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Research Article

Physico-chemical Properties and Hygienic Quality of Raw and Reconstituted Milk in the Region of Guelma-Algeria

[1,2]Sofiane Boudalia, [3]Dalal Benati, [3]Radja Boukharouba, [3]Besma Chemakh and [2]Mabrouk Chemmam

[1]Laboratoire de Biologie, Eau et Environnement, Université de 8 Mai 1945, Guelma, Algérie
[2]Département d'Ecologie et Génie de l'Environnement, Université de 8 Mai 1945, Guelma, Algérie
[3]Département de Biologie, Université de 8 Mai 1945, Guelma, Algérie

Abstract

The milk contains many essential nutrients. Very rich in proteins, fats, carbohydrates and minerals, the milk occupies a very important place in our diet. This study aims to identify and evaluated the hygienic and physicochemical qualities of raw and reconstituted milk, in the region of Guelma, Algeria. A total of 90 samples were collected and analyzed (for both types of milk: Raw and reconstituted milk). Physicochemical analysis of temperature, acidity, fat, proteins, lactose, density, solids and Solids-Non-Fat (SNF) was performed. Microbiological quality was evaluated by performing Total Mesophilic Aerobic Bacteria (TMAB) tests and the organoleptic qualities (odor or color) were also evaluated. Finally, the stability and reproducibility of raw and reconstituted milk properties for a period of three months was evaluated. The results obtained in this study indicate that raw and reconstituted milk shows a physicochemical and bacteriological quality that meets international and national standards. However, a slight variability was recorded on the stability of physicochemical parameters during the three months of the experiment.

Key words: Raw and reconstituted milk, physicochemical parameters, bacteriological analysis, stability

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Corresponding Author: Sofiane Boudalia, Département d'Ecologie et Génie de l'Environnement, Université de 8 Mai 1945, Guelma, Algérie
Tel: (213)7 98 65 87 83

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Milk is a complex fluid in which many chemical compounds have been found. The major components are water, fat, lactose, casein, whey proteins and minerals. The amount of these milk constituents differs according to the animal species (Pereira, 2014). Also, consumers of raw milk present less milk allergy, lactose intolerance and diabetes (Claeys *et al*., 2013), with a protective effect on asthma and allergies (Von Mutius and Vercelli, 2010; Sozanska *et al*., 2013). Algeria is the largest consumer of milk in the Maghreb, with an average consumption of 110 liters per capita per year, estimated at 115 L in 2010 (Ubifrance, 2014). The total consumption is approximately 3 billion liters of milk per year; local production is limited only to 2.2 billion liters per year. A billion liters of milk is so imported each year, mostly in the form of milk powder (Ubifrance, 2014).

In spite of this situation, the Algerian dairy chains remain embryonic and the number of industrial processing units remain very low. These units operate with imported milk powder to produce rather milk drinks or others dairy products.

Among the problems encountered in Algerian dairy industry, changes in organoleptic qualities, defects, contamination and pollution of milk are numerous, their causes are diverse: They may be of microbial origin, caused by organisms of contamination (Ahmed and Abdellatif, 2013). They may be of chemical origin, caused by veterinary drug residues (Gonzalez-Lobato *et al*., 2014) and pesticides residues (Tian, 2011).

Also, in industrial processing units, repeatability of the manufacturing process and measuring equipment which is normally constant remain problems to be solved. The determination of the reproducibility is to highlight the differences between the average spreads obtained by several operators (Lacroix, 2015).

This study aim to analyze and evaluate the following points:

- The physicochemical and bacteriological qualities of raw and reconstituted milk (i.e., pasteurized and packaged in one litter bag as a finished product) to determine quality health and hygiene
- The stability and reproducibility of manufacturing operations to ensure the same physicochemical and bacteriological quality of milk (raw and reconstituted) marketed by a company located in the Eastern Algerian market

MATERIALS AND METHODS

Area and study population: This study took place in the region of Guelma (Northern East of Algeria).

Survey of the situation: A survey was performed to collect information about the farms, the various collectors and dairies, in order to characterize each link in the milk production chain.

Sampling protocol: The study was conducted from early October, 2014 to late March, 2015.

Several tests were used at monthly intervals to assess the global quality of raw and reconstituted milk pasteurized and packaged in one litter bag as a finished product.

A total of 90 samples were collected and analyzed: (1) 45 for the raw milk (3-4 samples per week during 3 months) and (2) 45 samples taken from reconstituted milk preparation (3-4 preparations per week during 3 months).

