# Study Concerning Milk Quality – Raw Material for Dairy Industry

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***Abstract*—This paper presents a study of some factors that could have an influence on the quality of milk used as raw material in the dairy industry. The research was conducted over a period of 10 months in three milk collection centres located in different geographic regions from north-eastern Romania. The analytical methods used were the classic ones, but also modern methods, which gave accurate results in a short time and so, could be easily interpreted. The statistical analysis has shown that other methods with rapid result response, and not standardized yet, were used successfully, because all the values of the statistic factor, Relative Standard Deviation (RSD), are under 1%, that is the limit for a method to be efficient, accepted by the normative.**

***Index Terms*—milk composition, influence factors, standard methods, analytical method, quality milk**

## I. Introduction

Milk and milk products production and also their consumption have registered a continuous global augmentation. The world milk turn-over is estimated near 560 millions of tones per year, about a quarter originated from Europe. In the last 10 years, milk demand and milk supply have increased with 26% or annually with 2.4%. Year 2015 can be described in the form of these values: 830 mill tonnes, world milk production of all species, standardised to Enterprise Content Management (ECM): 4.0% fat, 3.3% protein; 114 kg/year represents the average world consumption per person, in milk equivalents; 2.9 milk animals/farm, average world dairy farm size, related to cows or buffalos; 2.1 tonnes per year, average world milk yield per dairy cow/buffalo; 28 USD/100kg milk is the annual world milk price level. Global per capita dairy consumption will increase by 13 kg ME in the next 10 years (in 2025: 27 kg per person) [1].

In Romania 2015, the milk production in acquisition units means over 1 millions of tones, whereby cow milk is more than 87%. For the moment, Romania has over 112,000 farms for animal breaded for milk production, 90% of them having only 1 to 3 heads. The milk collection from small farmers is made in acquisition centres, situated in countryside, centres that could be connected with a processing unit or could be independent. There are about 1600 acquisition centres all over the country, the first places being hold by Suceava county and Botosani County, represented by 42% from total quantity of milk in Romania [2].

The importance of milk derives also from its nutritive value as well as its versatility for technological conversion through a very large number of dairy products, over 1000, that is the explanation for food diversification. Milk composition is influenced by a lot of factors, most important are: breed, season, region of production, age and type of feeding for the animal, especial on lactation time, all of them being synthetically represented in Fig. 1 [3]–[9].

Especially in mountain areas, dairy farming helps to vitalize lands, which due to their intrinsic harsh environment, could be at risk of abandonment. Furthermore, it provides a distinctive character to the land, which becomes a booster for tourism. Not ultimately, a prospering milk sector is important for the economy and employment.

A complete and balanced nourishment should lead to milk production increasing, without changing the composition elements. The quality, the quantity and the composition of milk is also influenced by climatic conditions, such as: meteo conditions, air humidity, air temperature and all these could produce significant increase or decrease of milk turn-over and also, could influence the percent of milk fat and protein [10]–[15].

The different combinations of these factors give rise to an enormous variety of milk reaching the grocery stores, even though significant attempts are made by the dairy companies to produce milk with a reproducible flavour and chemical composition [16]–[22]. Factors such as the type and proportion of proteins, fats, sugars, nucleic acids, vitamins and minerals present in milk, are among those that can vary [23]–[27]. For example, in the Romania, cows are generally offered dry feed and are kept indoors during the colder winter months and are only allowed to feed on the pasture during the warmer spring and summer months. These differences in feeding affect milk yield, the composition and other quality parameters of milk. The impact of climatic changes may be due to a combination of factors, such as compositional changes in the pasture and potential stress caused to animals during hot weather. The composition of milk, in particular fat and protein, changes during pasture feeding and this contributes to dairy products yield.

