

EVALUATION OF THE PHYSICOCHEMICAL AND HYGIENIC QUALITY OF COW'S MILK AND ITS DERIVATIVES IN EL JADIDA CITY, MOROCCO

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ABSTRACT

Background. Despite the efforts and investments made for traceability and the guarantee of a fair and safe milk product, the informal sector threatens the safety of milk. In fact, during this circuit, the product does not undergo any treatment and therefore presents serious risks for the health of the consumer. In this context, studies have been carried out on samples of peddled milk and products derived from it.

Objective. The purpose of this study is to evaluate the relevance of the informal circuit in Morocco's Doukkala region (El Jadida Province) by physicochemical and microbiological investigation of raw milk and its derivatives at various points of sale.

Materials and method. 84 samples were taken between (23 for raw milk, 30 for the «Lben», and 31 for the «Raib») between January 1st, 2021 and October 30th, 2021. According to Moroccan rules, microbiological analyses revealed an extremely high non-compliance rate in most samples obtained at the level of outlets situated in the El Jadida region, with a non-compliance ratio of 65 percent for raw milk sold, 70 percent for the «Lben», and 40 percent for the «Raib».

Results. Likewise, these analyses revealed that majority of the samples did not fulfill international criteria for the pH values of raw milk samples «Lben» and «Raib», which are respectively between 5.85 and 6.71; 4.14 and 4.43 and 4.5. Other characteristics, including lactose, proteins, fat, mineral salts, density, and additional water, have also yielded results.

Conclusion. This has allowed us to analyze the major impact of the peddling circuit at the regional level, which is a risk factor for consumer health.

Key words: *points of sale, surveys, informal circuit, milk and its derivatives, physicochemical and hygienic quality, Doukkala.*

INTRODUCTION

Milk is a white, opaque, slightly sweet liquid that is produced by the mammary glands of humans as well as other female animals for the nourishment of their offspring [1]. It includes the majority of the elements necessary for the growth and maintenance of the body's activities (calcium, proteins, vitamins and fats). Milk and dairy products, are the most consumed food products in many countries, and provide a favorable environment for the growth of many microorganisms due to their richness in macro- and micronutrients [44]. Nevertheless, it is an impressive growth medium for a wide variety of microorganisms, including pathogenic bacteria. Thus, fermented milk (Lben and

Raib) is a dairy product created from the fermentation of milk, with or without composition adjustment, by the activity of suitable microorganisms, resulting in a pH lowering [15]. Because of the possible threats to human health, the hygienic and physicochemical quality of milk and its derivatives must be strictly monitored. Hawkers sell a considerable portion of the raw milk produced in the El Jadida area. This informal milk marketing circuit accounts for 25 to 30 percent of the milk consumed in various Moroccan cities [5, 47]. Furthermore, raw milk that has not been sterilized may include bacteria from the genera *Salmonella sp.*, *Escherichia coli*, *Staphylococcus aureus*, and *Listeria monocytogenes*, which can cause foodborne diseases such as fever, vomiting, diarrhea, and potentially

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renal failure, miscarriage, and death [17]. The purpose of this study is to evaluate the physicochemical and microbiological quality of milk and its derivatives sold in informal shops in the El Jadida region.

MATERIALS AND METHODS

Study area and food matrix

The research was carried out in the city of El Jadida. It is part of the Casablanca-Settat region, which has a total area of 19,448 km² and a population of 6.862 million people [48], a population density of 353 people per km², and accounts for 2.7 percent of the national territory [52]. This region is mostly known for the production of sugar beets, cereals, market gardening, milk, and red meats.

Thus, livestock production is a significant activity for the population; it is a vital supplement to crops for economic growth, and it is mostly centered on sheep and cattle [19]. With 323 757 hectares of arable land, or 26 percent of the region's size, including 96 hectares in the irrigated area, this region is one of the most significant agricultural pillars of the Casablanca-Settat region [32].

Nearly 380 million liters of milk per year is produced in the Doukkala area, according to the latest figures established by the Office Régional de Mise en Valeur Agricole (ORMVA) Doukkala [36]. The dairy sector in Doukkala contributes to 18% of national production and 58% of the production of the region Casablanca Settat, and that 85% of the total amount is produced in the irrigated area. Pointing out that this

region is considered the main producer of milk, with the existence of four units of dairy processing. It also contributes to the marketing of nearly 257 million liters of milk, or 68% of the total amount produced [36].

In the city of El Jadida, 84 samples of raw milk and its derivatives were collected from various sales outlets. Around the Hospital Mohammed V (EH MV); El Qalaa (EQ); Najd (NJD); Jawhara (Jaw); Ariha (Arh); Sidi Moussa (SM); El Ghorba (EGh); Bouchrit (Bou); Old Market (AM); El Mallah (EMH); Hay Salam (HS); and Mahlaba El Outmani (MO) (Figure 1).

«Lben» is a fermented dairy product in Morocco. Its basic preparation has continued at the family or artisanal level [10]; the milk is left alone until it coagulates. This procedure is performed at room temperature and takes 24 to 48 hours to complete, depending on the season. The subsequent churning lasts 30 - 40 minutes. Then, depending on the room temperature, a particular volume of water (approximately 10% of the volume of milk) is frequently added, hot or cold, to raise the temperature of the mixture to a level adequate for the collection of butter grains, a product of high market value [51]. It should also be mentioned that the chemical composition of «Lben» varies according on location, area, farm, raw milk chemical composition and production technique [20].

