Journal of Food and Nutrition Sciences
2024, Vol. 12, No. 3, pp. 127-137
https://doi.org/10.11648/j.jfns.20241203.11

SciencePG
Science Publishing Group

Research Article

Knowledge of Production Conditions and the Quality of Raw Milk Produced in Burundi

Iribagiza Albert[1, *], Niyonsaba Gérard[2], Munyaneza Napoleon[1], Ntunzwenimana Mélance[1]

[1]Research Center in Animal, Plant and Environmental Production Sciences, Department of Health and Animal Production, University of Burundi, Bujumbura, Burundi

[2]Ministry of the Environment, Agriculture and Livestock, National Veterinary Laboratory of Bujumbura, Bujumbura, Burundi

Abstract

In Burundi, despite the socio-economic importance and health impact of milk and dairy products, few researchers are interested in this sector. The few studies concerning the sector are related to the increase in the productivity of dairy cows. However, among all the actions that promote the development of the dairy sector, the improvement of the quality of dairy products constitutes an added value. In view of the above, the objective of this study is to know the production conditions and the quality of raw milk produced in the communes of Kayanza, Ngozi and Bubanza provinces and at the point of reception of raw milk of the Modern Dairy Burundi industry. To this end, a surveys were conducted in 40 dairy farms and carried out physico-chemical measurements on 84 samples of raw milk. The results revealed satisfactory hygiene in 40 farms monitored. The averages were: (i) fat: 46 ±4g / l, (ii) protein: 29.9 ±4.7g/l, (iii) pH: 6.7 ±0.07, (iv) density: 1.031 ±0.006 and (v) lactic acidity: 16.63 ±0.92 °D. The antibiotic residues were found in 9 of the 84 samples analyzed, 4 out of 84 samples were positive for alcohol test. It should be remembered that the presence of antibiotic residues in raw milk is an obstacle to processing, especially in the fermentation process. This study aims to contribute to the awareness of stakeholders to adopt good practices throughout the milk production chain in Burundi to better protect the health of consumers.

Keywords

Burundi, Production Condition, Quality, Raw Cow's Milk

1. Introduction

Raw milk is a highly nutritious product. The nutritional value of milk is linked to the physicochemical and organoleptic characteristics specific to each type of milk [1-8]. Therefore, milk production must be rigorously controlled due to the possible risks it may present for human health [4, 5, 9-11]. On a social level, in Burundi, as in most agropastoral communities, milk occupies an important place in customs. As a result, it constitutes one of the symbols of purity, abundance and hospitality [12-14].

In Burundi, milk produced locally comes from exclu-

*Corresponding author: iribagizaalbert@gmail.com (Iribagiza Albert)

Received: 11 April 2024; **Accepted:** 3 May 2024; **Published:** 17 May 2024

sively intensive production systems [15-19]. Indeed, the permanent stabilization put in place in recent years has led to a gradual abandonment of the extensive production system. This country is mountainous with very rugged terrain with production areas quite far from those of consumption. Consequently, the distribution circuits for locally produced milk can be relatively long given the means of transport which are, among others, on foot, by motorbike, by bicycle, by public transport cars or refrigerated trucks [20]. Added to this is the fact that a significant quantity of milk produced locally is consumed raw without any sanitation treatment [20]. From a health point of view, raw milk and its processing products are likely to naturally contain microorganisms potentially pathogenic for humans such as enteropathogenic *Escherichia coli*, *Staphylococcus aureus* and *Salmonella. spp.* [10, 21-23]. These flora, responsible for food poisoning, are capable of multiplying in milk and in certain poorly sanitized, poorly preserved or poorly packaged dairy products. Finally, other zoonotic bacterial agents such as mycobacteria, Listeria and brucella are also likely to be carried by raw milk [22, 23].

Problems related to quality management penalize producers, processors and consumers alike [20]. This is how in countries where the dairy sector is well organized, dairy producers and public authorities are organizing themselves to implement the quality approach in the sector. Common actions include zoo-sanitary measures such as active surveillance of tuberculosis and bovine brucellosis.

In Burundi, despite the socio-economic importance and health impact of milk and dairy products, few researchers are interested in this sector. The rare studies in the sector specifically concern increasing the productivity of dairy cows [13-19]. However, among all the actions that promote the development of the dairy sector, improving the quality of dairy products constitutes a certain added value for preserving public health which is fundamental [20].

1) The problem that arises is that the production conditions and quality of raw milk produced in Burundi are not known.
2) Research question:
   Are hygiene rules respected in the production and quality of raw milk produced in Burundi?
3) Assumption:
   The production conditions and quality of raw milk produced in Burundi respect hygiene rules.
4) The specific objectives of this study were:
   a) Characterize dairy farms and good hygiene practices in production and milk collection points;
   b) Evaluate the physicochemical indicators of the hygienic, technological and nutritional quality of raw milk produced in Burundi.

2. Material and Methods

2.1. Study Framework

This work took place from March to December 2021 in three provinces of Burundi including Ngozi, Kayanza and Bubanza (figure 1).