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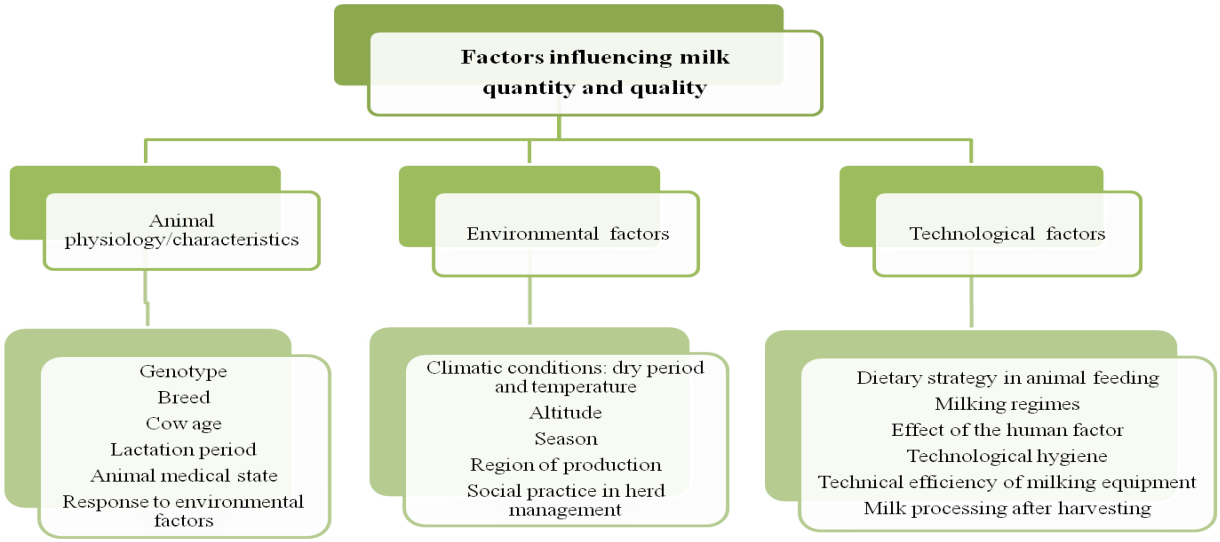


Figure 1. The main factors that influence quantity and quality of milk

FAO have synthesised those aspects that could influence the quantity and quality of milk (2011), as Good Farming Practice Guide, such as: animal health; milking hygiene; nutrition (feed and water); animal welfare; environment and socio-economic management. For example, the suggested good dairy farming practices for milking hygiene are set out under the following headings: "ensure milking routines, do not injure the animals or introduce contaminants into milk; ensure milking is carried out under hygienic conditions; ensure milk is handled properly after milking" [28].

Among the above aspects, in the present study we'll try to evaluate two of those environment factors: the region of production and the season time. In the speciality literature it has been asserted the significant influence of the season among milk composition, and must of all on fractions of milk major components [29].

A lot of experts have studied the influence of geographic milk origin [30]. In a 2014 study from FAO, it has shown that milk production per cow head, has generally ranged between 5000 and 9000 kg/dairy cow/year. Production per cow has presented significant differences, for example: started from 1290 kg milk/dairy cow/year in India, to more than 11600 kg milk/dairy cow/year in Israel. By combining production data with total number of animals that had led to an annual total milk production in volumes that were highly variable for the 15 countries that responded to the survey. The average was approximately 8 million tonnes per year, but has ranged from 1 million tonnes (Israel) to more than 100 million tonnes (India) [31].

Furthermore, in Japan, the specialist have developed brand-new checking methods for milk quality from each cow, every day, during milking and managing each cow, a system known as "*individual cow management*", because this demonstrate to be essential for a high-quality milk [32].

In the same time with technological development, also the technical assays for food quality and milk, by default, becomes more sophisticated, by using advanced equipments, able for higher precision results, in a shorter time, and being easier processed.

Because that milk is a perishable product, with low validity therm, it has to assert a rapid data processing, in a very short time from the reception that includes some initially physical-chemical analyses.

That is why, we have considered useful, to accomplish a number of analyses for the milk, by using as well as standard methods, with a large period of time, for determination and modern and rapid methods, with a short time of response.