«Raib» is a traditional Moroccan coagulated milk, obtained by spontaneous fermentation, has some resemblance to yogurt, with a pleasant taste and smell [11]. The coagulation is obtained or results

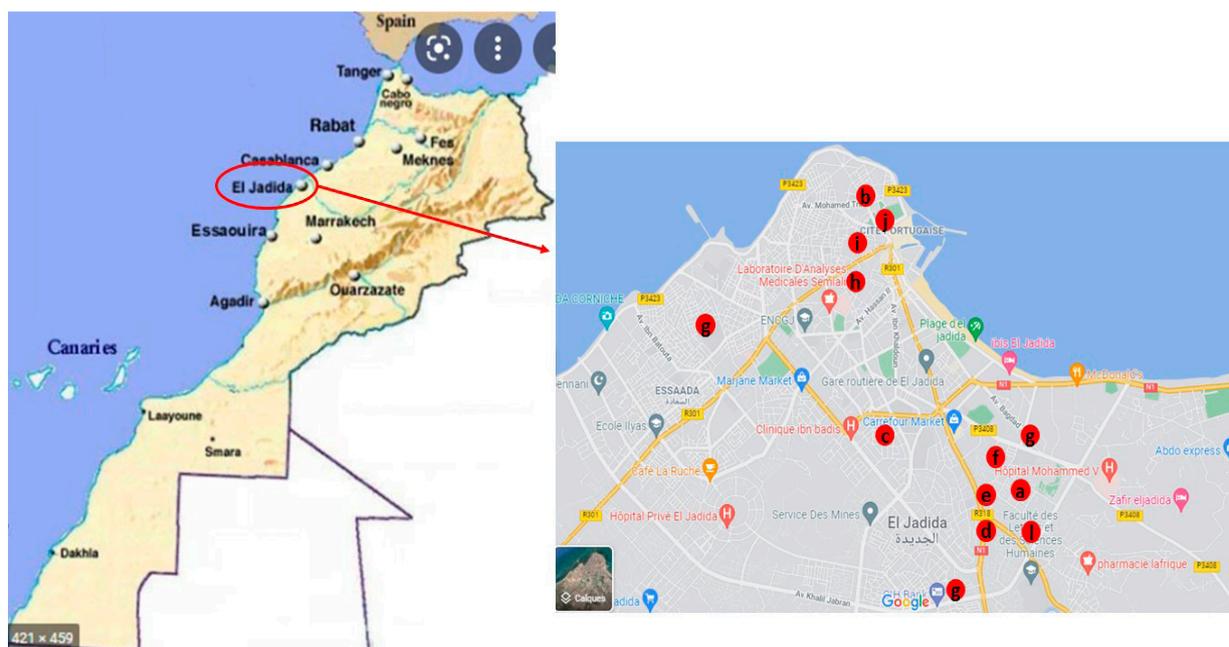


Figure 1: Geographical location of sales points for raw milk and its derivatives in the city of El Jadida, Morocco

a : Around Mohammed V Hospital (EH MV); b : El Qalaa (EQ); c : Najd (NJD); d : Jawhara (Jaw); e : Ariha (Arh); f : Sidi Moussa (SM); g : El Ghorba (EGh); h : Bouchrit (Bou); i : Old Market (AM); j : El Mallah (EMH); k : Hay Salam (HS), l : Around the Faculty of Letters (El let) and m: Mahlaba El Outmani (MO).

from the original microbial flora and contamination, with or without additions of organic acids (lemon, vinegar), for a period varied according to the season between 24 hours to 72 hours [26]. The organisms responsible for the fermentation are thermophilic lactobacilli in summer and mesophilic lactococci in winter [41]. The «Raib» consumed in Morocco by children of weaning age and the elderly. It represents a primary fermented whole milk product, from which other products can be processed (Lben and Zebda Beldiya). Fermentation normally takes place at room temperature (15-30°C) [9].

Physicochemical and microbiological analysis of milk and its derivatives

Method of sampling milk and its derivatives

To examine the quality of milk delivered to points of sale in El Jadida (grocery outlets specializing in the sale of milk and its derivatives), we conducted a representative sampling in several locations around the city. The total number of raw milk samples is 23, 30 for the «Lben» and 31 for the «Raib». All of the samples were collected between the hours of 8 a.m. and 11:30 a.m. The milk samples are delivered in 50 mL sterile, sealed plastic bottles. They are labeled and kept in a cool box at +4°C before being delivered straight to the Provincial Laboratory of Public Health in El Jadida. Upon arrival at the laboratory, the samples were subjected to a series of pH.

Physicochemical analysis

When the samples arrive at the laboratory, they are promptly registered and coded, with the kind, location of collection, label, and tank numbers noted. The maximum period between sampling and analysis is four hours. The physicochemical properties of milk and its derivatives (Lben and Raib) are measured using a device called a Milkotester (Master Pro, Bulgaria), which can measure numerous parameters such as lactose, fat, density, protein, solids-non-fat, freezing point, water content, and temperature. A pH meter would be used to determine the pH of the milk (Eutech Instruments Pte Ltd, Singapore).

Microbiological analysis

The raw milk samples were microbiologically analyzed at the Provincial Public Health Laboratory using established microbiological procedures. *Total Aerobic Mesophilic Flora* (TAMF), *Faecal Coliforms* (FC), *Staphylococci*, *Salmonella*, and *total Coliforms* (TC) were counted to characterize raw milk, «Lben» and «Raib». Sample preparation and decimal dilutions are carried out in accordance with Moroccan standard NM 08.0.100 [37].

