu*	*man*	*rha*	*ribo*	*fruc*
FTD-04 (n = 47)	+	-	-	+	+	+	±	+	+	-	+	+	+	+	+	+
FTD-07 (n = 14)	+	-	-	-	w	-	-	-	+	-	N	+	+	+	+	+
FTD-08 (n = 5)	+	+	w	+	±	+	+	+	+	-	+	+	+	+	+	+
FTD-05 (n = 8)	+	+	w	±	+	+	±	+	+	-	+	+	+	+	+	+
FTD-06 (n = 11)	+	-	-	-	w	-	-	-	w	+	+	+	+	+	+	+

Malt = maltose; mani = manitol; treh = trehalose; sor = sorbitol; raff = raffinose; arb = arabinose; sali = salicin; docl = dolcitol; escu = esculin; glu = glucose; man = mannose; rha = rhamanose; ribo = ribose; fruc = fructose; w = weak reaction; ± = delayed reaction; + = positive reaction; - = negative reaction; N = not observed; FTD-4 = *Lb. salivarius*; FTD-07 and FTD-06 = *Lb. delbrueckii* subsp. *bulgaricus*; FTD-05 and FTD-08 = *Lb. plantarum*; n = total number of species identified based on sugar fermentation profile

Table 4. Carbohydrate fermentation profile of lactic acid bacteria isolated using M_{17} agar from traditionally fermented camel milk (*Ititu*)

Type and number of species	*Types of sugar used*															
	malt	*mani*	*treh*	*sor*	*lact*	*sou*	*raff*	*arb*	*sali*	*dolc*	*escu*	*glu*	*man*	*rha*	*ribo*	*Fruc*
FTD-11 (n = 18)	+	+	+	w	+	+	w	-	+	-	+	+	+	w	-	+
FTD-17 (n = 7)	+	+	+	w	+	+	+	w	+	-	+	+	+	-	-	+
FTD-13 (n = 10)	+	-	-	w	+	+	-	-	+	-	-	+	+	-	-	+
FTD-18 (n = 17)	+	+	-	-	+	w	-	+	+	-	-	+	+	-	-	+
FTD-14 (n = 9)	+	w	+	-	w	+	-	-	-	-	-	+	+	-	-	+

Malt = maltose; mani = manitol; treh = trehalose; sor = sorbitol; raff = raffinose; arb = arabinose; sali = salicin; docl = dolcitol; escu = esculin; glu = glucose; man = mannose; rha = rhamanose; ribo = ribose; fruc = fructose; w = weak reaction; ± = delayed reaction; + = positive reaction; - = negative reaction; FTD-11 and FTD-17 = *Enterococcus faecalis*; FTD-13 = *Lc. lactis* subsp.*cremoris*; FTD-14 and FTD-18 = *Lc. lactis* subsp. *lactis*; n = total number of species identified based on sugar fermentation profile

They also attained final titratable acidity values of 1.17% and 1.08%, respectively (Figure 2) within the same period. However, Harun-Ur-Rashid *et al*. (2007) reported different values where *Lactobacillus delbrueckii* subspecies *bulgaricus* reduced the pH of skim milk medium from an initial pH value of 6.0 to a final pH value of 3.35 at about 72 h and attained a final acid level of 2.13%.

Lactococcus lactis subspecies *lactis* and *Lactococcus lactis* subspecies *cremoris* reduced the initial pH (6.76 and 6.77) of their respective growth medium to final pH values of 4.52 and 4.18, respectively at about 72 h of fermentation (Figure 1) and attained final titratable acidity values of 1.28% and 1.16%, respectively (Figure 2). Both species were characterized as slow acidifiers. The results observed in the current study deviate from that of earlier findings. For instance, Francesconi (2006) and Harun-Ur-Rashid *et al*. (2007) reported that *Lactococcus lactis* subspecies *lactis* isolated from traditional fermented milk had fast acid producing ability within 24 h incubation period. However, Huggins and Sandine (1984) reported that *Lactococcus lactis* subsp. *lactis* was a slow acid producer.

