

Changes of Physicochemical composition of Moroccan bovine's milk along the years

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Abstract: Milk production in Morocco has increased in recent years to meet local demand. For this reason, this work was carried out to study the evolution of the main factors of physicochemical variation of fresh mixture milk of the cow harvested in Moroccan farms and cooperatives, by comparing them with the results of research carried out in Morocco during the last century. 52 samples were taken to represent the different periods of the year. The results showed that the physicochemical properties studied were not significantly improved over the years. Thus, the protein content (3.05%) decreased concerning the fat content (3.57%) in recent decades. This change is mainly related to lactation, cow diet and climate change. Overall, these results could help further studies aimed at controlling the physicochemical properties of milk, taking into account the factors mentioned.

Keywords: Fat; Protein; Defatted dry extract; Density; Raw milk.

Introduction

Cow's milk plays a significant role in the human chain food, and especially in the early stage of child feeding. It is an excellent source of energy for childhood and adulthood that thoroughly covers the need of the other nutrients ¹. Moreover, cow's milk could maintain the balance of the human nutritional needs ². In the last decades, the dairy industry in Morocco reached 96% in national milk production with its derivatives. However, this production is mainly affected by climate change and further factors ³. The livestock milk, which is intended for human consumption, is a mixture product of several milking cows. Recent studies, which were conducted in different Moroccan regions, showed that the quantity and the chemical properties of cow's milk are usually affected by climate constraints. Thus, throughout this study, we focused on physicochemical properties of cow's milk collected from different regions in Morocco. Moreover, each sample was analyzed to define its average content in terms of dry extract, defatted dry extract, fat, density, and protein. The overall analyses are useful to control the quality of milk for the producer on the one hand, and the dairy industry evolution in Morocco.

Experimental

Milk samples were collected from Gharb Charda Beni Hssen (GCBH) farms region. The collected samples were directly stored in sterile vials, at 4°C in a more relaxed and transferred to the laboratory for further analysis within 5 hours. All samples are representative of the regular operation of the dairy unit. A total number of 52 samples representing the usual operation of the dairy unit were examined at different ranges of time for more significant result regardless of diet and herd structure. Two analyzes per sample were performed to ensure the reliability of the analysis. Milk samples were collected from all cow's ages, and their density was measured by a lactodensimeter.

The fat content was determined by the Gerber acid-butyrometer method, which consists of an attack of milk with sulphuric acid and separation by centrifugation in the presence of isoamyl alcohol of the fat released ⁴. The dry matter content was measured after the desiccation process in the oven at 103±2°C ⁵. The protein content was measured by the Kjeldahl method ⁶.

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Results and discussion

Physicochemical analysis

The physicochemical characteristics results and the raw cow's milk composition are summarized in [Table 1](#).

The results showed a significant variation in terms of chemical composition of fats, proteins and total solids content.

The density measured at 20°C was ranged between 1.028 and 1.032, with an average value of

1.030. These results are in agreement with those reported by Labioui ⁷.

The average fat content varied from 3.45% to 3.81% with an average of 3.57%. This value remains lower than 4.11% and 4.1% reported by Lagneau and Belle, respectively ⁸.

The protein content varied from 2.92% to 3.17% with an average of 3.05%, which is lower than 3.19% and 3.15% reported by Srairi and Bassbasi respectively ^{9,10}.

Table 1. Descriptive statistics of physicochemical analyzes of raw milk from cows in the GCBH region.

Statistic	Density	Fat (%)	Defatted dry extract (%)	Protein (%)
Number of observations	52	52	52	52
Minimum	1.028	3.451	8.920	2.919
Maximum	1.032	3.810	9.480	3.165
1st Quartile	1.029	3.479	9.120	2.993
Median	1.030	3.587	9.195	3.065
3rd Quartile	1.031	3.631	9.240	3.102
Mean	1.030	3.573	9.183	3.053
Variance (n-1)	0.000	0.008	0.028	0.005
Standard deviation (n-1)	0.001	0.092	0.168	0.069

The variations show a similar trend of all the chemical components studied, and the variation of the defatted dry extract is the highest observation

dispersion. However, there is no variation in density. This shows that there is no water added to the milk.

The relationship between protein content and fat content is illustrated in [Figure 1](#).