Stock solutions for each sample were made by combining 225 ml of buffered peptone water (BPW) with 25 ml of the analyte. This mixture had been homogenized. 1 ml of the stock solution was taken with a pipette and diluted in a tube with 9 ml of buffered peptone water (BPW). A shaker was used to homogenize this mixture.

Total Aerobic Mesophilic Flora (TAMF): Plate Count Agar (PCA) is used to count the *Total Aerobic Mesophilic Flora* (TAMF). One ml of each successive decimal dilution was added to the Petri dishes and then PCA was added to each. Plates were incubated at 37°C for 24 hours. The plates are read shortly following incubation.

Faecal Coliforms (FC) and Total Coliforms (TC): Desoxycholate agar is used to count *faecal coliforms*. The plates are inoculated with 1 ml of each sample from the stock solution, and then incubated for 24 hours with *faecal coliforms* at 44°C and total coliforms at 37°C.

Staphylococci. *Staphylococci* are counted on *Chapman* agar. Inoculation is accomplished by distributing 0.1 ml of each sample's stock solution with a sterile loop into petri plates containing culture medium and incubating at 37°C for 24 hours.

Salmonella. Research of *Salmonella*, it is carried out according to 4 stages:

Step 1: pre-enrichment, carried accomplished by incubating a portion of the mother solution for 18 hours at 37°C.

Step 2: Enrichment by suspending 1 ml of the pre-enrichment solution with 10 ml of selenite and incubating at 37°C for 24 hours.

Step 3: Isolation by streaking (looping) a drop of the enrichment culture onto *Salmonella-Shigella* agar (SS); the medium is incubated at 37°C for 24 hours. After incubation, colonies with a blackish or grayish center are visible.

Step 4: Identification, using the AP Gallery method.

These analyses are made according to the ministerial decree n° 624-04 of 17 Safar 1425 (2004) [7], which publishes the microbiological criteria fixed for the raw milk, the «Lben» and requires that the germs searched in the raw milk are: the TAMF (<3x10⁶ UFC/ml), the FC (<10³ UFC/ml) and the *Salmonella* (absence in 25 ml). For the «Lben», the TC <5 CFU/g and *Salmonella* must be absent in 25 ml of solution.

Data analysis and processing

Microsoft Office Excel 2010® spreadsheet software was used for data entry and processing. Proportion comparisons based on numerous criteria were carried out utilizing statistical tools in EpiInfo7 2010 and SPSS software (IBM SPSS Statistics for Window, version 25).

RESULTS

Physicochemical analysis of raw milk and its derivatives at the level of the points of sale

Raw milk

Table 1 shows the findings of the physicochemical examination of raw milk. According to these data, the pH of the milk ranges between 5.85 and 6.71. Only

48 g/l, which is within the normal range of 40- 50 g/l. It is also worth noting that the density values (g/cm³) of the examined samples range from 1.027 to 1.031 g/cm³. Only two samples had results that are not in the (1.028-1.038g/cm³) range. The freezing point (°C) ranges from -0.486°C to -0.572°C. Only two samples exhibit temperatures in the usual range of -0.530 to -0.575°C. Finally, the temperature (°C) of the tested samples ranges from 15 to 22.4°C.

Table 1. Physicochemical parameters of raw milk

| Points of sale | MG (g/l) | SNG (g/l) | D (g/cm ³) | P (g/l) | L (g/l) | S (g/l) | PC (°C) | E (%) | pH | T (°C) |
|----------------|----------|-----------|------------------------|---------|---------|---------|---------|-------|------|--------|
| EHMV | 37 | 88.66 | 1.02 | 30.5 | 46.33 | 6.5 | -0.55 | 0.9± | 6.41 | 20.43 |
| | ± | ± | ± | ± | ± | ± | ± | 2.2 | ± | ± |
| | 7.64 | 7.55 | 0.001 | 2.73 | 4.17 | 0.83 | 0.07 | | 0.06 | 1.36 |
| HS | 39 | 88.5 | 1.029 | 30.5 | 46.25 | 6.5 | -0.546 | 4 | 6.24 | 21.47 |
| | ± | ± | ± | ± | ± | ± | ± | ± | ± | ± |
| | 5.22 | 16.74 | 0.006 | 5.97 | 9.25 | 1.29 | 0.12 | 2 | 0.13 | 1.80 |
| EQ | 37.66 | 90.33 | 1.029 | 31.33 | 47 | 6.6 | -0.556 | 0 | 6.16 | 20.33 |
| | ± | ± | ± | ± | ± | ± | ± | | ± | ± |
| | 8.02 | 4.16 | 0.001 | 1.52 | 2 | 0.57 | 0.02 | | 0.24 | 2.05 |
| Njd | 42 | 88.5 | 1.02 | 30.5 | 46 | 6.5 | -0.546 | 0 | 6.35 | 22.25 |
| | ± | ± | ± | ± | ± | ± | ± | | ± | ± |
| | 15.55 | 2.12 | 0.07 | 0.70 | 1.41 | 0.70 | 0.02 | | 0.07 | 1.06 |
| EMH | 42 | 88.5 | 1.028 | 30.5 | 46 | 6.5 | -0.547 | 0 | 6.36 | 21.3 |
| | ± | ± | ± | ± | ± | ± | ± | | ± | ± |
| | 4.24 | 6.36 | 0.002 | 2.12 | 11.26 | 0.70 | 0.03 | | 0.01 | 0.70 |
| Jaw | 20 | 82 | 1.027 | 28 | 42 | 7 | -0.486 | 2.3 | 5.85 | 17 |
| Arh | 31 | 93 | 1.031 | 32 | 48 | 7 | -0.569 | 0 | 6.71 | 15 |
| AM | 39 | 92 | 1.030 | 32 | 48 | 7 | -0.572 | 0 | 6.33 | 22.8 |

EHMV: Around the hospital Mouhamed V, HS: Hay Salam, EQ: El Qalaa, Njd: Najd, EMH: El Mallah, Jaw: Jawhara, Arh: Ariha, A M: Ancien Marché.