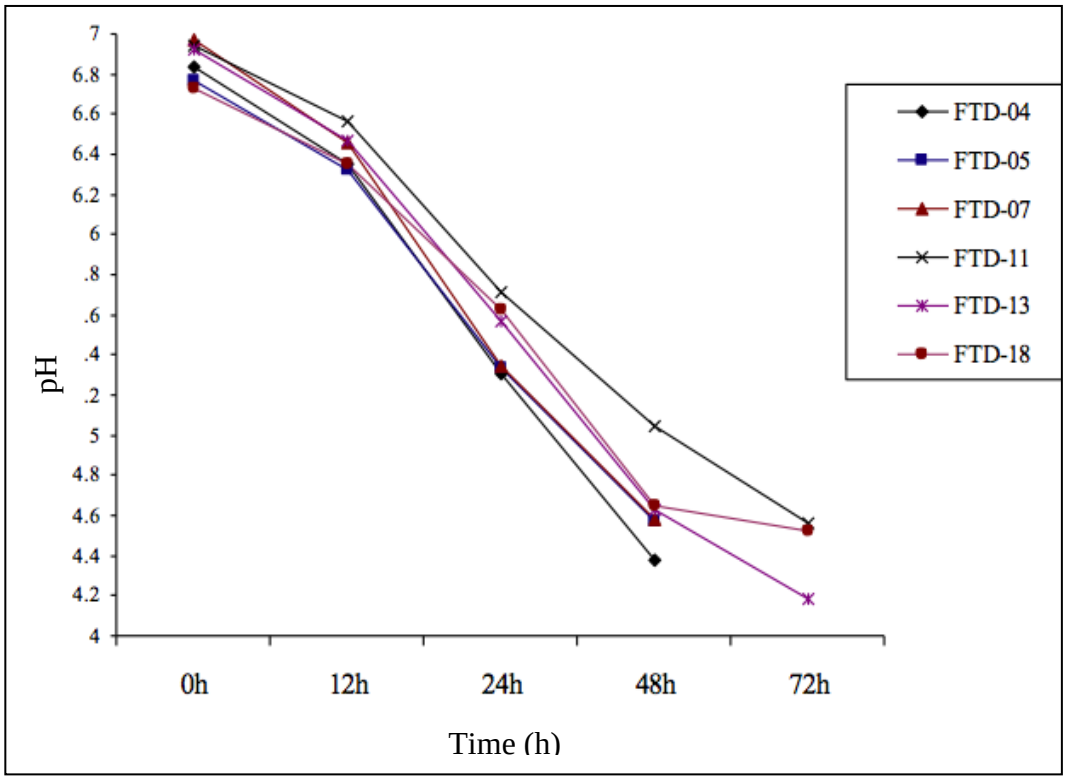

Figure 1. Change in pH of skim milk powder (medium) fermented by the isolated lactic acid bacteria and incubated at 30 or 38°C (FTD-04 = *Lb. salivarius*, FTD-05 = *Lb. plantarum*, FTD-07 = *Lb. delbrueckii* subsp. *bulgaricus*, FTD-11 = *Enterococcus faecalis*, FTD-13 = *Lactococcus lactis* subsp. *cremoris*, FTD-18 = *Lactococcus lactis* subsp *lactis*).

