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Handling and Microbial Load of Cow's Milk and *Irgo* -Fermented Milk Collected from Different Shops and Producers in Central Highlands of Ethiopia

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Abstract

Microbial analysis preceded by a survey was conducted to study the handling and the microbial properties of milk and *Irgo* - Ethiopian fermented milk. One-hundred-twenty-four producers (109 small-scale producers, 12 large-scale producers and 3 research centers) were interviewed for the survey. A total of 32 (milk=16 and *Irgo*=16), samples collected from different dairy product shops and 3 producer groups (small-scale, large-scale and research center) in the central highlands of Ethiopia were tested for their microbial properties (counts of aerobic mesophilic, coliforms and lactic acid bacteria) using standard classical methods. Milk samples collected from five different dairy product shops had mean aerobic mesophilic, coliform and lactic acid bacterial counts of 6.97, 5.4 and 6.81 log cfu mL^{-1}, respectively. *Irgo* samples had mean aerobic mesophilic, coliform and lactic acid bacterial counts of 7.1, 4.47 and 6.89 log cfu mL^{-1}, respectively. Mean aerobic mesophilic, coliform and lactic acid bacterial counts of milk sampled from all sources were 8.38, 6.57 and 7.68 cfu mL^{-1}, respectively. The values recorded for *Irgo* were 8.11, 4.82 and 6.7 cfu mL^{-1}, respectively. The highest aerobic mesophilic bacterial counts of 8.63 and 8.40 log cfu mL^{-1} were observed in milk and *Irgo* samples respectively collected from large scale farms. The highest coliform counts recorded for milk and *Irgo* sampled from large scale farms were 6.82 and 5.40 log cfu mL^{-1}, respectively. These high microbial counts indicate the importance of microbial contamination. The isolation and identification of emerging pathogens such as Enterohemorrhagic *Escherichia coli* O157:H7 deserve a due consideration.

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Further investigation in order to identify risk factors is crucial to design preventive interventions.

Key-words: Milk handling, Ethiopia, microbial quality, cow milk, *Irgo*

Introduction

The safety of dairy products with respect to food-borne diseases is of great concern around the world. This is especially true in developing countries where production of milk and various dairy products takes place under rather unsanitary conditions and poor production practices (Mogessie Ashenafi, 1990).

A commonly used procedure to measure the sanitary quality of milk is to estimate its bacterial content. The number of bacteria in aseptically drawn milk varies from animal to animal and even from different quarters of the same animal. On average, aseptically drawn milk from healthy udders contains between 500 and 1000 bacteria mL^{-1}. High initial counts (more than 10^5 bacteria mL^{-1}) are evidence of poor production hygiene (O'Connor, 1994). In proportion to the numbers present, existence of coliform bacteria in milk and milk products is suggestive of fecal contamination and unsanitary practices during production, processing, or storage (Richardson, 1985).

In Ethiopia, dairy processing is generally based on *Irgo* (Ethiopian fermented milk) where the fermentation is natural, with no defined starter cultures used to initiate it. Raw milk is left either at ambient temperatures or kept in a warm place to ferment. The souring is brought through the proliferation of the initial milk flora, with microbial succession determined by chemical changes in the fermenting milk (Mogessie Ashenafi, 2002). Understanding the microbial properties of this fermented product is therefore vital to encourage development of industrial dairy processing. Lactic acid bacteria that mainly produce lactic acid from carbohydrates such as lactose are involved in the fermentation. They are widespread and include the genera *Lactococcus* and *Lactobacillus. Lactococcus lactic subsp. lactis* and *Lactococcus lactic subsp. cremoris* grow rapidly in milk, especially above 20°C. So milk turns sour if kept uncooled and losses heat stability (Walstra *et al.*, 1999).

Most of the milk produced in Ethiopia is marketed to the consumers without being pasteurized or subjected to any quality standard and 98% of the annual milk is produced by subsistence farmers who live in rural areas where dairy infrastructure is almost non-existent (Tsehay Reda, 1998). This implies that dairy processing in the country is basically limited to smallholder level and hygienic qualities of products are generally poor. Information on the hygienic handling of dairy products is generally lacking and that on their microbial properties is limited. The aims of this study are te generate basic information on the quantification of total bacterial load, coliforms and lactic acid bacteria of cow's milk and *Irgo* collected from different dairy product shops and producer groups.