L: Lactose, MG: Fat, D: Density, P: Protein, SNG: Non-fat solids, PC: Freezing point, E: Water, T: Temperature, S: Mineral salts. NE : Number of samples

two samples (8.7 %) meet the acceptable pH range of 6.6 to 6.8 and have an average value of 6.71 in Ariha, while the other samples had values below the norm. In the examined samples, the additional water is between 0 and 4 percent. Water is added to raw milk sold at the Mohammed V Hospital (HVM), Jawhara (JW), and Hay Salam (HS) areas at a rate of 0.9 percent, 2.3 percent, and 4 percent, respectively. In terms of fat content (g/l), it ranges between 20 and 42 g/l. Five of the 23 samples do not meet the criteria (28.5 - 32.5 g/l). Nonfat solids (g/l) range from 82 to 93 g/l. One sample from the Old Market (92 g/l) is in conformity with the standard (out of the 23). Protein concentrations (g/l) in the samples range from 28 to 32 g/l. Only four samples obtained at the Ariha and Old Market levels show a value of 32 g/l. This corresponds to the norms (32-35 g/l). The salt content (g/l) of the samples ranges between 6.5 and 7 g/l, which is lower than the typical salt content (9 g/l). Lactose (g/l) levels vary from 42 to

Table 2. Physicochemical parameters of «Lben»

| Points of sale | T (°C) | pH |
|----------------|----------------|---------------|
| EHMV | 21.66 ± 0.8504 | 4.37 ± 0.0655 |
| EQ | 21.07 ± 1.09 | 4.18 ± 0.1138 |
| Njd | 20.2 ± 0.9899 | 4.38 ± 0.0282 |
| LZ | 21.95 ± 0.0707 | 4.24 ± 0.1697 |
| ARH | 19.5 | 4.21 |
| SM | 22 | 4.41 |
| Egh | 20.7 | 4.26 |
| Bou | 21.6 | 4.23 |
| AM | 21.5 | 4.19 |
| EMH | 21.75 ± 0.4949 | 4.31 ± 0.0353 |
| HS | 19.45 ± 0.7778 | 4.36 ± 0.0070 |

EHMV: Around the hospital Mouhamed V, E Q: El Qalaa, Njd: Najd, L Z: Lalla Zahra, Arh: Ariha, SM: Sidi Moussa, Egh: ElGhorba, Bou: Bouchrit, AM: Old Market, EMH:ElMallah, HS:Hay Salam. T: Temperature. NE: Number of Samples

«Lben»

Table 2 shows the results of physicochemical studies of «Lben» gathered from places of sale. The pH of the samples is found to range between 4.18 and 4.41. The examination found that 12 samples obtained from Bouchrit, El Qalâa, Ariha, Lala Zahra, and the Old Market were in conformity with pH values of 4.23, 4.18, 4.21, 4.24, and 4.19, respectively, whereas the remaining samples were not (pH>4.25). And the temperature (°C) of the samples ranges from 19.45 to 22°C.

«Raib»

Table 3 shows the findings of the Raib's physicochemical analysis. The pH of the bulk of samples is greater than 4.2, with the exception of the dairy Mahlaba Street Hassan II, where the pH value is 4.2. (Normal pH value of the Raib is 4.2). The temperature (°C) of the samples examined ranges from 14.7 to 22.4°C.

Evaluation of the microbiological quality of milk and its derivatives at the level of the points of sale in the Doukkala area

Raw milk

The microbiological studies given in Table 4 reveal that the TAMF values are higher in the majority of the samples, with an average value of 5.3×10^8 CFU/ml of the samples collected from a vendor near Mohammed V Hospital. This figure is significantly higher than the compliance value specified by the Moroccan standard in place (3×10^6 CFU/ml). Jawhara, Ariha, Hay Salam, and EL Qalâa samples are likewise noncompliant, with average TAMF values of 0.6×10^7 CFU/ml, 0.7×10^7 CFU/ml, 2.2×10^7 CFU/ml, and 4.9×10^8 CFU/ml, respectively. The average CF loads of milk taken from El Mallah, El Qalâa, and the Surroundings of Mohammed V Hospital are around 1.4×10^4 CFU/ml, 4.7×10^6 CFU/ml, and 5×10^6 CFU/ml, respectively. These results continue to be greater than those

Table 3. Physicochemical parameters of the «Raib»

| Points of sale | T (°C) | pH |
|----------------|---------------|-------------|
| MLZ | 21.53 ± 0.55 | 4.08 ± 0.29 |
| Njd | 20.75 ± 1.77 | 4.42 ± 0.21 |
| CV | 18.9 ± 0.7071 | 4.1 ± 0.07 |
| MRM V | 16.4 | 4.25 |
| MO | 18 | 4.15 |
| MEB | 16.7 | 5.78 |
| MRH II | 16.9 | 4.22 |
| MEQ | 20 | 4.43 |
| SM | 23 | 3.87 |
| ARH | 19.4 | 4.08 |
| OR | 14.7 | 4.29 |
| El let | 17 | 4.35 |
| HS | 14.9 | 4.1 |
| MEGh | 22.4 | 4.11 |
| Bou | 21.6 | 4.65 |

MLZ: Mahlaba Lalla Zahra, Njd: Najd; CV: City Center; MRM V: Mahlaba of Mohammed V Street; MO: Mahlaba of El Outmani; MEB: Mahlaba of El Boustane; MRH II: Mahlaba of Hassan II Street; MEQ: Mahlaba of El Qalaa; SM: Sidi Moussa; Arh: Ariha; OR: Om Rabiaa, El let: Surroundings of the Faculty of Letters; HS: Hay Salam, MEGh: Mahlaba of El Ghorba, Bou: Bouchrit; T: Temperature; NE: number of samples

permitted by the Moroccan CF standard in effect (10^3 CFU/ml). The other samples, on the other hand, are in accordance with the indicated standard.