For both types of milk (raw and reconstituted) about 200 mL were taken aseptically in sterile test tubes, from each tank for microbiological analysis. The same volume was also collected for performing the physicochemical analysis.

To avoid any influence on milk properties and composition. The equipment used in the samples was clean and sterile.

Physicochemical analysis: At the dairy processing units, in the end of the collection of the raw milk. The temperature, acidity, fat, proteins content, lactose, density, solids and Solids-Non-Fat (SNF) were measured, by using a LactoScan (Milkotronic Ltd., Bulgaria).

Bacteriological analysis: Subsequent decimal dilutions were prepared to 10^{-7}. The counting was carried using a counting of colonies (Colony Counter SC6). Total Mesophilic Aerobic Bacteria (TMAB) was enumerated on Plate Count Agar (PCA) and incubated at 30°C for 72 h.

The TMAB reflects the microbiological quality of the milk. Bacteria are recorded and converted into Colony Forming Units (CFU) (Amariglio, 1986).

Organoleptic analysis: The evaluation of the organoleptic quality is a subjective operation because it focuses on the following characters: Appearance, color, texture, consistency and flavor, which are the properties of milk.

According to Seczyk *et al.* (2016) procedure (with modifications) and for both types of milk (raw and reconstituted), organoleptic analysis were evaluated by a consumer panel consisting of 23 members (11 male, 12 female, aged 23-51 years, all are academic or scientific staff and Ph.D. students from Guelma University). Before testing, all participants were enquired for possible food allergies to wheat or wheat components. Participants were instructed to rinse with water (20°C) before they began testing and between samples. Milk samples were evaluated for the appearance, color, texture, consistency and flavor. Sensory attributes were evaluated using a nine-point hedonic scale and values ranged from 1-9, wherein: (1) Extremely unpleasant, (2) Very unpleasant, (3) Moderately unpleasant, (4) slightly unpleasant, (5) Neither pleasant nor unpleasant, (6) Slightly pleasant, (7) Moderately pleasant, (8) Very pleasant and (9) Extremely pleasant (Seczyk *et al.*, 2016).

These depend on many microbiological and technological factors. The factors affecting the consistency of the milk are especially the dry extract, the heat treatment and the homogenization (FAO., 1998).

Note that all analyzes are performed according to standards set by the Algerian Ministry of Commerce and the Food and Agricultural Organisation (FAO) (Algerian-Government, 1993, 1998; FAO., 2010).

Statistical analysis: The results were expressed in the form of the Mean±SD (Standard Deviation). Physico-chemical parameters were measured in duplicates.

All results were analyzed on the basis of a comparison of the mean and an analysis of variance (ANOVA), followed by the test of Tukey, when the conditions of normality and homogeneity of the variances are observed or by the nonparametric test of multiple comparisons of Kruskal-Wallis test if necessary. Significance was considered at $p<0.05$ using MiniTab software [Minitab, Ltd., United Kingdom (Version 16)].

RESULTS AND DISCUSSION

For all the analyzed criteria, the results obtained from this analysis have shown that the raw milk meets the Algerian and the International standards.

Physicochemical analysis of raw milk: Results revealed that the raw milk acidity is equal to 16°D. The raw milk is stable for three months of the experiment and all average values of acidity milk are very close to those reported in the literature and recommendations from international authorities (FAO., 2010) (Fig. 1a).

Regarding fats, the results illustrated in Fig. 1b shows that the rate is between 30-40 g L^{-1} with no variation in the three months. Also, we can see that the density (Fig. 1c) is greater than 1000, however, the kinetic analysis shows that there is a significant variation in the second month ($p<0.05$), before returning to the initial rate at the 3rd month. All these results are in accordance with results reported by previous work from literature (Jacquinot, 1986; Vignola, 2002).

Solids-non-fat: The dry quantity is located between 6 and 8 g/100 mL (60-80 g L^{-1}) and a significant variation was observed in this parameter in the second month ($p<0.05$) (Fig. 1d). These results obtained during the three months are lower than the international standards (92 g L^{-1}) (Jacquinot, 1986). Outside of races, food and climatic conditions are the most important factors of these differences.