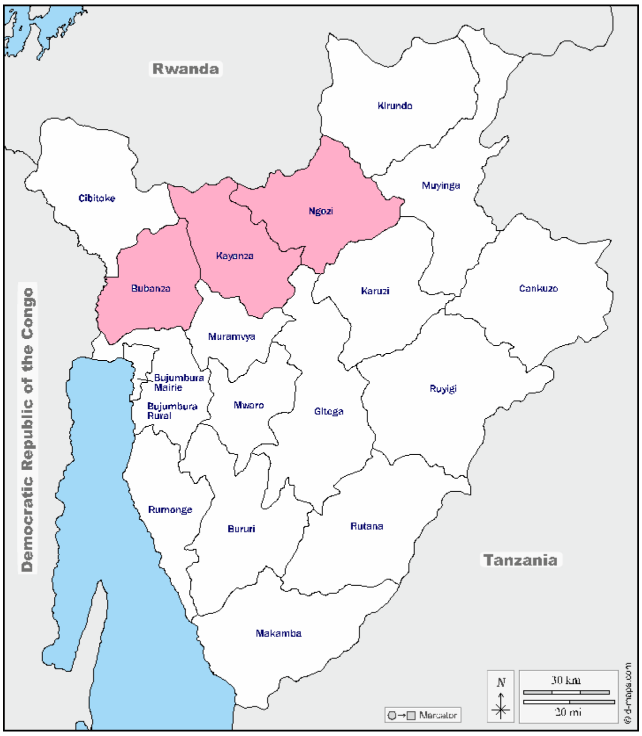

Figure 1. *Administrative map of Burundi [24].*

Burundi is a country located on the borders of Central and East Africa. Its surface area is 27,834 km^2 of which 25,000 km^2 are land. The country extends between 29.00 ° and 30.54 ° East and the parallel 2.20 ° and 4.28 ° South. Burundi is bordered to the north by Rwanda, to the southeast by the United Republic of Tanzania and to the west by the Democratic Republic of Congo. The political capital of Burundi is Gitega while the economic capital is Bujumbura Mairie. Burundi is 2,100 km from the Atlantic Ocean and 1,100 km from the Indian Ocean.

2.2. Material

2.2.1. Survey Material

The field survey materials consist of survey sheets, notepads and pens.

2.2.2. Biological Material

The biological material consists of 84 samples of raw milk collected from milk collection centers and the Moderne Dairy

Burundi (MDB) dairy processing plant.

2.2.3. Analysis Equipment

The analysis equipment is composed of equipment commonly used in milk recording laboratories under good laboratory practices. This material also depends on the targeted physico-chemical parameters.

2.3. Methods

This work was carried out in two phases, notably field missions to carry out investigations on dairy farms and at the Modern Dairy Burundi (MDB), the only modern dairy in Burundi. The second phase consisted of physicochemical analyzes of raw milk carried out at the collection center of milk (CCM), at the Moderne Dairy Burundi industry and at the National Veterinary Laboratory of Bujumbura.

2.3.1. Field Surveys

During the survey, two visits were carried out to 40 farms spread across eight communes (Rango, Gahombo, Muhanga, Busiga, Ngozi, Mwumba, Gashikanwa, Gihanga) in the provinces of Ngozi, Kayanza and Bubanza, with five farms dairy by municipality. The choice of these farms was based on certain following criteria:

1) breeding mainly for dairy cattle;
2) practice of permanent stabling;
3) agreement to take part in the study;
4) access facility.

During the surveys in dairy farms, the data collected depended on their sizes, feeding and watering practices, the condition and hygiene of the stables and that of milking and finally, the health of the dairy cows.. During these on-site investigations, certain physicochemical parameters (density, pH, temperature, alcohol test) were recorded on site while others (lactic acidity, defatted total solids, fat, protein dosage, lactose, minerals as well as the wetting and boiling test and the search for antibiotic residues) were measured or carried out in the MDB laboratory.

2.3.2. Sample Collection and Processing

The samples to be analyzed were taken aseptically and then placed in sterile bottles of approximately 250 ml. These samples were then sent directly to the laboratory under a positive cold regime (maximum 8℃) then aliquoted into as many parts as parameters to be measured.

2.3.3. Physico-Chemical Analyzes

(i). Temperature Measurement

The temperature was measured by immediately inserting the thermometer probe into the ladle containing the milk sample. The temperature is displayed on the thermometer screen (figure 2) held in a slightly inclined position.

Figure 2. *Food thermometer, LCD Digital Probe.*

(ii). Determination of Density

To measure the density of milk, it was used a lactodensimeter by proceeding as follows:

1) pour the milk into the test tube held tilted to avoid the formation of foam or air bubbles;
2) fill the test tube to a level such that the remaining volume is less than that of the lactodensimeter hull (it is convenient to mark this level by a gauge mark on the test tube);
3) introduce the lactodensimeter into the test tube full of milk to cause an overflow of liquid in order to rid the surface of the milk of traces of foam which hinder the reading;
4) place the test tube thus filled in a vertical position, it is recommended to immerse it in the bath at 20℃ when the temperature of the laboratory or the milk collection center is lower than 18℃ or higher than 22℃ since generally, the density of milk is measured at a temperature of 20℃;
5) gently immerse the lactodensimeter in the milk, keeping it in the axis of the test tube and turning it over as it descends until it is near its equilibrium position,
6) wait thirty seconds to one minute before reading the graduation.

The density reading is taken at the upper part of the meniscus, at the same time the temperature is measured on the lactodensimeter.

(iii). Determination of Titratable Acidity

The acidity titration was carried out with 0.1 N sodium hydroxide in the presence of a solution of phenolphthalein at 1% (m/v) in 95% ethanol; serving as a colored indicator. All reagents used were of analytical grade and the water used was distilled.

a. Procedure

The procedure was as follows:

1) Into a beaker, add 10 ml of milk, taken with a pipette, or 10g of milk, to the nearest 0.001g;
2) add four drops of the phenolphthalein solution to the

beaker;
3) titrate with 0.1N potassium hydroxide solution until it turns pink;
4) compare the color obtained with a control made from the same milk. it consider that the change is reached when the pink color persists for around ten seconds;
5) carry out at least two measurements on the same sample.

b. Expression of Results

The acidity (A) expressed in Dornic degree (°D), is given by the following formula:

$$A = V \times 10$$

where:

A: titratable acidity;

V: the volume in ml of the sodium hydroxide solution;

1 degree Dornic = 0.01% lactic acid.