Four *Staphylococci* sales points do not meet Moroccan standards (10^3 CFU/ml): In the vicinity of Mohamed V Hospital ($825\,533.3$ CFU/ml), Hay Salam ($208\,193.8$ CFU/ml), EL Qalâ ($16\,356.7$ CFU/ml), and Ariha (6.9×10^3 CFU/ml).

«Lben»

The microbial load of «Lben» in the current study is mostly consisted of microorganisms suggestive of

Table 4. Microbiological parameters of raw milk in different outlets (counts in CFU/ml)

| Points of sale | TAMF | FC | <i>Staphylococci</i> | <i>Salmonella</i> |
|----------------|----------------------------|---------------------------|---------------------------|-------------------|
| EH MV | $5.3 \times 10^8 \pm 5.2$ | $5 \times 10^6 \pm 8.3$ | 825533.3 ± 9 | Absence |
| HS | $2.2 \times 10^7 \pm 14.1$ | 7500 ± 3.9 | 208193.8 ± 12.6 | Absence |
| EQ | $4.9 \times 10^8 \pm 19$ | $4.7 \times 10^6 \pm 8.5$ | 16356.7 ± 7.8 | Absence |
| NJD | 24.5 ± 7.1 | 3772 ± 6.2 | $10^3 \pm 1$ | Absence |
| EMH | 23.8 ± 13.2 | $1.4 \times 10^6 \pm 5.8$ | $6.5 \times 10 \pm 3$ | Absence |
| AM | 0 | 0 | $10^3 \pm 1$ | Absence |
| Jaw | $0.6 \times 10^7 \pm 4.9$ | 950 ± 6.3 | $1.1 \times 10^3 \pm 1.2$ | Absence |
| Arh | $0.7 \times 10^7 \pm 3.7$ | 15 ± 16.8 | $6.9 \times 10^3 \pm 1$ | Absence |

TAMF – Total Aerobic Mesophilic Flora; FC – Faecal Coliforms.

EH MV – Environs de l'Hôpital Mohammed V; EQ - El Qalaa; NJD - Najd; Jaw -Jawhara; Arh - Ariha; SM- Sidi Moussa; EGH – El Ghorba; Bou - Bouchrit; AM - Ancien Marché; EMH – El Mallah; HS – Hay Salam, NE – Number of samples.

noncompliance or ignorance of appropriate hygiene procedures (TAMF) (Table 5). In fact, a number of 1.6×10^8 CFU/ml was discovered in the Hay Salam sample. When compared to the other samples, it is regarded as the best. This figure is less than the typical value specified by the Moroccan standard (2.9×10^9 CFU/ml). There are also bacteria that confirm the presence of fecal contamination (FC) with microbial loads of 3.0×10^8 CFU/ml and 5.8×10^6 CFU/ml at EL Qalâa and Hay Salam, respectively. The enumeration data shown in Table 5 demonstrate that the existence of

a high incidence of «Lben» non-compliance is justified by the severity of microbiological standards that do not surpass 5 CFU/ml for *Total Coliforms*. In the majority of samples, they had very high levels, with a highest value of 8.8×10^6 CFU/ml identified in a sample obtained in the El Ghorba region. Eight samples do not meet the criterion for *Staphylococci*, with a dominating microbial load of 2.2×10^5 CFU/ml in the sample obtained in the El Ghorba region. *Salmonella* does not exist in «Lben» raw milk (Table 5).

Table 5. Microbiological parameters of Lben in different outlets (counts in CFU/ml)

| Points of sale | TAMF | FC | <i>Staphylococci</i> | <i>Salmonella</i> |
|----------------|----------------------------|---------------------------|---------------------------|-------------------|
| EQ | $2.9 \times 10^6 \pm 2.8$ | $3.0 \times 10^8 \pm 3.9$ | $10^3 \pm 1$ | Absence |
| ARH | $3.5 \times 10^6 \pm 3$ | 0 | 950 ± 1.2 | Absence |
| EHMV | $6.3 \times 10^6 \pm 4.2$ | $10^3 \pm 1$ | 1250 ± 1.4 | Absence |
| SM | $1.1 \times 10^6 \pm 9.1$ | 0 | 550 ± 1.25 | Absence |
| HS | $1.6 \times 10^8 \pm 1.6$ | $5.8 \times 10^6 \pm 3.9$ | 995 ± 1.9 | Absence |
| EGh | $3.3 \times 10^5 \pm 3.4$ | $2.5 \times 10^6 \pm 2.4$ | $2.2 \times 10^5 \pm 2.8$ | Absence |
| Bou | $2.8 \times 10^5 \pm 1.2$ | $7.7 \times 10^5 \pm 7.7$ | 1250 ± 1.4 | Absence |
| LZ | $2.8 \times 10^7 \pm 2.7$ | $4 \times 10^5 \pm 4.5$ | 2800 ± 3 | Absence |
| NJD | $1.9 \times 10^7 \pm 18.1$ | $2.8 \times 10^4 \pm 2.7$ | 1350 ± 2.3 | Absence |
| AM | $1.8 \times 10^6 \pm 1.7$ | 0 | 925 ± 1.8 | Absence |
| EMH | $3.4 \times 10^7 \pm 7.5$ | 0 | 5 ± 2.2 | Absence |

TAMF: Total Aerobic Mesophilic Flora, FC: Faecal Coliforms.