Lactose: These results show a significant change at the 3rd month in which the lactose content is between 3-4 g/100 mL (30-40 g L^{-1}) ($p<0.05$) (Fig. 1e). However, the total dry matter is stable during the period of experimentation and it is situated between 0.60-0.70 g/10 mL (60-70 g L^{-1}) (Fig. 1f), these results are substandard because, from literature, the total dry matter content is 13% by weight of milk or 125-130 g L^{-1} (Carroll *et al.*, 2006).

The total protein in raw milk is stable and situated between 2.60-2.70 g/100 mL (26-27 g L^{-1}) (Fig. 1g), but these results are lower compared to international standards 30-36 g L^{-1} (Snappe *et al.*, 2010).

Regarding the temperature no significant variation was recorded during 3 months. The temperature is between 4 and 6°C (Fig. 1h).

Comparing to the international standards, lactose, total dry matter and proteins quantities, are slightly lower (Jacquinot, 1986; Snappe *et al.*, 2010). These variations recorded are probably due to some problems in power management dairy cows and also due to the effect of environment combined with husbandry practices (Bernabucci *et al.*, 2015). In the literature, the level of energy supply is primarily responsible for variations in milk protein content (Zhou *et al.*, 2015). It can say also, that the composition of raw milk is influenced by several factors, including nutrition, age, stage of lactation and breed (Palmquist *et al.*, 1993; De Peters and Cant, 1992).

To overcome this problem an energy supply is necessary to stimulate the synthesis of microbial protein in the rumen (Zhou *et al.*, 2015).

