Impact of capacity time and temperature on crude milk structure of dairy steers in tropical conditions

Muhammad Siddique Awan and Shahzad Akbar Khan

Research Institute on Environment and Agriculture (IN.E.R.A), 04 PO. Box 8645 Ouagadougou 04, Burkina Faso.

Abstract

Storage milk before reaching processing unit is a difficult step in tropical conditions. Milk samples of 240 mL each were collected from 50 lactating cows from November 2010 to March 2011 and stored at room temperature and at +4°C in the refrigerator at consecutive hours. Milk composition was determined using infrared spectroscopy (FMA 2001, Miris AB, Sweden). The data were subjected to analysis of variance and the least square means were compared using Tukey test at p< 0.05. Raw milk fat and protein contents were higher in evening than morning milk (p< 0.05). Milk fat was 3.12 ± 0.08 and 3.73 ± 0.08 % during morning and evening, respectively. It was similar for protein content, 2.77 ± 0.02 % and 3.39 ± 0.02 %. After 24 h at room temperature (+28-30°C), milk fat significantly decreases to 3.08 ± 0.02 %. At +4°C, milk fat was 3.69 ± 0.08% after 24 and 3.68 ± 0.08 %after 120 h storage time. It was concluded that, cooling milk at room temperature is completely discarded after 24 hours. However, +4°C was adapted to cool milk during four (04) days without any significant damage.

Keywords: Milk, composition, storage, temperature, time.

INTRODUCTION

The demand for dairy products is increasing in the urban areas due to population growth in most developing countries. The government of each country aims to set up several high capacity dairy units in order to increase milk processing. For example, in Burkina Faso, a dairy unit with processing capacity of 30,000 litres per day was set up at Koubri in the peri-urban area of Ouagadougou, capital of Burkina Faso. Providing raw milk to dairy processing unit recommends several farmers and collectors in most West and Central Africa cities.

The challenge is that, how to provide safety raw milk any time for the dairy unit for processing. Sometimes, dairy farms are located far from the cities and the dairy processor ought to set up collection center in order to stored milk for some hours before it reaches processing unit. It is well known that the rapid cooling is recommended on farm (Elrahman et al., 2013). It could

help the farmer to sale the safety product. It has been reported that poor milk quality has often been considered as one of the major reasons for losses and results in deduced income for the stallholder dairies (Lingathurai and Vellathurai, 2010).

In Burkina Faso as in most west and central Africa countries, milk production is slightly higher during the rainy season compare to dry season due to the peak calving period of dairy cows (Abeygunawardena and Dematawewa, 2004) and also during which period, natural green grasses is available on pasture (Sanon, 2007; Ouédraogo-Koné, 2008).

It appears how important is to organize and collect much quantity of milk when it is available. By doing this, many questions could be pointed out on how to storage milk in local conditions and then send it to dairy unit for processing. The high temperature in tropical climate is not favorable for long storage time of raw milk (Faye and

Loiseau, 2002). This question is important to be addressed and finding solutions on how to store raw milk and during which time, are also relevant.

It is well known that, there is a strong relationship between dairy products quality and the raw materials which has been used for processing. Different studies have been carried out to highlight how is important to store milk cool at optimal temperature (Bachman and Wilcox, 1990; Griffiths et al., 1988) and avoid contamination before processing (Fors bäck et al., 2010) and good storing conditions of dairy products (Faye and Loiseau, 2002).

According to previous studies (Faye and Loiseau, 2002, Sboui et al., 2009), most of bacteria grow up at +7°C and after. The development of bacteria slows down when the temperature becomes lower than +7°C. Furthermore, when the storage temperature decreases to +4°, the bacteria growth in milk slows down. Milk quality was better at +4°compare to +2°C storage temperature (Griffiths et al., 1988). Considering climate conditions of Burkina Faso similar to conditions of most tropical areas, very little researches were carried out in this area in order to help farmers and dairy processors.

The aim of the study was to investigate how raw milk reacts at different storage time and temperature and how farmers should store raw milk before it reaches dairy processing unit.