EH MV: Surroundings of Mohammed V Hospital; EQ: El Qalaa; NJD: Najd; LZ: Lalla Zahra; ARH: Ariha; SM: Sidi Moussa; EGh: El Ghorba; Bou: Bouchrit; AM: Old Market; EMH: El Mallah; HS: Hay Salam. NE: number of samples

Table 6. Microbiological parameters of the Raib in different outlets (counts in CFU/ml)

| Points of sale | TAMF | FC | <i>Staphylococci</i> | <i>Salmonella</i> |
|----------------|-----------------------------|----------------------------|----------------------------|-------------------|
| MLZ | $8.3 \times 10^7 \pm 47.5$ | 0 | 1100 ± 2.45 | Absence |
| Njd | $3.3 \times 10^7 \pm 14.1$ | $1.2 \times 10^6 \pm 9.1$ | $3.0 \times 10^5 \pm 8.02$ | Absence |
| CV | $10^7 \pm 7.06$ | 0 | $3.2 \times 10^2 \pm 1.3$ | Absence |
| MRMV | 1100 ± 2.45 | 15 ± 0.5 | $9.5 \times 10^2 \pm 1.3$ | Absence |
| MO | $1.5 \times 10^3 \pm 6.9$ | 60 ± 0.8 | 155 ± 2.1 | Absence |
| MB | $2.5 \times 10^6 \pm 17.07$ | $2.8 \times 10^6 \pm 13.7$ | $10^4 \pm 7.41$ | Absence |
| MRHII | 1100 ± 2.45 | 0 | 0 | Absence |
| MQ | $5.5 \times 10^3 \pm 5.1$ | 0 | $1.4 \times 10^3 \pm 3.2$ | Absence |
| SM | $5.1 \times 10^6 \pm 19.2$ | 130 ± 1.07 | 0 | Absence |
| ARH | $9.5 \times 10^4 \pm 6.01$ | 0 | 0 | Absence |
| OR | 150 ± 1.06 | 0 | 150 ± 1.2 | Absence |
| ELLET | 240 ± 2.04 | 0 | 0 | Absence |
| HS | $1.5 \times 10^4 \pm 4.03$ | 0 | 655 | Absence |
| EGh | $1.1 \times 10^5 \pm 7.01$ | $3.3 \times 10^6 \pm 9.09$ | $2.3 \times 10^6 \pm 8.01$ | Absence |
| Bou | $5.5 \times 10^7 \pm 9.01$ | 1100 ± 2.45 | $2.5 \times 10^3 \pm 4.01$ | Absence |

MLZ: Mahlaba lalla Zahra; NJD: Najd; C V: Downtown; MRMV: Mahlaba of Mohammed V Street; MO: Mahlaba of El Outmani; MB: Mahlaba of El Boustane; MRHII: Mahlaba of Hassan II Street; MQ: Mahlaba of El Qalaa; SM: Sidi Moussa; ARH: Ariha; OR: Om Rabiaa; ELLET: Environs de La fac de Lettre; HS: Hay Salam; EGh: El Ghorba; Bou: Bouchrit. NE: number of samples.

«Raib»

According to the results of the «Raib» samples gathered from vendors in El Jadida, the *Total Aerobic Mesophilic Flora* is high in the majority of samples, with an average value of 8.25×10^8 CFU/ml observed in a sample acquired from a vendor in Mahlaba Lala Zahra. This value is more than the Moroccan standard's compliance limit (3.5×10^8 CFU/ml). Furthermore, samples collected in Bouchrit, Najd, Mahlaba Lala Zahra, and Sidi Moussa show average TAMF values of 5.5×10^7 CFU/ml, 3.3×10^7 CFU/ml, 8.3×10^7 CFU/ml, and 5.1×10^6 CFU/ml, respectively (Table 6).

The greatest microbial load for *Faecal Coliforms* is documented at Mahlaba of El Boustane, with an average value of 2.8×10^6 CFU/ml (4.2×10^3 CFU/ml). Furthermore, the average value of *Staphylococci* discovered at the dairy of El Ghorba is 2.3×10^6 CFU/ml (Table 6).

DISCUSSION

Microbiological and physicochemical quality of milk and its derivatives at the level of sales points in the Doukkala area

Physicochemical analysis of raw milk and its derivatives «Lben» and «Raib» of the sales points

Raw milk

The pH of the raw milk at the outlets ranged from 5.85 to 6.71. Only two of the samples meet the criteria. This finding is comparable to the average pH value of raw milk discovered by *El Marnissi* et al [22], which is approximately 6.6, and it is also higher than that found by *Maiwore* et al [38] on fermented goods, which ranges between 3.4 and 4.16. The pH of raw milk varies owing to sanitary circumstances during milking, milk transit, total microbial flora, and metabolic activity [40] and also because of the transformation of lactose into lactic acid by bacterial fermentation [14].