(iv). pH Determination

* Calibrate the pH meter with the buffer solutions;

* Rinse the pH meter electrode with distilled water;

*Introduce the electrode into the beaker containing the milk to be analyzed, the temperature of which must be at 20 ℃.

Reading

The value indicated on the pH meter corresponds to the pH of the solution.

(v). Measuring Heat Stability of Milk

The heat stability of milk is measured through the boiling test and the alcohol *test.*

For the test boiling, 5 ml of milk are introduced into a test tube and placed in a Bain Marie at 100 ℃ for 5 minutes. After boiling, cool and rotate the tube two to three times without shaking. If the milk flows down the walls of the tube, without leaving traces of lumps, it is heat stable and if it leaves lumps, it is unsuitable for heat treatment.

Regarding the alcohol test, it mix an equal volume (2 ml) of milk and 75% ethyl alcohol in a test tube and observe whether there is flocculation or not. The test is said to be negative if no flocculation is observed for at least one minute.

(vi). Dosage of Fat, Defatted Solids, Proteins, Lactose and Mineral Salts

These parameters are determined directly using a chemical analyzer called Lactoscan (figure 3):

Figure 3. *Device for measuring the different constituents of "lactoscan" milk.*

The measurement of different parameters is done as follows:
1) introduce the quantity of milk to be analyzed into a beaker;
2) bring the beaker to the Lactoscan and dip the Latoscan electrode in the beaker then press the star button;
3) wait 2 minutes and 30 seconds for the device to absorb a quantity of the sample through a filter.

2.3.4. Testing for Antibiotic Residues in Milk

The search for antibiotic residues in milk was carried out using rapid immunoenzymatic methods (βeta star 25). This screening or semi-quantitative method is based on the use of a specific receptor linked to gold particles [25, 26]. It allows the rapid detection of beta-lactam residues (penicillins and cephalosporins) and tetracyclines in raw milk [26-28] below the Maximum Residue Limit.

Before starting, it is necessary to check the conformity of the milk by a rapid acidity determination test using reagent G. To do this, two (02) drops of the reagent are added to 5 ml of homogenized milk. The color obtained allows the milk to be classified as follows:
1) blue: fresh milk, compliant;
2) greenish: sour milk.

Once the conformity of the milk is verified, it was proceed to the antibiotic test by proceeding as follows (figure 4):
1) take a bottle out of the box;
2) take the raw milk from the bottle with the pipette;
3) put the bottle in one of the wells of the incubator stabilized at a temperature of 47.5 ℃, use a strip identified with the number of the tanker that transported the raw milk and the date of sampling;
4) insert the strip into the bottle and leave to incubate at

47.5 ℃;

5) five minutes after inserting the strip into the bottle, remove the strip and read immediately.

Figure 4. *Antibiotic residue detection kit “Receiver bottles”.*

Interpretation of the result:

1) no red band appears, the test is invalid;
2) the first band has an intensity greater than that of the reference band (figure 5), the sample is classified negative;
3) the first band has an intensity equivalent to or lower than that of the reference band, the sample contains antibiotics at a low concentration, it is classified as positive;

The first band is absent, the sample contains antibiotics at a high concentration, it is classified as concrete positive.

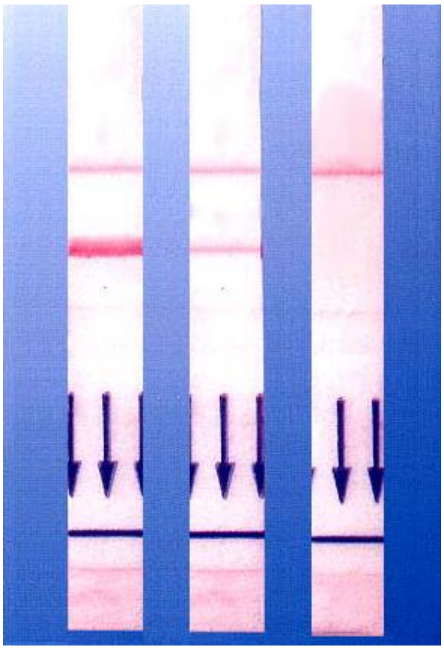

Figure 5. *Reference strips.*

2.4. Statistical Analysis of Results

The data collected was entered into Excel software then analyzed with R software. A descriptive analysis was carried out. The averages of the physical and nutritional values of raw milk found as well as their standard deviations were compared to reference values from the EAC and Codex Alimentarius.

3. Results and Discussion

3.1. Results

3.1.1. Characterization of Dairy Farms and Good Hygiene Practices in Production and Milk Collection Points

(i). Description of the Farms Monitored

The average size of cattle herds is 5.0 ± 2. The genetic structure of dairy cows is diverse. It is noted the presence of genetically improved and local breeds of cows. The improved breed cows come from a repopulation of cattle imported mainly from Uganda. All farms practiced cattle breeding or in association with other animals, notably sheep and goats, poultry (mainly chickens and geese).

Of the 40 cattle farms monitored, 32 farms have exclusively dairy farming and the other 8 have mixed production of milk and meat.

(ii). Feeding and Watering Practice

All animals on the farms surveyed were in permanent housing in accordance with the application of regulations for all breeding animals in Burundi. Water for drinking comes from rivers for 32 farms and from the public water distribution network for 8 farms. Regarding feed, it should be noted that 35 farms surveyed were characterized by the total absence of rationing practices based on a balanced diet. On 08 farms, the breeders removed the salt lick while some cows were pregnant.