MATERIALS AND METHOD

Characteristics of Dairy Farms

The experiment was carried out from November 2010 to March 2011 in two similar semi-intensive peri-urban dairy farms of Bobo-Dioulasso. In general, the dairy cattle are mainly crossbreds' cows and the local breeds. The most spread local breed for milk production in Burkina Faso is the Zebu cattle (*Bos indicus*). Furthermore, natural reproduction and artificial insemination were practiced in both farms. Animals were veterinary treated and both farms regularly visited by veterinarian. The feeding system was based on grazing all year around with high complementary or additional feeding during the dry season. Cows were access to water ad-libitum on barn but could also drink water on pasture. The ingredients in the diets were cotton seed cake and other rice or maize bran. Most of calving took place in the rain season. Cows were milked twice a day, morning and evening. Calf was used for stimulation before milk person getting access to the udder for milking.

Milk Sampling

Fifty (50) dairy cows were included in the study and milk samples were taken from milking box of each individual cow. Twenty cows were identified from one farm and

thirty others in the second one. The sampling took place after morning and evening milkings in each farm. Morning milking took place at 06h00 and the evening at 16h30 in both farms. Individual box was assigned to each cow for milking. The tubes for sampling were cleaned and dried before sampling. At the end of each milking, 240 mL of milk was collected in small box and being divided into 8 aliquots of 30 mL and be identified according to cow identification number. Samples were then transport to the laboratory in a cool box at +10-12°C, and all samples reached the laboratory within one hour. Each aliquot was assigned to single conservation time at each specific temperature. One aliquot was assigned to be analyzed immediately after sampling the same day. This aliquot was considered as day one aliquot. Two aliquots were stored each at room temperature during 24 and 48 hours and being analyzed, respectively. The average room temperature during the study was between +29 and 31°C. The other aliquots were stored each in refrigerator at +4°C during, 24, 48, 72, 96 and 120 hours and being analyzed after each storage time.

Laboratory Analyses of Milk Samples

Milk samples were run at Research Laboratory for Training in Animal Health and Biotechnology (LA.R.E.S.B.A)/Institute of Rural Development/ Polytechnic University of Bobo-Dioulasso. Each milk sample was run once after storage time and temperature.

Determination of Milk Composition

The concentration of fat, protein, lactose, dry matter and solid-non-fat (SNF) in the milk was determined with mid infra-red spectroscopy (FMA 2001, Miris AB, Uppsala, Sweden). Milk pH was determined directly after sampling using a pH-meter (Jenway 370 pH-meter, European Union).

Alcohol and Heat Test

Milk heat test was carried out to check if milk samples could curdle at +100°C. This test has been done on hotplate (IKA®RET basic safety control, German) during five (05) minutes. Alcohol test was also carried out (alcohol ethylic at 75°) in order to compare with milk heat test.

STATISTICAL ANALYSIS

Normal distribution of data was tested according to Anderson-Darling's test. All included variables were found normally distributed.

The general linear model was used for analysis of variance (Minitab version 15) and Tukey's test was used for pair wise comparisons of least square means for the different levels of handling the milk. Differences were considered significant at $p < 0.05$. The results are presented as least square mean (LS Mean) ± standard error of mean (SEM).

Table 1. Morning and evening raw milk composition and after being stored at room temperature during 24 and 48 hours (N = 50).

Variables (%)	Morning raw milk	Evening raw milk	Morning 24 h milk	Evening 24h milk	Morning 48h milk	Evening 48 h milk
Fat	$3.12 \pm 0.08^{a}**$	$3.73 \pm 0.08^{a}**$	$2.77 \pm 0.24^{a}*$	$3.08 \pm 0.27^{a}*$	NA	NA
Protein	$3.49 \pm 0.04^{a}*$	$3.39 \pm 0.04^{a}*$	$3.58 \pm 0.12^{a}*$	$3.46 \pm 0.13^{a}*$	NA	NA
Lactose	$5.44 \pm 0.02^{a}*$	$5.39 \pm 0.02^{a}*$	$5.21 \pm 0.05^{a}*$	$5.29 \pm 0.10^{a}*$	NA	NA
DM	$13.27 \pm 0.15^{a}*$	$14.03 \pm 0.15^{b}*$	$12.63 \pm 0.45^{a}*$	$13.38 \pm 0.32^{b}*$	NA	NA
MM	$11.86 \pm 0.26^{a}**$	$12.36 \pm 0.31^{b}**$	$10.34 \pm 0.25^{a}*$	$11.29 \pm 1.10^{b}*$	NA	NA
PDM	0.00	0.00	85.18	89.81	100	100