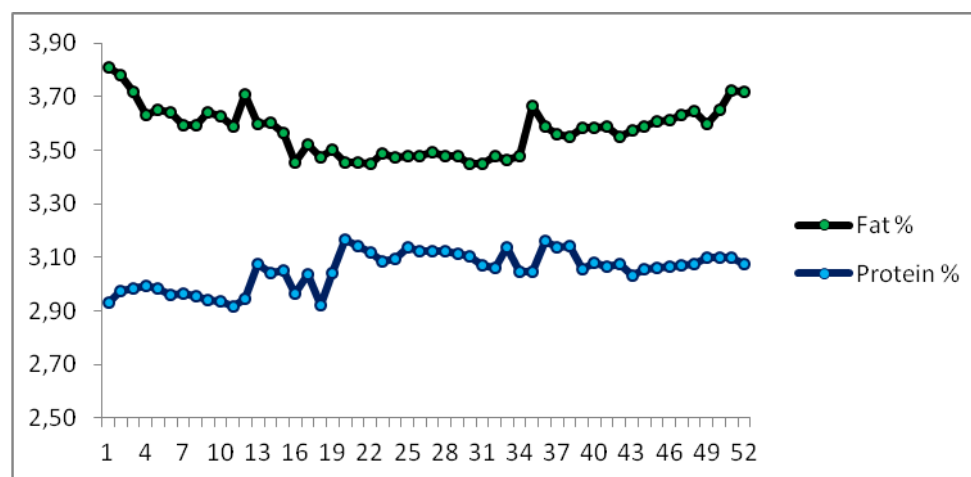


Figure 1. Relationship between protein and fat contents

According to [Figure 1](#), the protein content decreases compared to the content rate fat, which could be explained by the effect of the dietary factor on the fat and protein contents. Moreover, the lowest level of fat content leads to an increase in protein content and vice versa.

Evolution of Physicochemical properties of Moroccan bovine's milk

The evolution of milk composition concerning fat, protein content, dry extract, defatted dry content and density through years, since 1916 is showed in [Table 2](#).

Table 2. Evolution of the physicochemical composition of raw cow's milk in Morocco.

Milk from Morocco	Density	Protein (%)	Fat (%)	Defatted dry extract (%)	Dry extract (%)
Lagneau, 1916 ⁸	1.033	-	4.11	7	13.53
Velu et al., 1934 ¹¹	1.032	-	4.20	7.5	13.80
Belle, 1934 ⁸	1.032	-	4.10	7.21	13.48
Boujenane and Maty, 1986 ¹²	-	-	3.71	-	-
Boujenane et al., 2000 ¹³	-	-	3.65	-	-
Srairi et al., 2005 ¹⁰	1.028	3.19	3.70	-	-
Labioui et al., 2009 ⁷	1.030	-	3.60	-	12.1
Bassbasi et al., 2013 ⁹	-	3.15	3.76	9.01	-
El Hamdani et al., 2016 ¹⁴	1.031	3.18	3.47	8.6	-
Our analysis, 2018	1.030	3.05	3.57	9.18	-

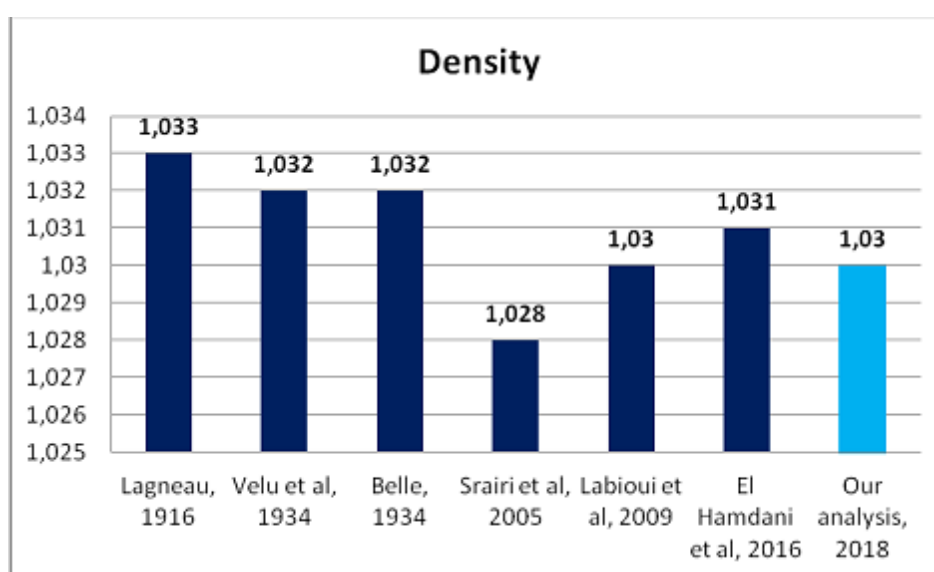
Overall, the quality of milk is always defined by numerous factors such as fat content, density as well as dry extract. These factors are taken into account during the industrial milk production (creams, skimmed milk, concentrated milk...) and especially during the process control ¹⁵.