Materials and Methods

Study area

The study was carried out in Addis Ababa (altitude: 2320 masl; annual rainfall: 1200 mm; average temperature min., max.: 10.7°C, 23°C) and four major towns around it, namely Debre Zeit (altitude: 1900 masl; annual rainfall: 851mm; average temperature min., max.: 11°C, 29°C), Sebeta (altitude: 2260 masl; annual rainfall: 1100 mm; average temperature min., max.: 10°C, 25°C), Selale (altitude: 2500 - >3000 masl; annual rainfall: 1200 mm; average temperature min., max.: 6°C, 21°C) and Holetta (altitude: 2400 masl; annual rainfall: 1100 mm; average temperature min., max.: 6°C, 24°C). Ethiopia is found in East Africa at a latitude of 3°24'N to 14°53'N and longitude of 33°00'E to 48°00'E).

Methodology

Survey. A semi-structured questionnaire was used to assess the hygienic conditions of milk and *Irgo* during production, processing, preservation, transportation and marketing. One-hundred-twenty-four respondents (109 randomly selected smallholder producers; 12 large-scale dairy farms; 3 Research Centers) were interviewed. Most of the producers were involved in all stages of the dairy chain. Laboratory microbial analysis of milk and *Irgo* samples followed the survey.

Sampling and study procedure. Milk and *Irgo* were sampled, transported and analyzed following standard procedures (Richardson, 1985). Milk in this study refers to unpastuerized whole (for small-scale producers, large-scale producers and research centers) and pasteurized or unpasteurized whole, semi-skimmed or skimmed cows' milk (for dairy product shops). At the time of sampling from 5 dairy product shops in Addis Ababa, products were not labeled with the details of the manufacturing and packaging conditions, except one or two of the samples. Information was gathers through informal discussion with sellers. As dairy product shops were so limited in number, categorizing the milk into the types (pasteurized, unpasteurized, skimmed, semi-skimmed, whole) may not give more sense from statistical point of view. It was therefore decided to consider rather the source of the samples as dairy product shops. The samples were collected aseptically in sterile bottles, kept in an icebox (at <5°C) and transported to laboratory for analysis within 8 hours of sampling.

Samples were collected from three groups of producers (Small-scale 'SS', Large-scale 'LS' and Research Centers 'RC') and Dairy Product Shops 'DPS'. Small-scale producers in this study are those that possessed <25 cows and most of them processed milk using locally available traditional technologies. Large-scale producers are those that possessed >25 cows. Research Centers refer to governmental and non-governmental research stations that are engaged in research activities targeted to improve the overall productivity of the livestock sector. Dairy product shops refer to kiosks of dairy products, and most of them belonged to Large-scale producers. Each of the analysis was made in duplicates and for each of them there was a control. All the analyses were performed within 24 h of sampling.

Microbial analysis

A total of 32 (fresh milk = 16 and *Irgo* = 16), samples were collected from the three producer groups and dairy product shops. The microbial analysis considered included: Aerobic Mesophylic Bacteria Count (AMBC), Coliform Count (CC) and Lactic Acid Bacteria Count (LABC). For AMBC, dilutions were selected so that the total number of colonies on a plate was between 30 and 250, while for CC, dilutions were selected for plate counts of between 15 and 150 (Richardson, 1985). For LABC, dilutions were selected so that colonies could be counted on a plate. One mL of fresh milk and *Irgo* samples were homogenized in 9 mL of 0.1% peptone water (Oxoid) using a vortex-mixer for 1 min before undertaking the microbial analysis. Peptone water and media prepared for each test [except Violet Red Bile Agar (VRBA) for which boiling for 2 min was employed] were autoclaved for 15 min at 121°C (Richardson, 1985). Media used were prepared according to the directions given by the manufacturers.

Aerobic Mesophylic Bacteria Count (AMBC). After autoclaving as mentioned earlier, Standard Plate Count Agar (SPCA) (Oxoid, UK) was cooled to 45°C in a water bath. AMBC was made after incubating appropriate decimal dilutions of the samples in the SPCA medium at 32°C for 48 h (Richardson, 1985).

Coliform counts (CC). Two tests were made to determine CC. Appropriate decimal dilutions of milk and *Irgo* samples were plated on VRBA (Oxoid, UK) and counts were made after incubating at 32°C for 24 h (Richardson, 1985). Typical dark red colonies normally measuring at least 0.5 mm in diameter were considered as coliform colonies. This was followed by a confirmatory test by transferring five colonies from each plate to tubes of 2% Brilliant Green Lactose Bile Broth (BGLBB) (Oxoid, UK). Gas production after 24 h of incubation at 32°C was considered sufficient evidence of presence of coliforms (Richardson, 1985).