## II. Materials and Methods

### A. Materials

The studied producing region is in north-eastern Romania, and the milk acquisition centres are in Suceava and Botoşani counties. Three centres have been identified:

- Dorna milk acquisition centre, in the mountainous region of Suceava County (occupying 2/3 of the county's terrain), 800-1800 m altitude;
- Fălticeni milk acquisition centre in the plateau region of Suceava County, 500-600 m altitude;
- Mihăloşeni acquisition centre, in the Moldavian Plain, which occupies ¾ of the county of Botoşani, 150-250 m altitude.

Volumes of milk collected by each acquisition centre comprised between 5000L and 10000L of milk per day. The milk mainly came from Holstein cows, but also from other breeds such as Bălţata Românească, Jersey and Brună. According to the season, cows were fed with hay, corn grain or silage, oat, concentrates or were put on pasture. Milking was usually done twice a day. Raw milk was generally collected every 24 h, or at maximum, every 48h. In the acquisition centres the milk was stored in tanks with a capacity between 1000L and 5000L.

This study was conducted during the period of January to October of 2016. Milk samples were collected daily from the three acquisition centres in compliance with the

reference standards: SR EN ISO 707:2009, SR 13438:1999 and SR 2418:2008 [33]–[35].

### B. Methods

The physical-chemical parameters of milk were analyzed in this experimental studies were: fat content, protein content and non-fat dry matter content.

Standard methods used were the acid-butirometric method for fat content - SR EN ISO 1211:2010, the Kjeldahl method for protein content - SR EN ISO 8968-1-4:2016 and oven drying method for the total dry substance – SR ISO 6731:96 [36]–[38].

Because of toxic chemical reagents, long-time reaction or titration, these methods are very difficult to apply for rapid raw milk quality analysis. For determination of protein, fat and non-fat dry matter content were used other analytical methods:

- **Ekomilk analyzer** (produced by EON TRADING LLC) is a device for the automatic analysis parameters in milk, with quick results for: fat, protein, non-fat dry matter, lactose, density, freezing point, added water, pH, temperature and conductivity of milk from cow, sheep / buffalo, goat. Some technical data: measuring time 180 s; Fat: 0.5% - 9% ± 0.1%; non-fat dry matter: 6% - 12% ± 0.2%; density: 1026-1033 g/cm$^3$ ± 0.0005; proteins: 2% - 6% ± 0.2%; added water in milk: 0% - 60% ± 5%;
- **Bentley 150 analyzer** (produced by BENTLEY) is a compact instrument used for highly accurate analysis of milk and dairy products. The unit consists of a computer, an optical system, a filter system and a unique infrared IR. The milk samples in specific vials (40mL) are inserted into the metal brackets attached to the apparatus and is heated in a water bath, until a temperature of 40 ℃ was reached. Further, the metal brackets supporting the vials are placed in a rail that guides the suction probe for analysis. Determination the composition of milk using a 150 Bentley device is made by measuring the absorbed energy specific to characteristic wavelengths in the middle of infrared region. The molecules of fat, protein, lactose and dry matter are agitated according to characteristic wavelengths and infrared radiation absorbed. The process of determining the concentration of components required is for 2 wavelengths. For each component, cells are radiated wavelength reference from first to tenth sample. This radiated infrared ray beam is collected in a detector. This process signal is sent to the computer. It calculates the result, comparing with reference measurements.
- **LACTOSTAR analyzer** (produced by FUNKE GERBER) is a device with a high degree of automation (washing, automatic rinsing, calibration to zero) for rapidly and accurately testing the milk. Some technical data: speed of analysis: 90 samples / hour; volume milk sample analyzed: 12-20 mL; reproducibility: ± 0.02% in the range of 0%...8%. For range of 8 and 40% reproducibility of 0.2%; measurement resolution is 0.01; accuracy depends on calibration. Results analysis is displayed in seconds. The sample is removed and pipelines are automatically washed and rinsed.

### C. Statistical Analysis

We have made also data statistic evaluation, by calculate, average (M), standard deviation (STDEV) and Relative Standard Deviation (RSD).