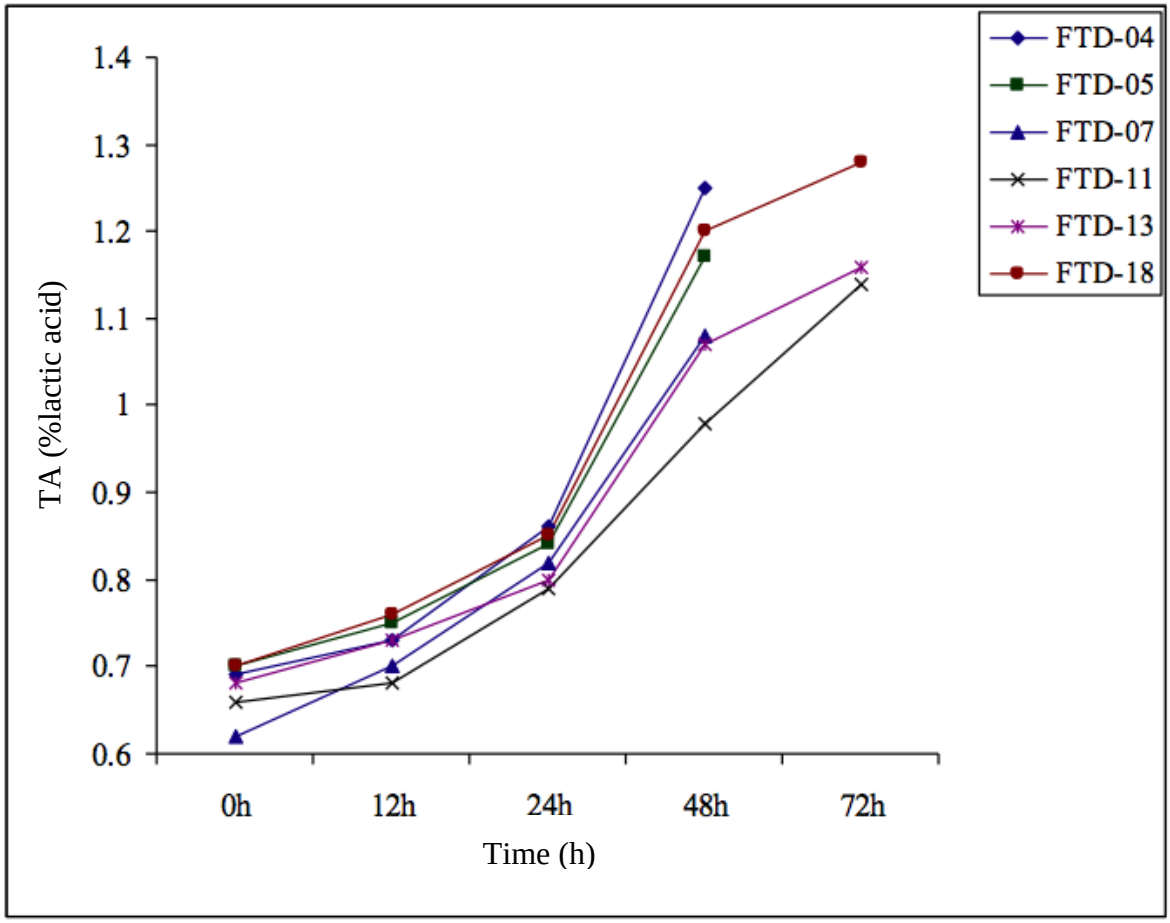

Figure 2. Change in titratable acidity (%lactic acid) of skim milk powder fermented by the isolated lactic acid bacteria and incubated at 30 or 38°C (FTD-04 = *Lb. salivarius*, FTD-05 = *Lb. plantarum*, FTD-07 = *Lb. delbrueckii* subsp. *bulgaricus*, FTD-11 = *Enterococcus faecalis*, FTD-13 = *Lactococcus lactis* subsp. *cremoris*, FTD-18 = *Lactococcus lactis* subsp *lactis*, TA = titratable acidity).

Enterococcus faecalis showed a slow acid production ability as it reduced the initial pH (6.75) of the skim milk medium to a final pH of 4.56 at about 72 h of fermentation (Figure 1) and attained a final titratable acidity of 1.14% (Figure 2). These values are similar to that reported by Hassaïne *et al*. (2007) who reported the acidifying abilities of *Enterococcus* species to be generally slow. The same authors also indicated that this species did not lower the pH of milk to pH < 5.0 after 24 h of incubation. In the present study, a clear difference was observed in acidifying activity between the isolated lactic acid bacteria species. *Lactobacillus salivarius* was a relatively fast acid producer bringing the initial pH of the skim milk medium to the target/final value of 4.6 before 48 h of incubation followed by *Lactobacillus plantarum* and *Lactobacillus delbrueckii* subspecies *bulgaricus*.

A rapid decrease in pH during fermentation of milk products is of paramount importance in the production process since it is essential for coagulation of casein and prevention of the growth of undesirable microorganisms (Hassaïne *et al.* 2007). In the current study, the observed difference in acid production ability between the isolated lactic acid bacteria species could be attributed to variations in nutrient requirement and metabolic activities of the species. As suggested by Hassaïne *et al.* (2007), fast acidifying strains of lactic acid bacteria could be potential candidates in the fermentation process as primary starter organisms whereas the poor acidifiers can be used as adjunct cultures depending on their desirable properties such as proteolytic and autolytic activities. The proteolytic activity of dairy lactic acid bacteria is essential for the development of flavour compounds in different fermented milk products (Hassaïne *et al.* 2007).

The production of good quality fermented dairy products is dependent on proteolytic properties of the starter bacteria, since peptidases and amino acids formed during fermentation have a direct impact on flavour development, or serve as flavour precursors in dairy products.

Prior to using lactic acid bacterial species as starter culture, one has to evaluate whether they would significantly contribute to an improvement of processing conditions and product quality with respect to rapid or accelerated acidification, desirable sensory attributes, improved safety and reduced hygienic risks (Holzapfel 1997). Thus, it is essential to assess other desirable characteristics such as proteolysis; lypolysis; development of flavour compounds; ability to inhibit undesirable microorganisms; and the contribution to sensory characteristics of lactic acid bacteria strains intended to be used as starter culture during production of fermented camel milk in addition to their acidification potential examined in the present study.

Conclusion

In the present study, the dominant lactic acid bacteria responsible for the spontaneous fermentation of the traditional fermented camel milk *Ititu* were identified. The isolates from the present study could be used in the development of starter cultures for the

production of fermented camel milk under controlled environment in the future. However, further research work is needed to evaluate the performance of these isolates when used in combination with other lactic acid bacteria strains (mixed cultures). Aroma production and other desirable characteristics of the isolates should also be the focus of future research, which can be used as additional criteria for screening lactic acid bacteria strains to be used as starter cultures.

Acknowledgements

This study was funded by the National Camel Research Program of Ethiopia.

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