Lactic Acid Bacteria (LAB) count. One mL of appropriate serial dilutions in peptone water of *Irgo* samples were added into a sterile dish. A molten MRS Agar (Oxoid, UK) (45°C) was then poured onto the dish and mixed thoroughly. After the medium had set, another layer of MRS Agar was poured over the surface to produce a layer-plate. Colonies were counted after plates were incubated at 35°C in an atmosphere of 5% CO_2 for 48 hours (Savadogo *et al.*, 2004).

Acidity: Acidity of milk and fermented milk samples was measured by titrating 10 mL of the product with 0.1N NaOH to a phenolphthalein end point. Acidity is expressed as % lactic acid (1 mL of 0.1 N NaOH = 0.009 g of lactic acid) (O'Connor, 1994; Richardson, 1985).

Statistical analysis

The qualitative data collected during the survey were described using chi-square test, while, the quantitative data were analyzed using the Means procedure of the Statistical Analysis System (SAS) version 8.2 (SAS, 2001). The number of microorganisms (colony forming units) per milliliter of milk and *Irgo* samples was calculated using the following mathematical formula (IDF, 1987).

$\sum C / (1 x n_1 + 0.1 x n_2) d$ Where,

$\sum C$ = Sum of all colonies on all plates counted

n_1 = Number of plates in first dilution counted

n_2 = Number of plates in second dilution counted

d = Dilution factor of the lowest dilution used

The results of microbial counts were first transformed to logarithmic values (log 10) and these transformed values were analyzed using the General Linear Model (GLM) for least squares means in SAS version 8.2 (SAS, 2001) using a fixed effect model. The Least Significant Difference (LSD) test was used to separate the means and differences were considered significant at $P<0.05$. The model used is presented below.

Model: $Y_{ij} = \mu+M_i+P_j+e_{ij}$

Where, Y = AMBC, CC and LAB count

M_i = effect of i^{th} market type P_j = effect of j^{th} producer

group

e_{ij} = random error, which is assumed to be independent and randomly distributed

Results

Handling of dairy products

Hygiene during milking. The three research centers considered, and about 79% of SS and 91% of LS producers, respectively reported to wash the udder of the cow before milking. However, about 52% of SS and 58% LS producers, respectively used collective towel to clean the udder or they didn't clean at all and 47% of SS and 33% of LS producers used river and/or bore hole water to clean the udder and milk utensils (Table 1). A few of these producers filtered the water, while most of them used the water without any treatment (Table 1).

Treatment of milk. Forty-five % of SS producers consumed milk without any treatment, while, filtration before sale was reported to be the only type of treatment by about 67% of LS producers (Table 2).

Preservation of dairy products. Over 70% of the SS producers kept dairy products at room temperature before consumption or marketing, while LS producers and RC kept dairy products either in refrigerator when products stayed long time or at room temperature when products were disposed immediately after production (Table 3). Organoleptic properties of dairy products are the commonly used quality tests. LS producers kept both milk and *Irgo* longer as compared to the other producer groups (Fig. 1).

Table 1. Frequency distribution of milking related hygienic practices taken by three producer groups in central Ethiopia

Hygienic practice	Producer: Small-scale		Large-scale		Research Center	
	Freq.*	%	Freq.	%	Freq.	%
Udder washing						
Washing udder before milking	86	78.9	12	90.9	3	100
Washing udder after milking	10	9.2	-	-	-	-
No hygienic practice	13	11.9	-	-	-	-
Total	109	100	12	100	3	100
Use of towel						
Collective towel	28	25.7	1	8.3	-	-
Individual towel	52	47.7	5	41.7	3	100
With bare hand	16	14.7	6	50	-	-
No hygienic practice	13	11.9	-	-	-	-
Total	109	100	12	100	3	100
Source of water						
Tap	58	53.2	8	66.7	3	100
River	14	12.8	-	-	-	-
Bore hole	37	33.9	4	33.3	-	-
Total	109	100	12	100	3	100
Treatment of water						
Heating	58	53.2	6	50	3	100
Filtration	14	12.8	-	-	-	-
No treatment	37	33.9	6	50	-	-
Total	109	100	12	100	3	100