The formulas used for this statistical analysis are:

$$M= [n1+\ldots(n-1)+ n]/n \quad (1)$$

$$STDEV=\sqrt{1/(n-1)} \times \sum(D-M)^2 \quad (2)$$

$$RSD = STDEV/M \quad (3)$$

Treatment of data and statistical test were analyzed using SPSS software, version 16.0. A $p < 0.05$ was considered statistically significant. Analysis of Variance (ANOVA) was used to evaluate the main effects and the effect of the variables interaction on milk characteristics. The research design comprise two independent variables and dependent variables are represented by the milk biochemical characteristics – fat content, protein content and non-fat dry matter.

## III. Results and Discussion

### A. Influence of Season on Milk Quality - Raw Material

Milk samples from three milk collection centres in different geographical areas were taken in compliance with the benchmarks and qualitative assessed simultaneously by traditional methods and modern methods of analysis. The results are summarized in Table I, Table II and Table III.

As we could observe, the main influence of season was demonstrate among fat content: so, milk fat has bigger values in cold months: January until March, and started from April, since the cows started to be feed on the pasture, and also, they had intense activity (mobility), the fat content has decreased, and again, from September had registered another growth movement.

TABLE I. Physical - Chemical Parameters of Raw Milk Aquisition Center "Depresiunea Dornei"

| 2016 Month | Physical-chemical parameters-average values | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fat [%] | | | | Protein [%] | | | | Non-fat dry matter [%] | | | |
| | Standard method | Eko-Milk | Bentley | Lactostar | Standard method | Eko-Milk | Bentley | Lactostar | Standard method | Eko-Milk | Bentley | Lactostar |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 4.18 | 4.15 | 4.16 | 4.18 | 3.48 | 3.40 | 3.45 | 3.48 | 8.95 | 8.90 | 8.92 | 8.94 |
| 02 | 4.28 | 4.20 | 4.29 | 4.29 | 3.44 | 3.40 | 3.46 | 3.46 | 8.97 | 8.90 | 8.95 | 8.97 |
| 03 | 4.08 | 4.06 | 4.08 | 4.06 | 3.52 | 3.40 | 3.48 | 3.50 | 8.88 | 8.90 | 8.89 | 8.89 |
| 04 | 3.88 | 3.82 | 3.88 | 3.86 | 3.40 | 3.30 | 3.41 | 3.41 | 8.82 | 8.80 | 8.79 | 8.80 |
| 05 | 3.90 | 3.91 | 3.90 | 3.91 | 3.40 | 3.30 | 3.40 | 3.39 | 8.73 | 8.70 | 8.72 | 8.73 |
| 06 | 3.72 | 3.69 | 3.70 | 3.70 | 3.30 | 3.30 | 3.32 | 3.31 | 8.48 | 8.50 | 8.48 | 8.50 |
| 07 | 3.78 | 3.74 | 3.74 | 3.76 | 3.35 | 3.30 | 3.36 | 3.35 | 8.62 | 8.60 | 8.60 | 8.63 |
| 08 | 3.98 | 3.92 | 3.97 | 3.96 | 3.37 | 3.30 | 3.37 | 3.37 | 8.82 | 8.80 | 8.82 | 8.82 |
| 09 | 4.08 | 4.06 | 4.05 | 4.06 | 3.42 | 3.40 | 3.39 | 3.40 | 8.65 | 8.60 | 8.66 | 8.66 |
| 10 | 4.15 | 4.16 | 4.20 | 4.18 | 3.44 | 3.40 | 3.46 | 3.46 | 8.76 | 8.80 | 8.77 | 8.78 |
| Average | 4.00 | 3.97 | 3.99 | 3.99 | 3.41 | 3.35 | 3.41 | 3.41 | 8.76 | 8.75 | 8.76 | 8.77 |
| STDEV | 0.17 | 0.17 | 0.18 | 0.18 | 0.06 | 0.05 | 0.04 | 0.05 | 0.14 | 0.13 | 0.14 | 0.13 |
| RSD | 0.04 | 0.04 | 0.05 | 0.05 | 0.02 | 0.02 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.02 |