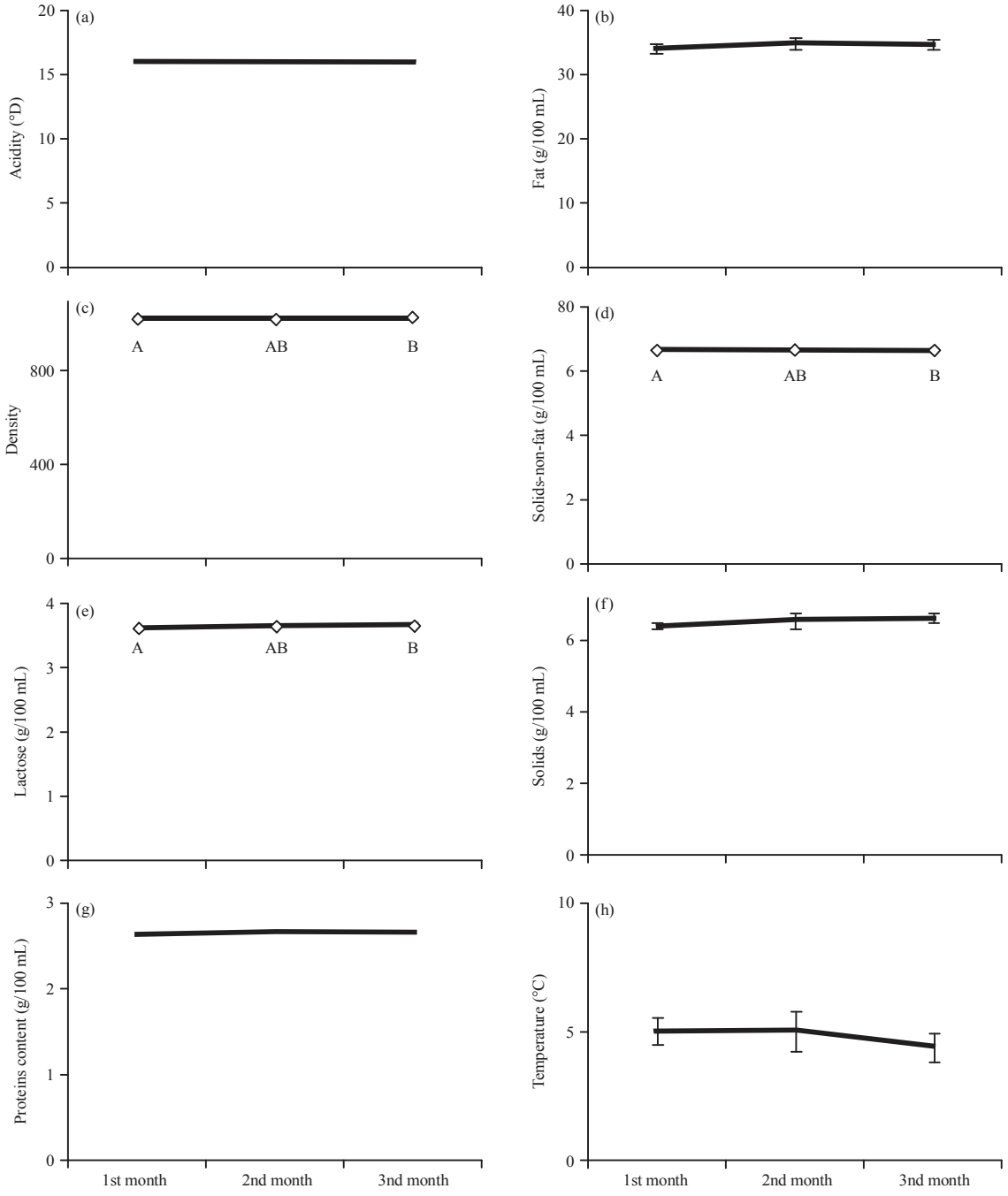

Fig. 1(a-h): Physicochemical analysis of raw milk levy over a period of three months in SAFIA dairy, (a) Acidity, (b) Fat, (c) Density, (d) Solids-non-fat, (e) Lactose, (f) Solids, (g) Proteins and (h) Temperature. The results are expressed as the Mean±SD (n = 5 samples/month). Data were subjected to analysis of variance (ANOVA) followed by Tukey's parametric test. A, B: Different letters indicate values significantly different ($p<0.05$)

Physicochemical analysis of reconstituted milk: As showed in raw milk, the acidity and fat content of reconstituted milk varies between 15-18°D and 15-16 g L^{-1}, respectively. The results are stable for three months of the experiment (Fig. 2a and b). Which correspond to Algerian and international standards (FAO., 2010; Algerian-Government, 1993).

In the same way, these results show that the density varied between 1028 and 1029 and the quantity of the solids-non-fat dry varied between 60-70 g L^{-1} (Fig. 2c and d).