*Frequency

Table 2. Treatment of milk and *Irgo* by different producers in central Ethiopia

Treatment	Producer: Small-Scale		Large-Scale		Research Center	
	Freq.*	%	Freq.	%	Freq.	%
Milk						
Pasteurization	-	-	1	8.33	1	33.3
Boiling	52	48	-	-		-
Fermentation	8	7	-	-		-
Filtration	-	-	8	66.67	2	66.7
No treatment	49	45	3	25	-	-
Total	109	100	12	100	3	100
Fermented milk						
Pasteurization	-	-	1	8.3	-	-
Boiling	-	-	1	8.3	-	-
Fermentation	102	93.6	4	33.3	3	100
No practice	7	6.4	6	50	-	-
Total	109	100	12	100	3	100

*Frequency

Microbial load of milk and Irgo

AMBC of milk and Irgo didn't vary significantly by producer group (Table 4 and 5). The lowest AMBC was recorded for samples obtained from RC; however, the highest AMBC was obtained for samples from LS producers (Table 4 and 5). CC of Irgo sampled from RC was 1.06 log cfu mL^{-1} lower ($P<0.05$) than that sampled from LS producers (Table 5). The difference in CC between SS and LS producers, however, was not significant ($P>0.5$). LAB count of milk (Table 4) and Irgo (Table 5) were higher for LS producers; though the difference was apparent ($P<0.05$) only for milk (Table 4). Coliform count of Irgo was significantly ($P<0.05$) lower for SS producers than the other two producer groups (Tables 5).

Table 3. Condition of keeping fresh and fermented milk produced by different producers

Dairy product	Condition of keeping								Total	
	In refrigerator		In water		At room temp.		No practice[1]			
	Freq.[2]	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Milk										
Small-scale	7	6.4	25	23	77	70.6	-	-	109	100
Large-scale	6	50	-	-	6	50	-	-	12	100
Research center	6	66.7	-	-	1	33.3	-	-	3	100
Fermented milk										
Small-scale	7	6.4	4	3.7	91	83.5	7	6.4	109	100
Large-scale	6	50	-	-	-	-	6	50	12	100
Research center	2	66.7	-	-	1	33.3	-	-	3	100

[1] refers to the absence of the practices (e.g. 7 of the small-scale farmers interviewed did not ferment milk, they rather disposed the fresh milk), [2]Frequency

Table 4. Least squares means (± s.e.) of microbial counts of ***milk*** for dairy product shops and different producers

Variable	Producer							Dairy product shops
	SS	LS	RC	Mean	C.V%	L.S.D	SL	
No. of observation	5	3	3	11				5
AMBC, log cfu mL^{-1}	8.34±0.17	8.63±0.23	8.18±0.23	8.38	4.8	0.70	NS	6.97±0.28
Coliform, log cfu mL^{1}	6.68±0.18^{a}	6.82±0.23^{a}	5.76±0.23^{b}	6.57	6.30	0.71	*	5.41±0.04
LABC, log cfu mL^{-1}	7.82±0.183^{ab}	7.16±0.236^{b}	7.16±0.236^{b}	7.68	5.33	0.72	*	6.81±0.21

Means with different superscripts within the same raw are significantly ($P<0.05$) different SS=Small-scale, LS=Large-scale, RC=research center, C.V.=Coefficient of variation, LSD=Least Significant Difference, SL=significance level , AMBC=Aerobic Mesophylic Bacteria Count, LABC=Lactic Acid Bacteria Count, NS=Non significant, *=P<0.05

Acidity

Titrable acidity of milk and *Irgo* samples collected from DPS was 0.27 and 0.87%, respectively. Samples of *Irgo* collected from SS, LS and RC had a titrable acidity of 0.85, 0.67 and 0.95%, respectively, while values observed for milk were 0.3, 0.34 and 0.21%, respectively. Milk might have been kept long at ambient temperature between milking and sampling at the farm extending the time between milking and analysis attributing to the high milk acidity.

Table 5. Least squares means (± s.e.) of microbial counts of ***Irgo*** for dairy product shops and different producers

Variable	Producer							Dairy product
	SS	LS	RC	Mean	C.V%	L.S.D	SL	shops
No. of observation	5	3	3	11				5
AMBC, log cfu mL^{-1}	8.14±0.26	8.40±0.34	7.77±0.34	8.38	7.2	1.02	NS	7.1±0.28
Coliform, log cfu mL^{-1}	4.22±0.168^{b}	5.40±0.217^{a}	5.22±0.217^{a}	6.57	7.80	0.66	*	4.47±0.40
LABC, log cfu mL^{-1}	6.71±0.232	6.91±0.301	6.49±0.301	7.68	7.80	0.91	NS	6.89±0.21