TABLE II. PHYSICAL - CHEMICAL PARAMETERS OF RAW MILK AQUISITION CENTER "PODIŞUL FĂLTICENI"

| 2016 Month | Physical-chemical parameters-average values | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fat [%] | | | | Protein [%] | | | | Non-fat dry matter [%] | | | |
| | Standard method | Eko-Milk | Bentley | Lactostar | Standard method | Eko-Milk | Bentley | Lactostar | Standard method | Eko-Milk | Bentley | Lactostar |
| 01 | 4.10 | 4.11 | 4.10 | 4.09 | 3.42 | 3.40 | 3.41 | 3.41 | 8.84 | 8.80 | 8.84 | 8.82 |
| 02 | 4.06 | 4.05 | 4.05 | 4.06 | 3.35 | 3.30 | 3.34 | 3.32 | 8.79 | 8.80 | 8.80 | 8.80 |
| 03 | 4.08 | 4.06 | 4.07 | 4.08 | 3.34 | 3.30 | 3.34 | 3.32 | 8.82 | 8.80 | 8.81 | 8.83 |
| 04 | 3.90 | 3.92 | 3.92 | 3.92 | 3.29 | 3.30 | 3.30 | 3.30 | 8.74 | 8.70 | 8.74 | 8.72 |
| 05 | 3.90 | 3.88 | 3.90 | 3.88 | 3.32 | 3.30 | 3.34 | 3.31 | 8.74 | 8.70 | 8.72 | 8.70 |
| 06 | 3.76 | 3.78 | 3.76 | 3.76 | 3.26 | 3.20 | 3.24 | 3.24 | 8.65 | 8.60 | 8.65 | 8.63 |
| 07 | 3.70 | 3.74 | 3.72 | 3.72 | 3.24 | 3.20 | 3.25 | 3.24 | 8.63 | 8.60 | 8.62 | 8.62 |
| 08 | 3.85 | 3.84 | 3.84 | 3.85 | 3.32 | 3.30 | 3.31 | 3.31 | 8.72 | 8.70 | 8.71 | 8.71 |
| 09 | 3.85 | 3.85 | 3.82 | 3.84 | 3.30 | 3.30 | 3.30 | 3.29 | 8.72 | 8.70 | 8.72 | 8.72 |
| 10 | 4.08 | 4.10 | 4.08 | 4.09 | 3.44 | 3.40 | 3.42 | 3.42 | 8.79 | 8.80 | 8.82 | 8.82 |
| Average | 3.92 | 3.93 | 3.92 | 3.92 | 3.32 | 3.30 | 3.32 | 3.31 | 8.74 | 8.72 | 8.74 | 8.73 |
| STDEV | 0.13 | 0.130 | 0.13 | 0.13 | 0.06 | 0.06 | 0.05 | 0.05 | 0.06 | 0.07 | 0.07 | 0.07 |
| RSD | 0.04 | 0.03 | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 |

TABLE III. PHYSICAL - CHEMICAL PARAMETERS OF RAW MILK AQUISITION CENTER "CAMPIA MOLDOVEI"