(iii). Stable Hygiene During Milking

The livestock building is used for shelter and accommodation. The majority of the farms visited (97%) had enclosed housing compared to 3% of housing without fences. The enclosed buildings had rest areas, feeding areas, exercise areas and also a restraining box. Most of these buildings were made of concrete. Observations made in the field and discussions with breeders showed sufficient hygiene inside and around the stables in 80% of the farms visited. In half of the farms, dung evacuation was carried out daily, especially for concrete stables. The other farms evacuated the dung at least every two days. In all the farms, the bedding was made of wild grass straw, dried banana leaves but also rice straw. Overall, the level of hygiene of the farms monitored was satisfactory.

(iv). Dairy Cow Health and Milking Hygiene

Based on the information collected during the surveys on farms, it turned out that the health monitoring of dairy cows boiled down to the symptomatic detection of cows suffering from brucellosis, tuberculosis, inflammations and/or infections of the udder. This work was systematic and regular in 22 of the 40 farms monitored. Regarding milking, this was done manually. The milkers were men in 33 barns, 7 farms used women to milk the cows. Concerning milking hygiene, only 25 stables out of 40 units monitored used soapy water to clean the udders and quarters. The others only used water. Udder flushing was carried out in 3% of farms. On the farm, the milk collected was kept in plastic buckets or plastic recovery cans or stainless steel jugs. The milking utensils consisted of a calabash, an aluminum ladle and a basin. They were cleaned with soapy water. The major problem would lie in the quality of the water used which was not controlled. Likewise, the suitability of the equipment used for cleaning and disinfection left much to be desired. The milking containers were used to receive the milk while they still contained the rest of the water. After milking, the milk was filtered using a sieve to retain foreign bodies (hair, dried dung or hair) before being delivered to consumers. The milk did not undergo any sanitation treatment apart from sieving while the condition of the sieve was not satisfactory. The cold chain was also not respected in any operation.

Evaluation of physicochemical indicators of the hygienic, technological and nutritional quality of raw milk produced in Burundi

3.1.2. Physical Indicators of Raw Milk

The physical parameters of raw milk are shown in table 1

Table 1. Physical parameters of raw milk.

Indicators	Average	Standard deviation
CCM temperature (℃)	29.89	±1.21
MDB temperature (℃)	4	-
pH	6.67	±0.07
Dornic Acidity (°D)	16.63	±0.92
Density	1.031	±0.006

3.1.3. Nutritional Indicators of Raw Milk Analyzed

The average fat content was 46±5g/l.

Regarding the average protein content of the 84 samples analyzed, it was 29.9±4.7g/l.

3.1.4. Testing for Antibiotic Residues in Raw Milk

The result of antibiotic residues in raw milk is also shown in table 2 and table 3.

Of the 84 samples; 09 samples were positive in the test for antibiotic residues, for a positivity rate of 9.33%.

Table 2. Sensitivity of Delvotest SP NT according to AOAC approval.

Antibiotics	Sensitivity	Antibiotics	Detection sensitivity
Amoxiclline	2.5 ppb	Cephapirin	5.8 ppb (ng /g)
Ampicillin	3.0 ppb	Penicillin G	1.5 ppb (ng /g)

Table 3. Sensitivity - BETASTAR S Combo Test Detection Levels in ppb (parts per trillion).

Antibiotics	European Maximum Limits (EU-MRL)	Detection level
Tetracycline	100	45
Doxycycline	-	50
Oxytetracycline	100	50

3.2. Discussion

3.2.1. Characterization of Dairy Farms and Good Hygiene Practices in Production and Milk Collection Points

On dairy farms, there is no appropriate medical monitoring of dairy females. No breeder had a prophylaxis or surveillance program for tuberculosis, brucellosis and mastitis. Milking was manual and the use of the cold chain was little known. In addition, the farms were in a poor state of hygiene with frequent presence of dung and dust. The absence of quality water can also be a factor in milk contamination on farms. Dairy dishes must be clean or even disinfected.

No milker was subject to medical monitoring and the wearing of work clothing was also not compulsory during the milking operation. These same milkers are unaware of the hand cleaning technique. This washing must in fact be done correctly by wetting, soaping the hands and rubbing them together before rinsing and drying them [29-31].

The breeding and milking practices described are likely to negatively influence the quality and safety of milk. Thus, these poor dietary practices are all the more dangerous since the feeding and watering of breeding animals in general and dairy cows in particular conditions the health state and the level of productivity (in quantity and in quality) of the animal [29-31]. Added to this are the low technical and operational capacities of producers as well as the absence of official controls in the milk sector. These findings are similar to those of Mali, Cameroun and Chad [29-31].

3.2.2. Evaluation of Physicochemical Indicators of the Hygienic, Technological and Nutritional Quality of Raw Milk Produced in Burundi

The average temperature measured at the milk collection center was 29.89 ±1.21 ℃ while that measured at Modern Dairy Burundi whose milk was refrigerated at 4 ℃.

The average pH after transport to the milk collection centers was 6.67±0.07. The pH value reported in this study is located in the range of 6.6 and 6.8 which characterizes normal and stable milk [1] and is close to those of Gaddour *and al.* [2] with a pH equal to 6.7, Bedjera *and al.* reported a pH of 6.67 [32] and Maïwore *and al.* (pH= 6.67-7,67) [31]. On the other hand, it is slightly higher than that found by Bedjera *and al.* (pH=6.34) [32], Saidane *and al.*(pH=6,46) [33], Sboui *and al*.(6,56) [34] and Benbrahim *and al.* (pH=4,82-5,91) [5] in Algerie. But the pH is lower than that found by Raounek (pH= 6,95-7,77) [35]. The pH as well as the taste of the milk can depend on the nature of the fodder, genetics, the health status of the animal and the availability of water.