Means with different superscripts within the same row are significantly (P<0.05) different SS=Small-scale, LS=Large-scale, RC=research center, C.V.=Coefficient of variation, LSD=Least Significant Difference, SL=significance level , AMBC=Aerobic Mesophylic Bacteria Count, LABC=Lactic Acid Bacteria Count, NS=Non significant, *=P<0.05

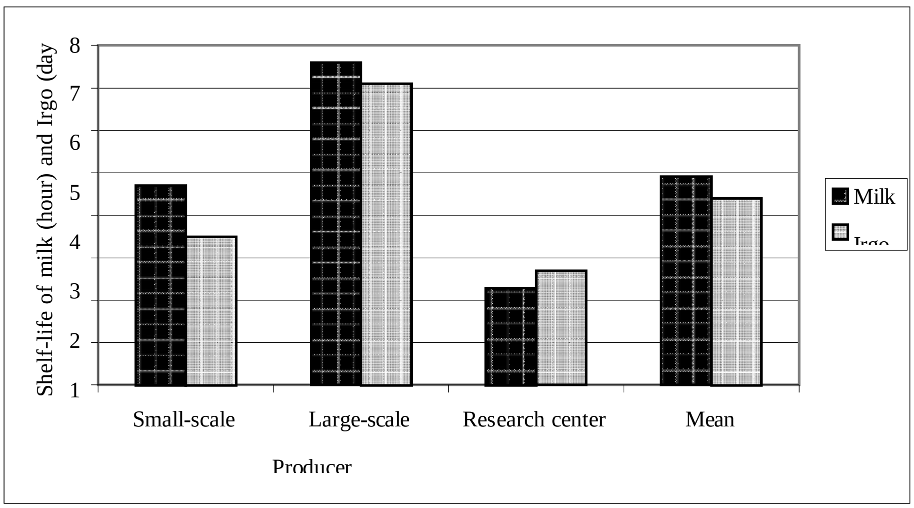

Fig. 1. Shelf-life of milk and *Irgo* before consumption and/or sale under different production systems

Discussion

Handling of dairy products

The sanitary measures taken by the producers during handling of milk and milk products at different stages were generally substandard. This holds true particularly for small-scale and large-scale producers where the use of collective towel for udder cleaning was common and most of this former groups responded not to treat surface water before use. The organoleptic properties of products used as a quality test by most SS producers doesn't guarantee the absence of pathogenic organisms. The sanitary procedures practiced for manufacturing an apparently similar product varied considerably among producer groups, even within the same group. Fekadu Beyene (1994) and Duteurtre (1998) also reported similar results.

Microbial load of raw milk and *Irgo*

AMBC in milk was associated with ambient temperature, time elapsed since milking and level of hygiene. AMBC obtained for milk in this study were generally high (6.97 log cfu mL^{-1} for DPS and 8.38 log cfu mL^{-1} for the three producers) as compared to the acceptable value ($1x10^5$ bacteria per mL of milk) (O'Connor, 1994). As indicated earlier in the Material and Methods section, types of milk samples collected from DPS were different. However, no apparent difference was observed in microbial load among the samples indicating either the absence of pasteurization, incorrect pasteurization or post pasteurization contamination. This high bacterial concentration could be associated with the original heavy load of bacteria in raw milk before pasteurization. Pasteurization usually reduces the percentage of bacteria to about 1%, but this number can be substantial if the original bacterial load in raw milk is high. In addition, bacterial cells can recover after thermal injury under the favorable tropical temperatures that prevail during transportation or at retail outlets that do not have chilling facilities such as kiosks (Omore *et al.*, 2001). The utensils holding the raw and pasteurized milk and the plastic sacs used for bagging the pasteurized milk as indicated by Mahari Tetemke and Birhanu Abegaz Gashe (1990) could also contribute to further contamination. A number of workers reported similar values of aerobic mesophilic counts that ranged between 4×10^7 and 3×10^9 cfu mL^{-1} (Kurwijila *et al.,* 1992; Mogessie Ashenafi, 1995; Taye Tolemariam *et al.*, 2000; Bekele Godefay and Bayleyegn Molla, 2000). Fekadu Beyene (1994), however, obtained lower counts (1×10^3 - 7.5×10^5 cfu mL^{-1}) and higher values up to 8.7×10^9 cfu mL^{-1} were reported for milk sampled from markets in central Ethiopia (ILCA, 1993). AMBC of 10^6 cfu mL^{-1} were also reported for camel milk (Teshager Semereab and Bayleyegn Molla, 2001).