h = hour; PDM (Percentage of damage milk); NA: damage and not analyzed. Least Square Means in the same column with different superscripts a*, b* and c* are statistically significant different at p < 0.05.

Table 2. Morning and evening milk stored in the refrigerator at +4°C during 24, 48, 72, 96 and 120 hours (N =50).

Variables (%)	24h Morning	24h evening	48h Morning	48h evening	72 h Morning	72h evening	96 h Morning	96h evening	120h Morning	120h evening
Fat	$3.06 \pm 0.08^{a}*$	$3.69 \pm 0.08^{b}*$	$3.07 \pm 0.09^{a}*$	$3.66 \pm 0.08^{b}*$	$3.00 \pm 0.09^{a}*$	$3.65 \pm 0.09^{b}*$	$2.90 \pm 0.09^{a}*$	$3.67 \pm 0.09^{b}*$	$2.99 \pm 0.08^{a}*$	$3.68 \pm 0.08^{b}*$
Protein	$3.42 \pm 0.04^{a}*$	$3.32 \pm 0.04^{a}*$	$3.40 \pm 0.04^{a}*$	$3.31 \pm 0.04^{a}*$	$3.40 \pm 0.04^{a}*$	$3.36 \pm 0.04^{a}*$	$3.39 \pm 0.04^{a}*$	$3.34 \pm 0.04^{a}*$	$3.43 \pm 0.04^{a}*$	$3.74 \pm 0.36^{a}**$
Lactose	$5.43 \pm 0.02^{a}*$	$5.39 \pm 0.02^{a}*$	$5.45 \pm 0.02^{a}*$	$5.33 \pm 0.03^{a}*$	$5.41 \pm 0.02^{a}*$	$5.31 \pm 0.02^{a}*$	$5.36 \pm 0.02^{a}*$	$5.26 \pm 0.02^{a}*$	$5.40 \pm 0.02^{a}*$	$5.39 \pm 0.02^{a}*$
DM	$13.14 \pm 0.15^{a}*$	$13.92 \pm 0.15^{b}*$	$13.15 \pm 0.15^{a}*$	$13.83 \pm 0.15^{b}*$	$12.89 \pm 0.16^{a}*$	$13.65 \pm 0.15^{b}*$	$12.79 \pm 0.16^{a}*$	$13.56 \pm 0.16^{b}*$	$13.04 \pm 0.15^{a}*$	$13.96 \pm 0.15^{b}*$
SNF	$11.74 \pm 0.26^{a}*$	$12.22 \pm 0.30^{b}*$	$11.77 \pm 0.25^{a}*$	$12.16 \pm 0.28^{b}*$	$11.83 \pm 0.29^{a}*$	$12.30 \pm 0.34^{b}*$	$11.71 \pm 0.29^{a}*$	$12.25 \pm 0.35^{b}*$	$11.67 \pm 0.24^{a}*$	$12.29 \pm 0.30^{b}*$
PDM	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

h = hour; PDM: Percentage of damage milk. Least Square Means in the same column with different superscripts a*, b* and c* are statistically significant different at p < 0.05.

RESULTS

Effect of Different Milk Storage Time and Temperature on Milk Composition

Milk protein, lactose and dry matter contents in raw milk were similar to those found in milk samples stored at room temperature and run after 24 hours (p> 0.05) when considering morning and evening milk separately. However, the concentration of dry matter and solid-non-fat were higher in raw milk than milk samples stored at room temperature and run after 24 hours (p< 0.05). Also, milk fat content of raw milk was higher than milk fat content found in milk samples stored at room temperature during 24 hours (p< 0.05). It has also been observed that milk fat and solid-non-fat contents decrease after 24 hours storing time (Table 1).