The average Dornic acidity was 16.63±0.92 °D. This acidity value is lower than other values previously found by Benbrahim *and al*. (19-23 °D) [5], Elhadj *and al.*(18-20 °D) [36], Raounek *and al.* (17,5 °D) [35] and Bedjera *and al.*(20,33+/-1,11) [32] and different from the Maïwore *and al.* value (18,70 and 26,72 °D) [31] in Cameroun. This high value would indicate a significant development of the lactic flora. The pH and acidity depend on the content of casein, mineral salts and ions, hygienic conditions during milking, the total microbial flora and its metabolic activity and the milk handling reported by Sboui *and al* [34].

The average density measured was 1.031±0.006. This value is in the range of 1.028 to 1.033, indicating that the milk had not been wet and that its fat content is normal. The density obtained is comparable to that found by Maïwaro *and al.*, Amira and Elhouda, Elhadj *and al.*, and Saidane *and al.* (1.03) [1, 31, 33, 36] and also slightly higher than that found by Gaddour *and al.* in Tunisie, Sboui *and al*. (1,028) [2, 34], and Benbrahim (1,025-1,040) [5]. The density of milk essentially depends on the fat content influenced by the diet of dairy cows reported by Benbrahim *and al.*, Gaddour *and al.* and Amira and Elhouda [1, 2, 5].

The average fat content was 46±5g/l. The value found in this study is higher than that found by Benbrahim (31,38±0,833g/l) [5] but it is lower than those obtained by Gaddour *and al.* (22,5 g/l) [2], Elhadj *and al*.(34g/l) [36], Sboui *and al*.(32,5g/l) [34] and Saidane *and al.* (31.03g/l) [33]. This variability could be explained by the difference in dietary practices reported as by Benbrahim *and al*. and Sboui *and al.* [5, 34].

Regarding the average protein content of the 84 samples analyzed, it was 29.9±4.7g/l. This content is lower than that of Benbrahim *and al.* (32±0,099g/l) [5], Saidane *and al.* (30.5g/l) [33]. Thus, the fat and protein levels constitute indicators of milk quality. However, they vary from one breed to another reported by Benbrahim *and al.* and Amira and Elhouda [1, 5]. Indeed, Holstein milk has, on average, a fat content of 39.7 per 1,000 and a nitrogen content of 31.9 per 1,000 (in grams per kilogram); while that of Normandy is on average 42.8 per 1,000 and a nitrogen content of 34.5 per 1,000. This second breed is less productive in quantity but its richer milk is sold more expensive and is appreciated for cheese production. These rates vary depending on the breed and different factors, notably diet and the lactation period.

During research for antibiotic residues in raw milk it was noted the use of antibiotics in lactating cows leading to the absence of milking for a specific period of time. It was noted the presence in milk of ampicillin, amoxicillin, cephapirin, pinicillinG, tetracycline, doxycycline, oxytetracycline. Of the 84 samples, 09 samples were positive in the test for antibiotic residues, for a positivity rate of 9.33%. The absence of strict control procedures for accessing antibiotics, and prescription by a veterinary doctor not being a requirement for the sale of antibiotics, create a high risk in the field of distribution of anti-infectious products in the health sector livestock breeding in Burundi. Wissem and Soumia found the presence of Bêta-lamines and tetracyclines in raw milk in Algerie. Of the 117 samples, 9,09% of samples contained the antibiocs residues [27]. That result is comparable with us. In Mauritania, Razak found high levels of tetracycline (Terramycin) residues in 2012. Of the 54 milk samples tested, 6 (11%) were positive [37]. That study has been carried in the dry saison where the animal's feed are non-enough in quantity and quality. Thus, the farmers use many veterinary products in order to complement the animal's feed. Also, in Mali, Bonfoh found a high value of antibioc residue in cow milk (16, 7%) [38]. These results are because farmers practice self-medication, exposing consumers to the risk of antibiotic residues in foodstuffs of animal origin. They also fail to respect waiting periods and prescribed doses [37, 38].

3.2.3. Limitation of the Study

This study is preliminary. It is also limited in space (only 3 provinces out of 18) and was approached without funding.

3.2.4. Outlook

In perspective, it is advised that other researchers address the data related to age, race, sex, number and stage of lactation and if possible extend it to other provinces in order to make a comparison.

4. Conclusion

This work reviewed on the one hand, the conditions of production of raw cow's milk at the level of dairy farms in Burundi and on the other hand analyzed 84 samples of raw milk taken at the collection centers of the 3 Provinces Kayanza, Ngozi and Bubanza and at the Modern Dairy Burundi industry reception point.

The field surveys concerned forty (40) dairy farms, six (06) collection centers, one (01) private dairy processing unit. From the results obtained, it appears that the average size of the farms was 5.0 ±2 dairy cows. It was noted that 35 out of the 40 farms did not practice rationing which takes into account a balanced diet. Eight (8) breeders out of the forty (40) do not provide salt licks for pregnant cows. Field surveys revealed that the implementation of the quality approach in the milk sector is almost non-existent. On dairy farms, there is no appropriate medical monitoring of dairy females. No breeder had a prophylaxis or surveillance program for tuberculosis, brucellosis and mastitis. Milking was manual and the use of the cold chain was little known.