Coliform count, on the other hand, is especially associated with the level of hygiene during production and subsequent handling since they are mainly of fecal origin (Omore *et al.,* 2001). Coliforms comprise all aerobic and facultative anaerobic, gram-negative, non-spore-forming rods able to ferment lactose with the production of acid and gas at 32°C within 48 hours (Feng *et al.*, 1998).

Milk sampled from DPS and the three producer groups had proved high level of contamination with CC of 5.41 and 6.57 log cfu mL^{-1}, respectively. CC of >100 cells/mL of raw milk shows that the production condition is unhygienic and the products are unsafe for consumption (Ingalls, 1998). The high AMBC and CC obtained in this study might be attributed to poor hygienic handling practices leading to initial contamination and/or related to udder infections, the case of which needs further investigation. Coliforms are inhabitants of the intestinal tract of warm-blooded animals and most of them are classified in the genera *Escherichia*, *Enterobacter, Klebsiella* and *Citrobacter*. Application of the test for coliforms is intended to measure the quality of practices used to minimize bacterial contamination of dairy products. Such tests are also conducted following pasteurization to detect bacterial contamination of milk, cream and other processed dairy products (Richardson, 1985).

The higher CC of milk samples obtained for SS and LS farms as compared to RC might be due to differences in hygienic measures taken during production. Although LS farms produce milk, they also collect a considerable amount from SS producers. This could justify the similar results obtained for these two producers. Coliforms could contaminate milk from manure, bedding materials, contaminated water, soil and inadequately cleaned milking utensils (Lampert, 1975; Kalogridou-Vassiliadou, 1991). According to the survey result, around 34% and 33% of SS and LS producers used bore hole water for cleaning the udder before milking and for washing milk utensils. About 34% of SS and 50% of LS producers, respectively, used the water without any treatment. This type of management obviously renders further contamination possible. Of course, it is not practical to produce milk that is always free of coliforms. Their presence in raw milk may therefore be tolerated. However, if present in large numbers, say over ten coliform organisms per milliliter of pasteurized milk, it means that the milk was produced under improper procedures (O'Connor, 1994; Walstra *et al.*, 1999).

The reason for the low CC of fermented milk samples for SS producers as compared to LS producers and research centers is not clear as their acidity was similar. However, variations in holding time at ambient temperature practiced by the different producers could be accountable. Fekadu Beyene (1994) reported ≥ 8.6 log cfu mL^{-1} of AMBC for fermented milk sampled from Southern Ethiopia. CC of >4.4 log cfu mL^{-1} were also reported for fermented milk samples by the same author. Tarik Kassaye *et al.* (1991) reported

AMBC of fermented milk (*Ititu*) samples collected from individual households in Borana region (Southern Ethiopia) to be 10^{12} cfu mL^{-1}, mainly dominated by lactic acid bacteria. Taye Tolemariam *et al.* (2000) and Mogessie Ashenafi (1995) on the other hand reported CC of 10^3-10^6 cfu mL^{-1} for raw milk sampled from different parts of Ethiopia. CC of 10^4 cfu mL^{-1} were also obtained for camel milk (Teshager Semereab and Bayleyegn Molla, 2001). Eyasu Seifu and Fekadu Beyene (2000) indicated that goats' milk after 24 h of storage at 25°C had AMBC, CC and LAB counts of 7.34, 5.46 and 6.78 log cfu mL^{-1}, respectively.

The markedly lower LAB count observed in raw milk for research centers could be attributed to the freshness of the product and the reduced level of contamination due to better management level.

In the study areas, an earthen pot is used for fermentation and butter-making. This pot is usually smoked using burning embers of *weira* (Amharic term for *Olia africana*) before each batch of fermentation and butter-making by most SS producers. This smoking process, as reported by O'Mahoney (1988), Fekadu Beyene (1994) and Mogessie Ashenafi (2002), has anti microbial properties. Mogessie Ashenafi (2002) for instance reported 12 more hours to be needed to reach total non LAB counts of $>10^8$ cfu mL^{-1} in milk kept in smoked containers than that kept in an unsmoked containers. This may justify the apparently lower concentration of coliforms in *Irgo* samples collected from SS producers as this smoking is commonly practiced by this group of producers.

The mean milk LAB count of 7.68 log cfu mL^{-1} obtained for dairy product shops in this study is comparable with that reported for market milk sampled from the central Ethiopia (ILCA, 1993). Mogessie Ashenafi and Fekadu Beyene (1993) reported that LAB accounted for 50% of the microflora of fermented milk (pH 4.6) from Awassa College Dairy Farm. LAB count of ≥ 7.9 log. cfu mL^{-1} were also obtained in 75% of locally produced fermented milk samples from Southern Ethiopia (Fekadu Beyene, 1994).