| 2016 Month | Physical-chemical parameters-average values | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fat [%] | | | | Protein [%] | | | | Non-fat dry matter [%] | | | |
| | Standard method | Eko-Milk | Bentley | Lactostar | Standard method | Eko-Milk | Bentley | Lactostar | Standard method | Eko-Milk | Bentley | Lactostar |
| 01 | 3.80 | 3.78 | 3.76 | 3.76 | 3.32 | 3.30 | 3.32 | 3.33 | 8.65 | 8.60 | 8.64 | 8.64 |
| 02 | 3.72 | 3.73 | 3.72 | 3.72 | 3.30 | 3.30 | 3.32 | 3.32 | 8.62 | 8.60 | 8.59 | 8.60 |
| 03 | 3.68 | 3.70 | 3.72 | 3.71 | 3.31 | 3.30 | 3.31 | 3.34 | 8.64 | 8.60 | 8.64 | 8.62 |
| 04 | 3.46 | 3.45 | 3.45 | 3.46 | 3.27 | 3.30 | 3.28 | 3.27 | 8.54 | 8.50 | 8.56 | 8.56 |
| 05 | 3.41 | 3.42 | 3.41 | 3.42 | 3.28 | 3.30 | 3.26 | 3.26 | 8.52 | 8.50 | 8.52 | 8.50 |
| 06 | 3.35 | 3.36 | 3.35 | 3.32 | 3.25 | 3.20 | 3.25 | 3.24 | 8.48 | 8.50 | 8.47 | 8.48 |
| 07 | 3.36 | 3.35 | 3.34 | 3.34 | 3.24 | 3.20 | 3.24 | 3.21 | 8.51 | 8.50 | 8.50 | 8.50 |
| 08 | 3.60 | 3.60 | 3.58 | 3.59 | 3.32 | 3.30 | 3.31 | 3.32 | 8.58 | 8.60 | 8.62 | 8.60 |
| 09 | 3.72 | 3.72 | 3.72 | 3.72 | 3.38 | 3.40 | 3.36 | 3.40 | 8.64 | 8.60 | 8.62 | 8.64 |
| 10 | 3.82 | 3.84 | 3.82 | 3.80 | 3.39 | 3.40 | 3.39 | 3.38 | 8.72 | 8.70 | 8.74 | 8.72 |
| Average | 3.59 | 3.59 | 3.58 | 3.58 | 3.30 | 3.30 | 3.30 | 3.30 | 8.59 | 8.57 | 8.59 | 8.59 |
| STDEV | 0.17 | 0.17 | 0.17 | 0.17 | 0.04 | 0.06 | 0.04 | 0.05 | 0.07 | 0.06 | 0.07 | 0.07 |
| RSD | 0.05 | 0.05 | 0.05 | 0.05 | 0.01 | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 |

The season influence on the protein content was not as significant, as it has considered, even if exists some interrelation between fat and protein. The differences observed among table values are explained by the analytical principle of the equipment. The standard methods, in this case, Kjeldahl method is more sensible,

the result depends fundamental by the weigh of the sample. By comparison, the other three methods use the volume of the sample.

Looking at non-fat dry matter related with season, the conclusion is simple, because it depends of difference between total dry substance and fat and protein, whose variability was already discussed.

Although, at first sight, there are some differences between the values of those three parameters, effectuated by meaning of four analytical methods, the statistical analyze has shown that we could use successfully other methods with rapid result response, that are not standardized, because all the values of the statistic factor, RSD (relative standard deviation), are under 1%, that is the limit for a method to be performant, accepted by the normatives.

### *B. Influence of Region of Production on Milk Quality - Raw Material*

The evaluation results of the main effects of region of production on the milk characteristics (fat, protein and non-fat dry matter content) on the one hand and the interaction effect between the factors, on the other hand, are presented in Fig. 2.

Analysis of variance revealed significant interaction effect for acquisition centre on milk characteristics (fat content, protein and non-fat dry matter content) and statistically less significant interaction effects between acquisition centre and analysis method. Multiple comparisons indicate that in "Vatra Dornei" acquisition centre, the mean value of fat content was higher than in "Falticeni", respective, in "Campia Moldovei".

Regarding fat content, the mean difference was significant at $p < 0.05$ between milk acquisition in Vatra-Dornei and Campia Moldovei centres, and between the milk acquisition in Falticeni and Campia Moldovei centres. Non significant difference ($p > 0.05$) was found between the mean value of the fat content of milk from Falticeni acquisition centre and Vatra-Dornei.

From the point of view of protein content, the mean difference was significant at $p < 0.05$ between milk acquisitions in Vatra-Dornei and Falticeni, respective, Campia Moldovei, while non significant difference ($p > 0.05$) was found between the mean value of milk from Falticeni and Campia Moldovei centres.