Lactose levels ranging from 36 to 58 g/l are higher than the milk analyzed by Mathieu in 1998 [40] that had an average value of 49 g/l. The fat content represents the essential parameter of milk quality that determines the nutritional value of milk. However, fat is the most variable component of bovine milk [8]. The fat in our study fluctuates between 20 and 53 g/l. These values are on average higher than those of *Labioui* et al [35] with a value of 31.45 g/l and those advanced by AFNOR in 2001 [3] with the range of 28.5 to 32.5 g/l and *Boudalia* et al [16] which is 3.28%. These results may be due to feed abundance [13], as mentioned by *Hamidi* et al [29] in a study conducted in a semi-arid region of Algeria with lower fat content where plant abundance and richness are lower. Indicating that 25% of samples are not compatible with the norm. The freezing point

of the samples is between -0.415°C and -0.704°C , while other studies conducted by *Labioui* et al [35] and *Boudalia* et al [13] found -0.52°C and $-0.55 \pm 0.11^\circ\text{C}$ respectively. The density observed ranges between 1.0226 to 1.0367 g/cm³, which is equivalent to the average value of 1.0297 g/cm³ reported by *Labioui* et al [13]. However, our value is higher than the one found by *Boudalia* et al [13] which is 1.03 ± 6.33 kg/m³.

Except for three samples that have undergone a rate of wetting, which naturally lowers the content of milk in its various constituents and thus the density of milk, the milk at the points of sale is generally of good nutritional quality, in this case the protein content, lactose, solids non-fat and fat. *Saidane* et al [49] states that the higher the milk fat content, the higher and more significant the milk density.

«Lben» and «Raib»

Fermented milks, in this case the «Lben» and «Raib», are the result of lactic fermentation to acidify and gel milk. Milk fermentation causes microbiological, biochemical, physicochemical, and organoleptic changes [4].

The pH of the milk products evaluated in our study ranges between 4.14 and 4.43 for «Lben» and less than 4.6 for «Raib», which are similar to the results obtained by *Mulonda Kakumbwa* in 2016 [45] on curdled milk from Bukavu in the Democratic Republic of the Congo, which ranged between 4.3 and 5.5. The acidic pH of «Lben» and «Raib» might be attributed to the manufacturing process utilized to create each product [38]. Our findings are comparable to those found in Moroccan research [28, 22] with an average value of 4.5 for «Lben» and 4.2 for «Raib». We may conclude from these findings that the physicochemical quality of «Lben» and «Raib» are under the conditions of our investigation is satisfactory.

Microbiological analysis of raw milk and its derivatives «Lben» and «Raib» at the point of sale

The search for microorganisms that are indicative of fecal contamination can be used to assess a product's sanitary state. Even at modest levels, they would attest to poor sanitary conditions during milking, transportation, and selling.

Raw milk

The TAMF values are quite high, with an average of 2.3×10^8 CFU/ml. This number can be explained by the insufficiency of the product's manufacturing environment and utensils used; the non-observance of general hygiene norms; and/or contamination during milking, collecting, transport, or distribution of raw milk at room temperature. We discovered that milk is carried to the point of sale in unrefrigerated plastic

containers during sample collecting. These procedures have the potential to contaminate the milk produced. According to *Kaouche* [34], high levels of total flora indicate poor hygiene practice during milking. *El Marnissi et al* [22] acquired a substantially lower average load of 4.5×10^5 CFU/ml than we did. Our mean value is also much higher than that reported by another research of raw milk [35] in Morocco's Mnasra area, which is 6.4×10^6 CFU/ml, and higher than that found by a study done in Burkina Faso [42]. And also higher than the results found in the region of Guelma in northeastern Algeria [12], and which were a satisfactory quality of raw milk in light of the standard (10^5 CFU/mL).

Our results are also in disagreement with the results obtained by *Ghazi et al* [25] and *Jora* [33] who agree that there is a significant contamination if the bacterial load is higher than 10^5 UFC/ml. Therefore, as a conclusion the quality of our samples is considered non-compliant.

Presence of coliform bacteria in food surfaces does not necessarily indicate faecal contaminations but may indicate that the hygiene status of the preparation and processing is poor [50] cited by *Gwandu et al* [27].

The highest value of *Faecal Coliforms* is 4.7×10^6 found at the point of sale El Qalaa UFC/ml. The presence of faecal coliforms in some samples can be explained by an exogenous contamination of faecal origin. They are evidence of defective hygiene during or after processing [16]. Thus, poor hand hygiene, the manufacturing environment, the addition of ferment after pasteurization, defective or contaminated equipment are likely sources of contamination [18]. Our value is higher than that reported by *El Marnissi et al* [22] which is 8.6×10^2 CFU/ml and also higher than that found by *Hamiroune et al* [30], which is 4.6×10^4 CFU/ml.

Staphylococci are germs found on the mucous membranes and skin of most warm-blooded animals, including humans. They are sometimes incriminated as agents causing mastitis in dairy herds [22]. A survey of three thousand two hundred dairy products from a plant in Canada showed that handlers are the main source of staphylococcal contamination [52]. In our study, *Staphylococci* were present at a mean value of 132521.7 CFU/ml. This value remains higher compared to *El Marnissi et al* [22] who found a value of 3.9 CFU/ml and also to that of [13] where no contamination by *Staphylococcus aureus* was recorded.

Salmonella are absent in all samples of raw milk analyzed. Our results agree with the conclusion of *El Marnissi et al* [22] and *Boudalia et al* [13] who reported, also, the absence of this bacteria. These samples comply with the standard provided by the AFNOR [2] (total absence of *Salmonella* in fermented milk).