Among others, lack of knowledge on clean milk production, use of unclean milking equipment coupled with lack of potable water for cleaning purpose might have contributed to the poor hygienic quality of the dairy products. Differences in microbial qualities of dairy products produced by the different groups presumed to be the result of variations in production, processing and preservation practices followed at different stages. There is no as such a standard practice in the method of processing and handling of the dairy products in these farms. The existence of such variation suggests the need for intervention aimed at developing standard code of practice for production of a given product of certain quality based on local production conditions.

Drinking of raw milk is not uncommon in the country in general and in the study area in particular, which is highly inadvisable. However, the consumption of fermented milk and fermented milk products has little deleterious effect on the health of the consumers. The lactic acid bacteria rapidly hydrolyze the lactose found in milk to yield lactic acid, which is not a suitable carbon source for most pathogens. These bacteria also form compounds that are antagonistic to some pathogens. Most pathogens, if present, die within a few weeks in fermented products. However, there is a real danger if pathogens are present in raw milk and products such as soft cheeses made from raw milk (Walstra *et al.*, 1999). Heat treatment such as pasteurization, when applicable, is a reliable means of reducing bacterial load and excluding pathogenic ones. Milk should be boiled using available materials at pasteurization time and temperature.

Acidity

The percentage of acid present in dairy products at any time is a rough indication of the age of the milk and the manner in which it has been handled. Its measurement is affected by any conditions that cause a change in the calcium phosphate of the samples (Richardson, 1985; O'Connor, 1994). *Irgo* samples had over 150% more acidity than milk samples as expected. This had resulted in reduced microbial load of *Irgo* as acidity checks out certain microbes. Lactic acid resulted from the fermentation by LAB is an effective inhibitor for many bacteria if it is undissociated (Walstra *et al.*, 1999). Hardly any bacteria can grow in milk brought to a pH of <4.5 by this acid, but yeasts and molds can (Walstra *et al.*, 1999). Bacteria also can produce other inhibiting substances, such as acetic acid, and antibiotics. Some strains of *Lactococcus lactis subsp. lactics* produce the powerful antibiotic nisin (Walstra *et al.*, 1999).

Conclusion

The sanitary measures taken at different stages in the dairy chain of the study area were generally unsatisfactory and cause deterioration and contamination of the products. Adequate sanitary measures should be taken at all stages from production to consumption. These include measures at the level of the cow, the personnel, milking and processing equipment, milking and milk handling environment, cleaning water, and all other things that come in contact with dairy products from farm to table. Variations in microbial qualities of dairy products produced by various producers were observed. Dairy products sampled from different dairy product shops and producer groups had high counts of aerobic mesophilic and coliform groups of bacteria. Further investigation is recommended to identify contaminants at species level. Such an effort to identify emerging pathogens like Enterohemorrhagic *Escherichia coli* O157:H7 deserve particular concern.

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Reference

Bekele Godefay and Bayileyegn Molla. 2000. Bacteriological quality of raw cow's milk from four dairy farms and a milk collection center in and around Addis Ababa. Berl. Munch. Tierarztl. Wochenschr. 113: 276-278.

Duteurtre, G. 1998. Compétitivité prix et hors-prix sur le marché des produits laitiers d'Addis Abeba (Éthiopie). Thèse de Doctorat en Agro-Économie. Ministère de l'Agriculture – Ecole Nationale Supérieure, Agronomique de Montpellier (ENSA-M). CIRAD-EMVT (Montpeliier) – ILRI (Addis Abeba), 353 p.

Eyasu Siefu and Fekadu Beyene. 2000. Microbiological quality of raw and pasteurized goat's milk. Proceedings of the 7th annual conference of the Ethiopian Society of Animal Production (ESAP), 26-27 May, 1999, Addis Ababa, Ethiopia, pp. 410-418.

Fekadu Beyene. 1994. Farm-made dairy products in Southern Ethiopia: Fermented milk and cottage cheese. Awassa College of Agriculture, Awassa, Ethiopia. pp. 7-19.

Feng, P, Stephen, D. W. and Michael, A. G. 1998. Enumeration of *Escherichia coli* and the coliform bacteria. Bacteriological Analytical Manual on line, 8th Edition, Revision A. retrieved on June 11, 2006 at http://www.cfsan.fda.gov/~ebam/bam-4.html

IDF. 1987. Milk and milk products. Enumeration of microorganisms. International Dairy Federation (IDF). Standard 100A. Brussels, Belgium.