In addition, the farms were in a poor state of hygiene with frequent presence of dung and dust. The absence of quality water can also be a factor in milk contamination on farms. Dairy dishes must be clean or even disinfected.

It is recommended throughout the raw milk collection circuits to have a cold chain. Likewise, dietary supplementation and compliance with prophylactic schedules are necessary to improve the quality of raw milk.

The results of physicochemical analysis and antibiotic residus of the milk allowed us to assess the quality of raw milk. The average fat was 46 ±4g/l which is within a normal limit according to East African state standards (≥34 g/l), the pH was 6.7±0.07 while the African Community standard is 6.6 - 6.8, the average density was 1.031±0.006 while the EAC standard is between 1.028-1.034. The average lactic acidity is 16.63 ±0.92 °D while the EAC standard is between 14-18. Antibiotics were found in 9/84 milk samples. A sample is rejected when an antibiotic is found in it. For this study, the alcohol test was positive for 4 of the 84 samples.

This study aims to contribute to the awareness of stakeholders to adopt good practices throughout the milk production chain in Burundi to better protect the health of consumers.

Abbreviations

PB: Postal Box
CCM: Collect Center of Milk
EAC: East Africa Community
pH: Potential of Hydrogen
g: Gram
l: Liter
°D: Dornic Degree
°C: Celsius Degree
MDB: Modern Dairy Burundi
EU-MRL: European Maximum Limits
AOAC: Association of Official Agricultural Chemists

Acknowledgments

Authors thank the team of the national veterinary laboratory of Bujumbura, that of the Modern dairy Burundi laboratory, the breeders with the municipal veterinary technicians for agreeing to participate in this study and the University of Burundi.

Author Contributions

Iribagiza Albert: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Resources, Software, Validation, Visualization, Writing - original draft, Writing - review & editing

Niyonsaba Gérard: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Resources, Software, Validation, Visualization

Munyaneza Napoleon: Conceptualization, Formal Analysis, Methodology, Supervision, Validation, Visualization, Writing - review & editing

Ntunzwenimana Médance: Funding acquisition, Project administration, Supervision, Validation

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Amira T, Elhouda SN. Étude des caractéristiques physico-chimiques du lait cru provenant de quatre espèces animales dans une région aride [Study of the physico-chemical characteristics of raw milk from four animal species in an arid region]. [Internet] [Mémoire de master 2]. [Algérie]: Université Mohamed Khider de Biskra; 2023 [cité 6 avr 2024]. Disponible sur: http://archives.univ-biskra.dz/bitstream/123456789/27655/1/TOUIR_Amira_SALHAOUI_Nour_Elhouda.pdf

[2] Gaddour A, Najari S, Abdennebi M. Caractérisation physico-chimique du lait de chèvre et de vache collecté localement dans les régions arides de la Tunisie [Physicochemical characterization of locally collected goat and cow's milk in arid regions of Tunisia]. 2013; (108).

[3] RENIFFI M. Détermination des principales caractéristiques physico-chimiques et microbiologiques des laits de vache de 4 fermes de la région sud-ouest de la wilaya de Tizi Ouzou [Determination of the main physico-chemical and microbiological characteristics of cow's milk from 4 farms in the south-western region of the wilaya of Tizi Ouzou] [Internet] [PhD Thesis]. 2023 [cité 6 avr 2024]. Disponible sur: http://dspace.ensa.dz:8080/jspui/handle/123456789/3660

[4] Aimeur R, Boussena S, Hireche S, Bouchoucha B, Zeghilet N, Bouaziz O. Appréciation de la qualité physico-chimique et hygiénique du lait cru de collecte au niveau de 2 laiteries [Assessment of the physico-chemical and hygienic quality of raw milk collected at 2 dairies.] [cité 6 avr 2024]; Disponible sur: http://archives.umc.edu.dz/handle/123456789/13005

[5] Benbrahim A, Kiache A, Kebir B, Nani A/ promoteur. Etude de La qualité physico-chimique, organoleptique et hygiénique du lait cru de vache produit et commercialisé dans la Région d'ADRAR [Study of the physico-chemical, organoleptic and hygienic quality of raw cow's milk produced and marketed in the ADRAR Region] [Internet] [Thesis]. UNIVERSITE AHMED DRAIA- ADRAR; 2023 [cité 5 avr 2024]. Disponible sur: https://dspace.univ-adrar.edu.dz/jspui/handle/123456789/8978

[6] Djellouli K, Merzougui N, MEKHATI M. Qualité physico-chimique du lait cru de vaches de quelques exploitations laitières de la wilaya d'Ain Defla [Physico-chemical quality of raw milk from cows from some dairy farms in the wilaya of Ain Defla]. 2022 [cité 6 avr 2024]; Disponible sur: http://dspace.univ-km.dz/xmlui/handle/123456789/5663

[7] Hamdi H. Effet de la saison sur la qualité physico-chimique du lait cru des vaches [Effect of the season on the physico-chemical quality of raw cow milk]. 2013 [cité 6 avr 2024]; Disponible sur: https://dspace.univ-guelma.dz/xmlui/handle/123456789/1859

[8] Miguiri K, Adama S, GUIGMA WVH, ZABRE M, BATHILY A, SAWADOGO G. Evaluation de la qualité nutritionnelle du lait cru dans les élevages traditionnels de Kaolackau Sénégal [Evaluation of the nutritional quality of raw milk in traditional livestock farms in Kaolack, Senegal]. International Journal of Biological and Chemical Sciences. 1 juill 2015; 9: 901-9.