Over the years, a list of criteria was established to determine milk prices to the farmer, along with supplementing the product with nitrogenous matter and especially with protein content. These variations of the composition of Moroccan milk over the years could be explained by the influence of various factors such as climate, diet, age, environment, race and producer.

Evolution of density

The density of the milk is not related to the cow's race, but the diet instead. Therefore, the more the fat content in milk is high, the more its density becomes low, whereas skim milk is characterized by a high density ¹⁶. Thus, density and fat content are two major fundamental parameters to determine the value of pure milk ¹⁷.

According to the comparison with the recent studies (Figure 2) and the current one in the GCBH region, we found out a slight variation between two densities (1.031 and 1.030 respectively). High-Fat milk has a low density, whereas skim milk has a high density of ¹⁶. This showed that density and fat remain two fundamental parameters that determine the value of milk ¹⁷. Comparison of our results with those reported in previous studies (Figure 2) in the GCBH region showed a slight variation in densities.

**Figure 2.** Evolution of the density of raw cow's milk from Morocco

Evolution of fat

The quality of the milk can be reached when the fat content of the milk is reached. Indeed, this factor is taken into consideration during the milk payment process. It is important to emphasize that the Moroccan milk cows composition from 1916 to 1934 did not show a critical variation (Figure 3). However, during this period, the fat content increased slightly from 4.1% to 4.2% in Moroccan cow's milk. Otherwise, the butter production reached the highest level comparing to the milk production due to the average fat content (3.8 up to 4.8%)¹⁸.

In contrast, the proportions of fat content between 1934 and 2018 were important (4.1% and 3.57% respectively). The fat content percentage depends mainly on food intake and the milking time. Indeed, results showed that the milk obtained during milking at the evening was more abundant in fat comparing to that obtained in the morning¹⁸. Besides, the fat content variation could also depend on other factors such as lactation stage, climate change and diet.

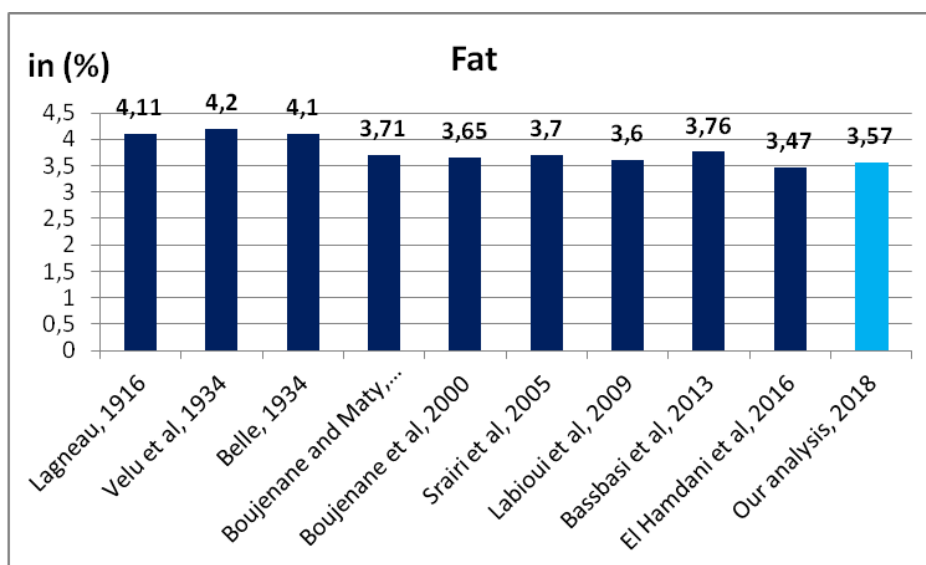


Figure 3. Evolution of the fat of raw cow's milk from Morocco.

Evolution of protein

The old works were not interested in the protein content in the milk. Indeed, it was not included in many cow's milk research. For many years, milk in Morocco was paid based on its weight, and then, it was paid according to its fat content, whereas in

many cases this milk was transformed into a product, such as cheese, contains fats and proteins in a concentrated form. This situation was maintained by the fact that the industries did not carry out a precise daily control concerning the protein content of the milk on hundreds of samples¹⁹.