The results on milk samples stored at +4°C during 24, 48, 72, 96 and 120 hours showed that all milk samples were not denatured (Table 2). It was also found that milk fat, dry matter and solid-non-fat contents were higher for evening milks than morning milks after being stored at +4°C during 24, 48, 72, 96 and 120 hours (p< 0.05). However, milk protein and lactose contents of morning milks were slightly higher than those found in evening milks when stored at +4°C during 24, 48, 72, 96 and 120 hours respectively (p> 0.05).

The results showed that, the concentration of milk fat, protein, lactose, dry matter and solid-non-fat was slightly higher in evening milk than morning milk (Table 1). All milk samples stored during 48 hours at room temperature were denatured and not be run. The average room temperature during the study was +28.5 ± 1.9 °C in morning and +30.1 ± 2.0°C in evening. Room temperature variation was 3.76 %.

Table 3. Morning and evening raw milk pH and temperature and after being stored in the refrigerator at +4°C during 24, 48, 72, 96 and 120 hours (N= 50).

Variables	raw milk	A24h	A48h	Q24h	Q48h	Q72h	Q96h	Q120h
Morning milk pH	6.5 ± 0.01^a	5.2 ± 0.08^b	NA	6.5 ± 0.01^a	6.4 ± 0.01^a	6.5 ± 0.02^a	6.4 ± 0.01^a	6.4 ± 0.01^a
Morning milk T°C	31.3 ± 0.5^a	28.7 ± 0.2^b	NA	30.7 ± 0.7^a	30.4 ± 0.6^a	29.7 ± 0.8^a	30.9 ± 0.6^a	29.8 ± 0.6^a
Evening milk pH	64 ± 0.05^a	5.0 ± 0.07^b	NA	6.4 ± 0.01^a	6.4 ± 0.02^a	6.4 ± 0.01^a	6.4 ± 0.01^a	6.4 ± 0.01^a
Evening milk T°C	31.0 ± 0.4^a	29.7 ± 0.3^b	NA	30.2 ± 0.5^a	30.2 ± 0.6^a	29.1 ± 0.6^a	30.8 ± 0.7^a	30.7 ± 0.7^a

h = hour; NA: damage and not analyzed. LS Means in the same column with different superscripts a, b and c are statistically significant different at $p < 0.05$.

In the Table 2, it was found that milk fat content of morning milks decreased when stored at +4°C from 24 to 120 hours storing time without any difference ($p > 0.05$). In contrast, no significant variation was observed between different storing times at +4°C for milk fat content of evening milks. In morning milks, milk protein and lactose showed also no significant variation between different storing times at +4°C.

Effect of Storage Time and Temperature of Milk pH

In the current study, raw milk pH was 6.5, much higher to 5.2 found in milk stored at room temperature during 24 hours (Table 3). Morning and evening milk pH significantly decreased after 24 hours of storing time at room temperature. In contrast, when morning and evening milks was stored at +4°C, the variation of milk pH was more or less stable from 24 to 120 hours storing time.

Results of Alcohol and Heat Test

Alcohol and heat tests have been used to check how milk samples after being stored at room temperature and in the refrigerator at +4°C could react with alcohol (75°) and heat (+100°C during five (05) minutes). It was found that, all milk samples stored at room temperature were positive to both test and the number of clotted cream increased with storage time. In contrast, all milk samples stored in the refrigerator negatively react with alcohol and heat. However, when milk samples were left two (02) hours at room temperature, they positively react with alcohol and heat (+100°C during five (05) minutes.