[9] MAHOUZ F. Suivi et évaluation de la qualité hygiénique du lait de vache dans la région de TIARET [Monitoring and evaluation of the hygienic quality of cow's milk in the TIARET region]. [Internet] [PhD Thesis]. Tiaret; 2007 [cité 6 avr 2024]. Disponible sur: https://www.ccdz.cerist.dz/admin/notice.php?id=00000000000000532592000000

[10] Park YK, Koo HC, Kim SH, Hwang SY, Jung WK. The Analysis of Milk Components and Pathogenic Bacteria Isolated from Bovine Raw Milk in Korea - ScienceDirect [Internet]. 2007 [cité 13 janv 2023]. Disponible sur: https://www.sciencedirect.com/science/article/pii/S0022030207720131

[11] Sauvant D, Schmidely P. La maîtrise de la composition et de la qualité du lait à la ferme [Control of the composition and quality of milk on the farm]. Bulletin de l'Académie Nationale de Médecine. 1 avr 2008; 192(4): 693-702.

[12] Manirakiza J. Paramètres génétiques des ruminants et typologie socioéconomique des élevages en milieu rural Burundais [Genetic parameters of ruminants and socio-economic typology of livestock farming in rural Burundi]. 2020 [cité 6 avr 2024]; Disponible sur: https://orbi.uliege.be/handle/2268/243694

[13] Manirakiza J, Hatungumukama G, Besbes B, Detilleux J. Characteristics of smallholders' goat production systems and effect of Boer crossbreeding on body measurements of goats in Burundi. Pastoralism: Research, Policy and Practice [Internet]. 2020 [cité 15 mars 2022]; 10(2). Disponible sur: https://search.ebscohost.com/login.aspx?direct=true&db=lah&AN=20203319172&site=ehost-live

[14] Manirakiza J, Moula N, Detilleux J, Hatungumukama G, Antoine-Moussiaux N. Socioeconomic assessment of the relevance of a community-based goat breeding project in smallholding systems. Animal [Internet]. 2021 [cité 15 mars 2022]; 15(1). Disponible sur: https://search.ebscohost.com/login.aspx?direct=true&db=lah&AN=20210148296&site=ehost-live

[15] Hatungumukama G, Hornick JL, Detilleux J. Aspects zootechniques de l'élevage bovin laitier au Burundi : présent et future [Zootechnical aspects of dairy cattle farming in Burundi: present and future] [Internet]. 2007 [cité 29 mars 2022]. Disponible sur: http://www.facmv.ulg.ac.be/amv/articles/2007_151_3_02.pdf

[16] Hatungumukama G, Hornick JL, Detilleux J. Effects of non genetic and crossbreeding factors on daily milk yield of Jersey × Sahiwal × Ankole cows in Burundi. Journal of Animal and Veterinary Advances. 2009; 8(4): 794-8.

[17] Hatungumukama G, Leroy PL, Detilleux J. Effects of non-genetic factors on daily milk yields of Friesian cows in Mahwa Station (South Burundi). Revue d'Élevage et de Médecine Vétérinaire des Pays Tropicaux. 2008; (No.1): 45-9.

[18] Hatungumukama G, Detilleux J. Estimation of genetic and crossbreeding parameters for daily milk yield of Ayrshire × Sahiwal × Ankole crossbred cows in Burundi. Livestock Science. 2009; 122(2/3): 359-62.

[19] Hatungumukama G, Sidikou DI, Leroy P, Detilleux J. Effects of non-genetic and crossbreeding factors on daily milk yield of Ayrshire × (Sahiwal × Ankole) cows in Mahwa station (Burundi). Livestock Science. 2007; 110(1/2): 111-7.

[20] Iribagiza A. Evaluation du niveau de mise en oeuvre de démarche qualité dans la filière lait au Burundi [Evaluation of the level of implementation of a quality approach in the dairy sector in Burundi] [Thèse de médécine vétérinaire]. [Dakar. Sénégal]: Université Cheikh Anta Diop de Dakar; Ecole Inter-Etats des Sciences et Médecine Vétérinaire de; 2019.

[21] Michel V, Hauwuy A, Chamba JF. La flore microbienne de laits crus de vache : diversité et influence des conditions de production [The microbial flora of raw cow's milk: diversity and influence of production conditions]. Lait. sept 2001; 81(5): 575-92.

[22] Kurawige D. CONTRIBUTION A LA CONNAISSANCE DES MALADIES TRANSMISES PAR LES ALIMENTS ET DES MOYENS DE LEUR MAÎTRISE [CONTRIBUTION TO THE KNOWLEDGE OF FOODBORNE DISEASES AND THE MEANS OF THEIR CONTROL] [Thèse de médécine vétérinaire]. [Dakar. Sénégal]: Université Cheikh Anta Diop de Dakar; Ecole Inter-Etats des Sciences et Médecine Vétérinaire de Dakar; 2014.

[23] Kapoor S, Goel AD, Jain V. Milk-borne diseases through the lens of one health. Front Microbiol. 6 avr 2023; 14: 1041051.

[24] Reference map of Burundi - Administrative (provinces) - Burundi | ReliefWeb [Internet]. 2004 [cité 9 avr 2024]. Disponible sur: https://reliefweb.int/map/burundi/reference-map-burundi-administrative-provinces

[25] Gaudin V. Caractérisation de la performance et validation des méthodes de dépistage des résidus d'antibiotiques dans les denrées alimentaires [Performance characterization and validation of methods for the detection of antibiotic residues in foodstuffs]. 2016.

[26] Denhartigh A, Reynolds L, Palmer K, Klein F, Rice J, Rejman JJ, et al. Validation of the BetaStar® Advanced for Beta-lactams Test Kit for the Screening of Bulk Tank and Tanker Truck Milks for the Presence of Beta-lactam Drug Residues. J AOAC Int. 1 nov 2018; 101(6): 1813-27.