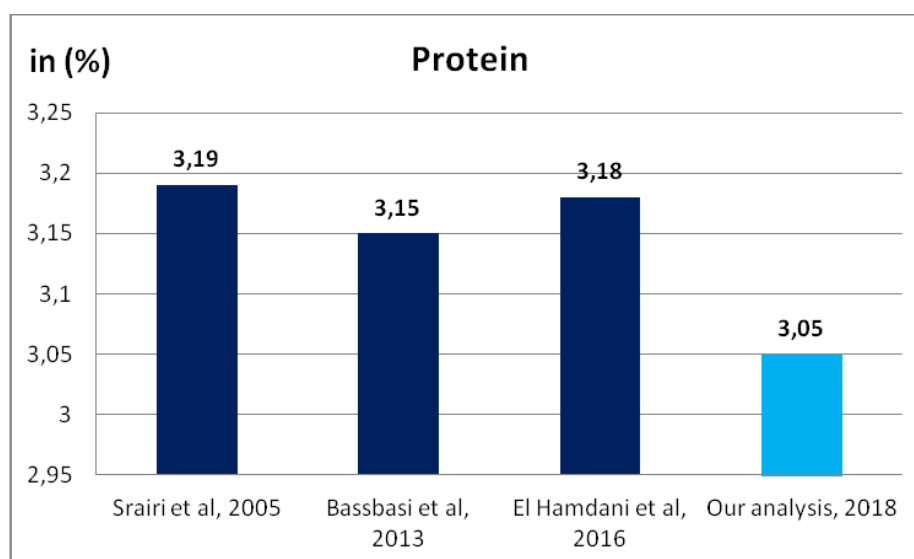


Figure 4. Evolution of the protein of raw cow's milk from Morocco

The protein content is much more stable than the fat content (Table 1), and this is for all studied cases. This observation is in agreement with the results of the previous studies (Table 2) highest level of concentrates, which are considered as a stabilizing factor of protein content²⁰. In our study, the average protein content did not reach 3.05%. On the other hand, it did not reach 3.19% for all studies treated (Figure 4). These contents are essential and showed the effect of massive and regular inputs of concentrates. Overall, protein content in cow's milk should be improved in further studies, along with

reducing fat content and adopting a high protein diet, ensuring the high quality of production in Morocco²¹.

Evolution of defatted dry extract

Moroccan cow's milk between 1916 and 1934 and that of 2017 showed an essential difference in terms of dry extract composition (Figure 5). However, the composition of the milk provided by Moroccan cows between 1916 and 1934, was the highest in dry extract. Therefore, the dry extract variation in cow's milk is exceptionally related to the fat and protein content variation.

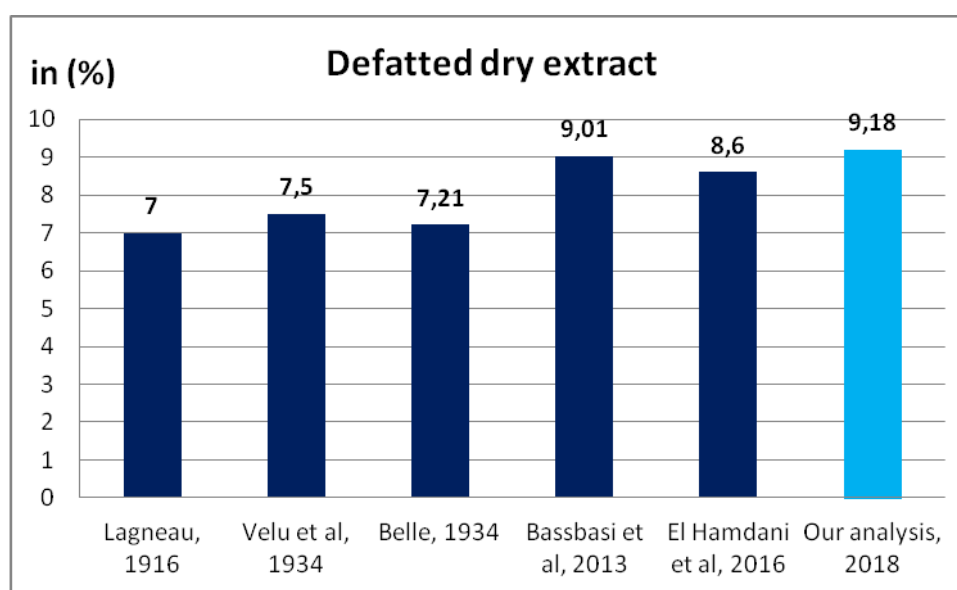


Figure 5. Evolution of the defatted dry extract of raw cow's milk from Morocco.

Conclusion

Our investigation on physical characteristics of raw milk in GCBH region did not show a significant variation of most studied parameters. This could be due to the mixing milk, which reduces extremely the importance of individual variations. Overall, in the last decades, chemical composition standards of cow's milk (fat, protein and dry extract content) remain important in the evolution of the dairy sector in Morocco. In the future, research will pose significant challenges if we try to increase the protein content while reducing the fat content.

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Conflict of Interest

The authors have no conflict of interest.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent

Not applicable.

Author contributions statements

Marouane Chrif did the analyzes and writing with the help of all the authors. All authors examined the manuscript.

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