ILCA. 1993. The investigation of techniques and systems for milk processing and preservation. International Livestock Center for Africa (ILCA), Addis Ababa, Ethiopia.

Ingalls, W. 1998. Milk Quality and Factors Influencing the Production of High Quality Milk. West Agro, Inc., Kansas City. Retrieved on June 10 2006 at http://www.moomilk.com/archive/u-health-25.htm

Kalogridou-Vassiliadou, D. 1991. Mastitis-related pathogens in goat milk. *Small Rum. Res.* 4:203-212.

Kurwijila, R. L., Hansen, K. K., Macha, I. E., Abdalah, K. and Kadigi, H. I. S. 1992. Milk bacteriological quality in Morogoro dairy herd. *Afr. Livest. Res.* 2: 59-67.

Lampert, M. 1975. Modern Dairy Products. Food Trade Press Ltd., London.

Mahari Tetemke, Birhanu Abegaz Gashe. 1990. A survey of the microflora of raw and pasteurized milk and the sources of contamination in a milk processing plant in Addis Ababa, Ethiopia. J. Dairy Res. 57(2): 233-8.

Mogessie Ashenafi and Fekadu Beyene. 1993. Effect of container smoking and cleaning on the microflora and keeping quality of raw milk from a dairy farm in Awassa, Ethiopia. *Tropical Science* 33:368-376.

Mogessie Ashenafi. 1990. Microbiological quality of *Ayib*, a traditional Ethiopian cottage cheese. Int. J. Food Microbiol. 10: 261-268.

Mogessie Ashenafi. 1995. Microbial development and some chemical changes during the making of Irgo, a traditional Ethiopian fermented milk. *Bull. Anim. Hlth Prod. Afr.* 43: 171-176.

Mogessie Ashenafi. 2002. The microbiology of Ethiopian foods and beverages: A review. SINET: Ethiop. J. Sci. 25(1):97-140.

O'Connor, C. B. 1994. Rural dairy technology. ILRI training manual. International Livestock Research Institute (ILRI), Addis Ababa, Ethiopia, 133 p.

O'Mahoney, F. 1988. Rural dairy technology – experiences in Ethiopia. ILCA Manual No 4. International Livestock Center for Africa (ILCA), Addis Ababa, Ethiopia.

Omore, A., Arimi, S., Kaugethe, E., McDermott, J., Staal, S., Ouma, E., Odhiambo, J., Mwangi, A., Aboge, G., Koroti, E. and Koech, R. 2001. Assessing and managing milk-born health risks for the benefit of consumers in Kenya. Smallholder Dairy (R&D) Project (SDP), Nairobi, Kenya. 46 p.

Richardson, G. H. 1985. Standard methods for the analysis of dairy products. 15th edition. American Public Health Association, Washington, D.C., USA.

SAS. 2001. SAS User's guide version 8.2. Statistical Analysis System (SAS). Inc., Cary North Carolina, USA.

Savadogo, A., Ouattara, C. A. T., Savadogo, P. W., Barro, N., Ouattara, A. S. and Traore, A. S. 2004. Identification of exopolysaccharides-producing lactic acid bacteria from Burkina faso fermented milk samples. Afri. J. Biotechnol. 3(3): 189-194.

Tarik Kassaye, Simpson, B. K., Smith, J. P. and O'Connor, C. B. 1991. Chemical and microbial properties of Ititu. Milchwissensch. 46: 649-653.

Taye Tolemariam, Baars, R. M. T. and Fekadu Beyene. 2000. Evaluation of lactoperoxidase system for preservation of milk in Arsi highlands. Proceedings of the 7th annual conference of the Ethiopian Society of Animal Production (ESAP), 26-27 May, 1999, Addis Ababa, Ethiopia, pp. 160-166.

Teshager Semereab and Bayleyegn Molla. 2001. Bacteriological quality of raw camel *(Camelus dromedarius*) milk in Afar region (Ethiopia). *J. Camel Pract. Res.* 51: 51-54.

Tsehay Reda. 1998. Milk processing and marketing options for rural small-scale producers. Proceedings of the 6th National Conference of the Ethiopian Society of Animal Production (ESAP), May 14-15, 1997. Addis Ababa, Ethiopia, pp. 61-67.

Walstra, P., Geurts, T. J., Omen, A., Jellema, D. and Van Boekel, M. A. J. S. 1999. Dairy Technology: Principles of milk properties and processes. Marcel Dekker, Inc., New York.