[27] Wissem M, Soumia B. Recherche des résidus d'antibiotiques dans le lait cru de vache et de chèvre [Research for antibiotic residues in raw cow and goat milk] [Mémoire de master 2]. [Algérie]: Université BLID-1; 2017.

[28] Bessadi M, Berkane A. Recherche de résidus d'antibiotiques dans le lait cru d'origine bovine [Testing for antibiotic residues in raw milk of bovine origin] [Internet] [PhD Thesis]. Université Mouloud Mammeri; 2023 [cité 6 avr 2024]. Disponible sur: https://dspace.ummto.dz/items/6a2d72bf-db01-48fe-8a49-87ec09bb9e8a

[29] Mahamat MB. Amélioration de l'hygiène dans la chaîne de production laitière par utilisation du matériel approprié et une meilleure technique de nettoyage et de désinfection Cas de la laiterie traditionnelle «Total» à N'Djamena (Tchad) [Improvement of hygiene in the dairy production chain through the use of appropriate equipment and better cleaning and disinfection techniques Case of the traditional dairy "Total" in N'Djamena (Chad)] [memoire de master]. [Dakar. Sénégal]: Université Cheikh Anta Diop de Dakar; Ecole Inter-Etats des Sciences et Médecine Vétérinaire de; 2006.

[30] Organisation des Nations Unies pour l'alimentation et l'agriculture, Fédération internationale de laiterie, éditeurs. Guide de bonnes pratiques en production laitière [Guide to Good Practices in Dairy Production]. Rome: FAO; 2012. (FAO production et santé animales).

[31] Maïworé J, Baane MP, Amadou AT, Ouassing AD, Ngoune LT. Influence des conditions de la traite sur les qualités physico-chimiques et microbiologiques du lait cru collecté à Maroua [Influence of milking conditions on the physico-chemical and microbiological qualities of raw milk collected in Maroua], Cameroun. 2018.

[32] BEDJERA M, BENAISSA A, BABELHADJ B. L'évaluation et comparaison de la qualité physico-chimique du lait cru et du lait conservé selon différents modes [Evaluation and comparison of the physico-chemical quality of raw milk and preserved milk according to different modes] [Internet] [PhD Thesis]. UNIVERSITE KASDI MERBAH OUARGLA; [cité 6 avr 2024]. Disponible sur: https://dspace.univ-ouargla.dz/jspui/handle/123456789/35429

[33] SAIDANE Z, HOMRANI M, DAHOU AE, BOUABSA FS, HOMRANI A. Pratiques d'élevage dans une ferme laitière à Hassi-Mameche et leurs impacts sur les paramètres physico-chimiques et microbiologiques du lait [Husbandry practices on a dairy farm in Hassi-Mameche and their impacts on the physicochemical and microbiological parameters of milk]. 2023 [cité 6 avr 2024]; Disponible sur: https://www.researchgate.net/profile/Zohra-Saidane/publication/370104586_Pratiques_d'elevage_dans_une_ferme_laitiere_a_Hassi-Mameche_et_leurs_impacts_sur_les_parametres_physico-chimiques_et_microbiologiques_du_lait/links/643f72bb2eca706c8b6b8367/Pratiques-delevage-dans-une-ferme-laitiere-a-Hassi-Mameche-et-leurs-impacts-sur-les-parametres-physico-chimiques-et-microbiologiques-du-lait.pdf

[34] Sboui A, Khorchani T, Djegham M, Belhadj O. Comparaison de la composition physicochimique du lait camelin et bovin du Sud tunisien; variation du pH et de l'acidité à différentes températures [Comparison of the physico-chemical composition of camel and bovine milk from southern Tunisia; variation of pH and acidity at different temperatures.]. Afrique Science: Revue Internationale des Sciences et Technologie [Internet]. 2009 [cité 13 janv 2023]; 5(2). Disponible sur: https://www.ajol.info/index.php/afsci/article/view/61744

[35] Raounek A, Djenadbia Randa GA, Hassina R. Etude physico-chimique et bactériologique du lait de vache [Physico-chemical and bacteriological study of cow's milk] [Internet]. SNV. STU; 2022 [cité 6 avr 2024]. Disponible sur: https://dspace.univ-guelma.dz/jspui/handle/123456789/13771

[36] Elhadj T, Samira B, Messaouda H, Nassira B. Etude de la qualité physico-chimique et microbiologique de laits crus de vache dans deux fermes de la wilaya de Tissemsilt (Algérie) [Study of the physico-chemical and microbiological quality of raw cow's milk in two farms in the wilaya of Tissemsilt (Algeria)]. Revue ElWahat pour les Recherches et les Etudes. 2015; 8(2): 26-33.

[37] Razak IGA. Evaluation des pratiques d'utilisation des médicaments vétérinaires et détermination de la prévalence des résidus d'antibiotiques dans la viande et le lait dans le Gorgol en Mauritanie [Evaluation of the practices of use of veterinary drugs and determination of the prevalence of antibiotic residues in meat and milk in Gorgol in Mauritania] [memoire de master]. [Dakar. Sénégal]: Université Cheikh Anta Diop de Dakar; Ecole Inter-Etats des Sciences et Médecine Vétérinaire de; 2012.

[38] Bonfoh B, Dem S, Keita O, Delorenzi S, Traore H, Simbe CF, et al. Assessment of antibiotic residues by microbial inhibitor tests in fresh cow milk sold in Bamako (Mali). Milchwissenschaft. 1 janv 2003; 58(5-6): 304-7.