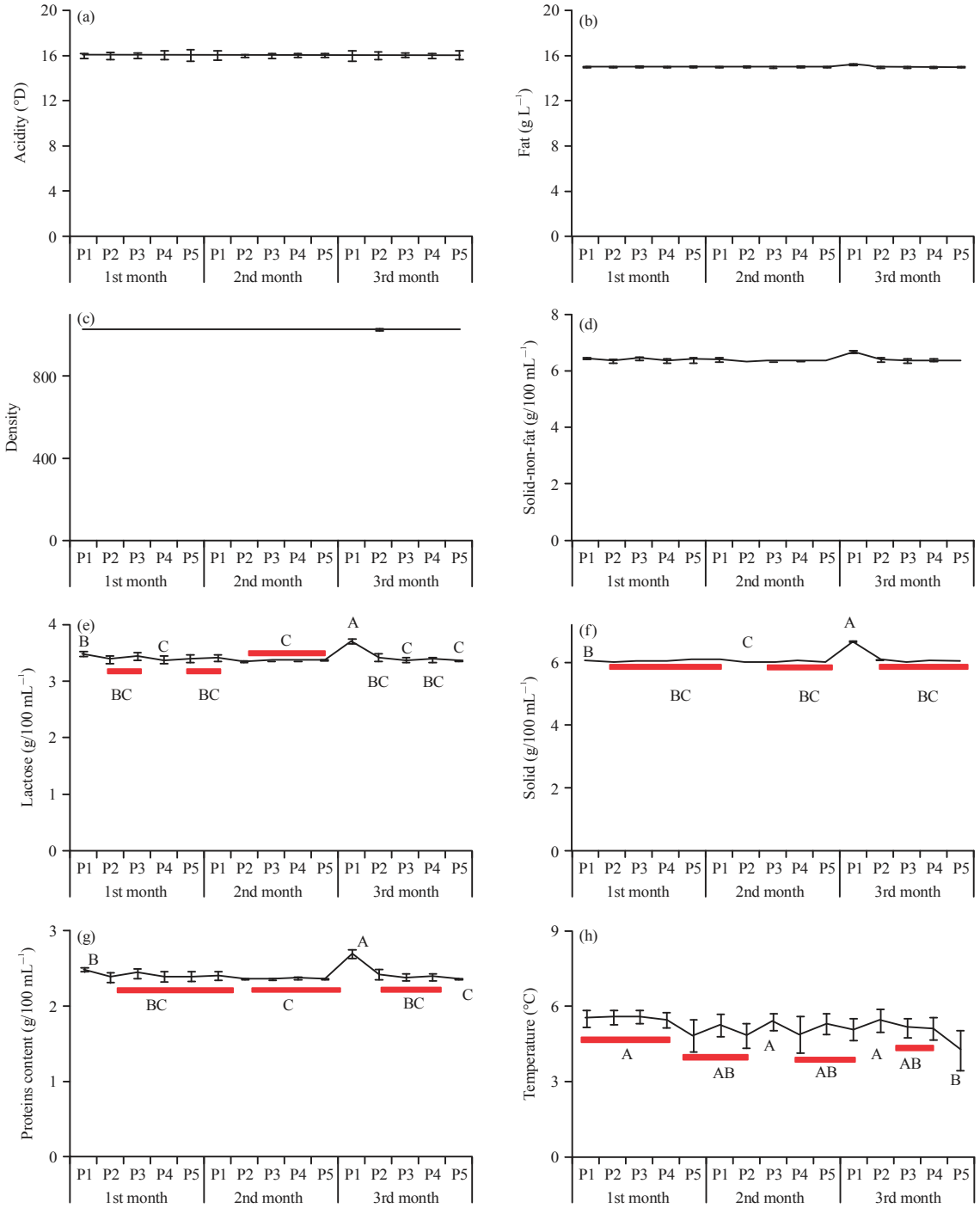

Fig. 2(a-h): Physicochemical analyzes reconstituted milk levy over a period of three months in SAFIA dairy, (a) Acidity, (b) Fat, (c) Density, (d) Solids-non-fat, (e) Lactose, (f) Solids, (g) Proteins and (h) Temperature. The results are expressed as the Mean±SD (n = 5 samples/month). Data were subjected to analysis of variance (ANOVA) followed by Tukey's parametric test. A, B, C: Different letters indicate values significantly different ($p<0.05$)

The quantity of lactose was also observed that varied between (30-40 g L^{-1}). During the experience, fluctuations was recorded with a significant peak at the first sampling of the 3rd month (Fig. 2e).

During the period of experimentation, total dry matter quantity situated between (60-66 g L^{-1}) (Fig. 2f). Furthermore, we have recorded some variations with a significant peak (Fig. 2f).

The total protein in reconstituted milk is situated between 20-30 g L^{-1} (Fig. 2g). However, we recorded fluctuations with a significant peak at the 1st sampling the 3rd month ($p<0.05$) (Fig. 2g).

The temperature showed significant fluctuations during the three months with significant variation starting from the 5th sampling ($p<0.05$) (Fig. 2h). The temperature was between 4 and 6°C.

All these significant variations or fluctuations recorded during the three months of the experimentation (rate lactose, total solids, protein and temperature) depend on the manufacturing process and/or measurement equipment and/or the quality of import milk powder.

Also, variations have recorded in lactose rate, total solids and protein content (compared to standards) and these changes are likely due to a fault in the manufacturing process and/or the quality of import milk powder, which is in concordance with other studies from literature (Ahmed and Abdellatif, 2013).

Bacteriological analysis: After incubation at 37°C for 24 h, the bacteriological results of milk (raw and reconstituted) reported that all samples show no contamination by germs, except the presence of some mesophilic total flora, between 10 and 300. Compared to the regulations, it can say that this products are considered as good in term of health quality. The preparation and the storage are made in satisfactory conditions (Algerian-Government, 1998).

Organoleptic analysis: The organoleptic characteristics of milk (raw and reconstituted) showed no change that can affect the taste, odor or color (data not shown), this also proves that no physicochemical and/or microbiological alteration has occurred in the products in question.

For both kinds of milk (raw and reconstituted) the interpretation of bacteriological results, has shown an acceptable hygienic quality, which meets the international standards (FAO., 2010; Amariglio, 1986) and Algerian standards (Algerian-Government, 1993).

CONCLUSION

Hygienic, bacteriological and organoleptic properties of milk (raw and reconstituted) present an acceptable threshold for human consumption with slight variations for some physicochemical parameters.

In the second part of this study, stability and reproducibility of the manufacturing process (physicochemical and bacteriological characteristics of milk) have demonstrated over a period of three months.

Finally, in order to guarantee the quality of the finished products:

- Management of dairy cows alimentation must be controlled (raw milk)
- Manufacturing units must be supplied with milk powder of good quality (reconstituted milk)

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