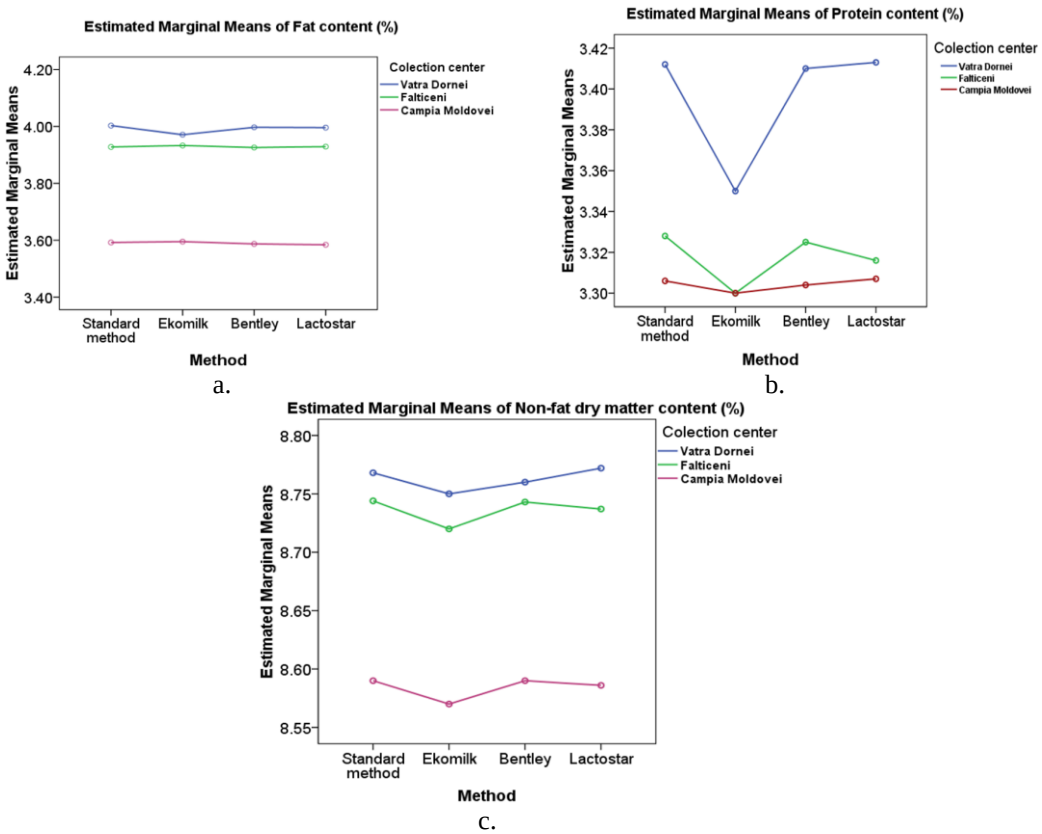


Figure 2. Estimated marginal means of: a) fat content; b) protein content; c) Non-fat dry matter content

About non-fat dry matter content, the mean difference was significant at $p < 0.05$ between milk acquisitions in Vatra-Dornei and Campia Moldovei and, between milk acquisitions in Falticeni and Campia Moldovei centers. Non significant difference ($p > 0.05$) was found between the mean value of milk from Vatra-Dornei and Falticeni centres. Regarding milk characteristics measured through four methods, the highest content of fat, protein and non-fat dry matter was obtained for milk collected in "Vatra

Dornei" centre and the lowest values were obtained for the milk collected in the "Câmpia Moldovei" centre, without attending the analytical method.

From Fig. 3 it can be observed that by Ekomilk method, the same protein content values were obtained for both

Falticeni milk and for the collected from Câmpia Moldovei. The Ecomilk method produced lower values for protein content, compared to other methods used.