DISCUSSION

Effect of Storage Time and Temperature on Milk Quality

- At room temperature

The results of the current study showed that milk quality completely decreased after being stored during 24 hours at room temperature. Morning and evening milks showed the same results, milk fat, proteins, lactose, DM and SNF contents decreased (Table 1). All milk samples stored during 48 hours at room temperature were completely denatured. Similar results have been found at +25°C in Algeria in dairy camel milk samples (Sboui et al., 2009).The higher room temperature (+28-30°C) contributes to decrease milk quality. The average milk temperature found by Millogo et al. (2008) was +30°C and considered to be high and favorable for microbes' rapid growth in milk. In practice, milk stored during 24 hours at room temperature could be used. After 24 hours storage time bacteria lactic grow up and decrease milk pH (Weber, 1985) and at that time milk is not able to be used for consumption. The practical advice for farmers from the current is that, it is not possible to mix raw milk or milk stored in refrigerator at +4°C with milk which has been stored at room temperature more than 24 hours.

Milk fat, proteins, lactose are the major components of raw milk. It was also found that milk fat and proteins contents were higher in evening milk than in morning milk. It closes to the finding which has been observed by Svennersten et al. (1997) and Millogo et al. (2009; 2010). Furthermore, the denatured milk samples were higher in evening milk than morning milk, which means that when milk quality is good, if the storage conditions are bad, that quality decreases more rapidly due the fact that microorganisms have more nutrients to also rapidly grow up.

Milk quality started to decrease after being stored at room temperature and at +4°C in the refrigerator. Milk pH decrease rapidly after 24 hours storage time which means that after 24 hours, it is not advisable to pasteurized milk or use it for consumption. Alcohol or heat tests were negative and could be used in tropical conditions to check milk quality easily, separate raw milk and which has been stored during 24 hours or more.

- At +4°C in the refrigerator

The finding in the current study was that, when milk was stored in the refrigerator at +4°C, milk fat, protein, lactose, dry matter and solid-non-fat contents decrease from 24 to 120 hours storing time. The current results are similar to what have been found by Sboui et al. (2009)

which study covered seven (07) days compare to five days in the current one. Furthermore, the same milk divided into aliquots was considered in the current study. The reason of why milk quality decrease was that even in refrigerator at +4°C, some bacteria called psychrophilic bacteria could grow up and destroyed milk. Those bacteria used nutrients in milk and decrease its quality (Weber, 1985). It is recommended for that reason to avoid as much as possible contamination of raw milk. More you have higher bacteria count in raw milk, more the quality is bad even when storing at +4°C in the refrigerator.

Raw milk could be stored at +4°C in the refrigerator during five (05) days. However, the advice is that, if milk is going to be pasteurized, two days storing time is recommended because the current results showed that after 72 hours, milk fat, protein and lactose contents started to decrease. In that case, if somatic cell count in raw milk was high, it could be worst to mix raw to milk stored during two (02) days.

Effect of Storage Time and Temperature on Milk pH

The average raw milk pH in this study was 6.5 in the range of pH found by different authors in tropical conditions (Millogo et al., 2008; Sraïri et al., 2009; Sboui et al., 2009). When milk was stored at room temperature, milk pH decreased immediately after 24 hours (Table 3). In contrast, when milk was stored in the refrigerator at +4°C, we found very little variation between milk pH from 24 to 120 hours of storage time. When milk is stored in the refrigerator at +4°C, the variation of milk pH is very slow.

CONCLUSION

The Main Findings from this Study were

Raw milk quality rapidly decreases at room temperature after 24 hours storage time in Burkina Faso. Five (05) days storage time at +4°C in the refrigerator had less effect on milk quality and very little variation was observed between milk fat, protein, lactose and dry matter contents between days.

It was concluded that raw milk could be stored at +4°C in the refrigerator during four (04) days without any significant damage of the product. However, in practice, do not mix raw milk with the one stored at +4°C more than 48 hours. Some bacteria such as psychrophilic bacteria could rapidly growth within days and denatured milk quality.

Since many farmers in tropical conditions have not access to the refrigerator, raw milk could be stored only 24 hours at room temperature. Microbiological assessment in the coming study could help for additional information on milk quality stored at room temperature and at +4°C in the refrigerator at consecutives hours.

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