The results of the enumeration of milk from the point of sale show that 57% of the milk samples do not comply with the standards, with high values of TAMF, CF, and especially *Staphylococcus*. Thus, if consumed in a fresh state, *Staphylococci* could present a danger to the health of the consumer. This depreciation of the microbial quality is due to several causes, including the non-respect of the hygienic conditions and the cold chain at the level of the points of sale for the delivered milk.

«Lben»

The microbial load at the Hay Salam outflow is dominated by bacteria of fecal origin, with a mean value of 5.8×10^6 CFU/ml. This is higher than the average value discovered by *El Marnissi et al* [22], which is 1.8×10^4 CFU/ml.

The results demonstrate the presence of a considerable number of TAMF, with a mean value of 3.4×10^7 CFU/ml observed at the EH MV outlet level. This figure is more than the value reported by *El Marnissi et al* [22], which is 7.8×10^6 CFU/ml. However, *Filali* [24] showed that the mesophilic count should not exceed 3×10^6 CFU.g-1 cited by *Benkirane et al* [11].

The enumeration results show that the average TC value is around 8.8×10^6 CFU/ml. This value is lower than that reported by *Hadrya et al.* [31] which is 2×10^7 CFU/ml. According to *Filali* [24] the coliform count, should not exceed 5 CFU.g-1.

Staphylococci enumeration showed an average load of roughly 2.2×10^5 CFU/ml at the EGh outflow. This result is much higher than the value obtained by *El Marnissi et al* [22], which is 32.3 CFU/ml, as well as the value published by *Benkerroum and Tamime* [10], which is 10^3 CFU/ml. Furthermore, unlike prior research, none of the «Lben» samples studied confirmed the presence of *Salmonella* [21, 22]. According to *Matallah et al* [39], the absence of *Salmonella spp.* could be explained by the absence of udder infection.

According to the enumeration results, 70% of the examined samples are not in accordance with Moroccan rules. The harshness of the microbiological standards, which do not exceed 5 CFU/ml for *Total Coliforms*, justifies the occurrence of a significant percentage of non-compliance with «Lben».

The «Lben» is the dairy product that presents a health risk compared to other dairy products studied, because it is characterized by a rapid perishability, especially during the summer season and it is a product that is consumed cold. Indeed, a study already conducted indicates that dairy products rank first in terms of involvement in foodborne diseases (26.4%), including dairy products designed in a traditional way, such as «Lben» [6].

« Raib »

According to this analysis, the total flora was high, with an average value of 8.3×10^7 CFU/ml in TAMF, indicating that the studied product «Raib» does not meet sanitary standards. This figure is lower than that observed in a research that discovered a total flora load of around 3.5×10^8 CFU/ml [28]. Furthermore, the presence of *Staphylococci* is indicated by a result of 3.0×10^5 CFU/ml. This is higher than the figure reported by *Hamama* and *Bayi* [28], who found 10^4 CFU/ml in the majority of the «Raib» samples. The fecal contamination had a higher value of around 2.8×10^6 CFU/ml, whereas [28] investigation found a minimum value of 4.2×10^3 CFU/ml.

In this study, *Salmonella* was absent in all samples. This finding is comparable with the study of *Hamama* and *Bayi* [28] and also with those of *Elham* et al [23] obtained for fermented products from Lebanon, as they found no samples with *Salmonella* [38].

The results of the enumeration revealed that 42% of the samples evaluated do not conform with Moroccan requirements. These findings reveal the existence of germs, in this case *Staphylococci*, even in heat-treated milk, such as «Raib» from El Ghorba's dairy. These microorganisms, which cause food poisoning, might endanger public health. Indeed, according to *Benkirane* et al [11], the frequent use of unpasteurized raw milk, lack of hygiene, and unfavorable environmental conditions cause Rayeb to have variable characteristics and higher risks of spoilage.

CONCLUSION

Through physicochemical and microbiological analysis of milk and its derivatives at the point of sale in the Doukkala area, we attempted to contribute to the study of risks associated with the consumption of raw milk and its derivatives from the informal circuit, as well as to see the importance of this circuit in the dairy industry.

In the majority of samples, microbiological investigation revealed a very high incidence of noncompliance. According to the findings, the microbiological quality of milk and its derivatives is deficient in the analyzed region. This deterioration in microbiological quality would be caused by a variety of factors, including a failure to maintain sanitary conditions, a breakdown in the cold chain at the farm level during milking, a breakdown in the transport chain, or a breakdown in the points of sale for the sold milk.

The presence of germs in this case *Staphylococcus* even in heat-treated milk, such as «Raib» represents a danger to public health. It should be noted, however, that *Salmonella* in all samples is not present.

The physicochemical properties of raw milk and its derivatives revealed that the majority of samples did not meet international criteria for pH and other factors such as lactose, proteins, fat, minerals, density, and added water.

It would be prudent to enhance the microbiological and physicochemical quality of milk and its derivatives through this research in order to protect consumer health:

- To provide training on cleanliness rules for farmers and collection center managers at the primary production level.
- Establishment of a quality policy, both upstream and downstream, to enhance breeding and milk collecting circumstances and to provide acceptable milk storage and delivery conditions.
- Strengthening of the payment system based on raw material quality;
- Strengthening the regulatory framework for identifying and organizing hawker activities.
- To counteract the informal sector, the regulations controlling the activities of traditional dairies are being strengthened by implementing traceability restrictions.

Declaration of interest

The authors declare that they have no conflict of interest regarding this article.

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