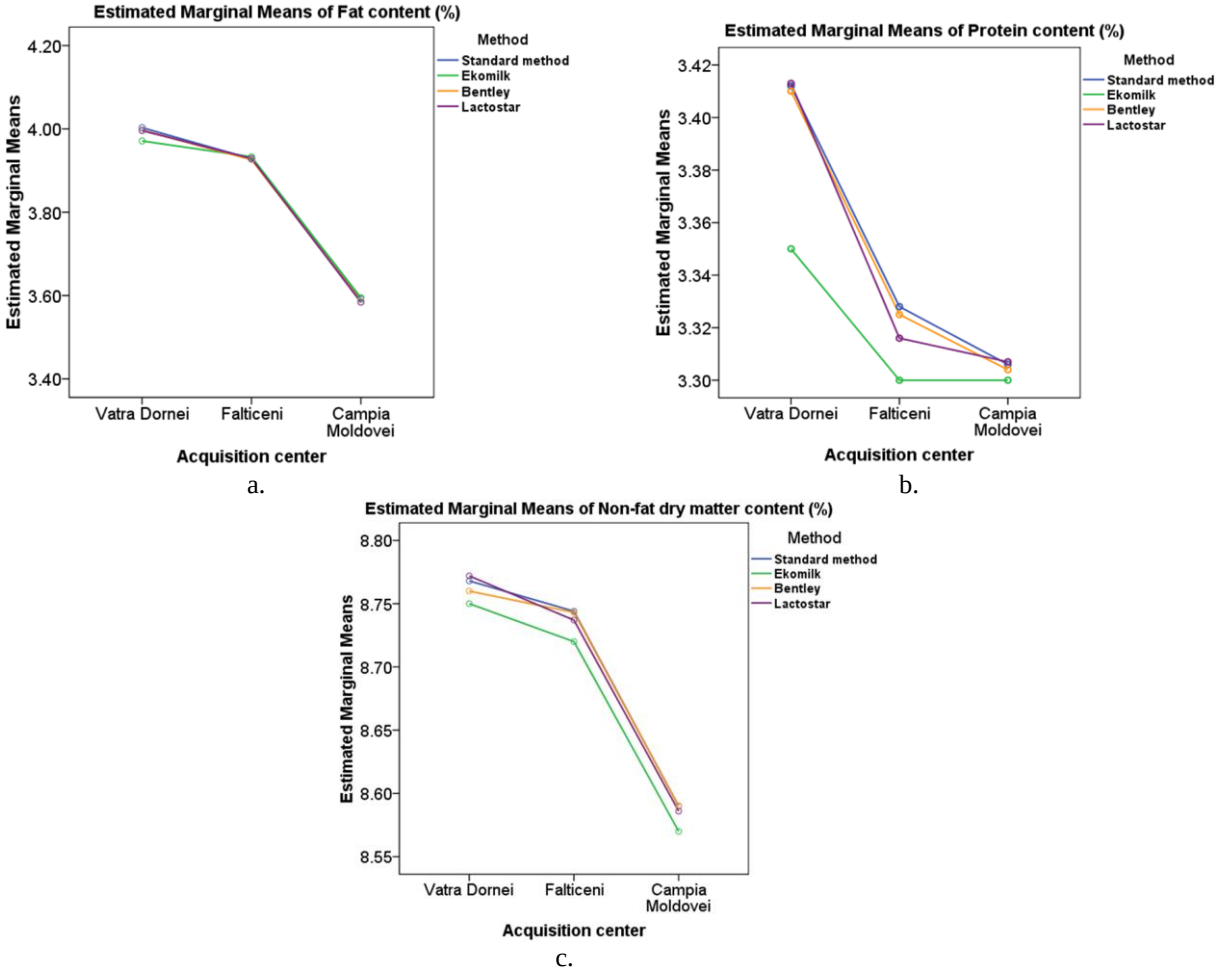


Figure 3. Estimated marginal means of: a) fat content; b) protein content; c) Non-fat dry matter content

## IV. Conclusions

This paper presents results from a study on milk quality, carried out over 10 months among three milk collection centres, from different geographical areas, in north-eastern Romania.

Quality rating of milk has concerned specialists in the field, whom thought to find the most appropriate and accurate analytical methods, in order to highlight its physical and chemical parameters, in order to determine the processing destination in the dairy industry. The methods used in this work were standardized methods and modern methods that will produce quick results in a shorter time.

The variation of cow milk composition that has been studied could be explained by following reasons: climatic conditions varies from season to season, from year to year, which leads to thermal stress on these animals, with repercussions in milk composition; animal care by empirical methods; the constant aging of rural inhabitants leads to decreasing labour power and their ability for a properly caring of animals and especially, for aligning in conformity with European normatives and standards; the existence of animals with low quantitative and qualitative productivity etc.

However in recent years the quality of cow's milk in Romania has improved thanks to the interest of manufacturers to produce a wide range of dairy products of constant quality.

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