STUDIES REGARDING THE EFFECT OF BOILING ON COW MILK QUALITY WITH ANALYSIS OF SOME PHYSICO-CHEMICAL CHARACTERISTICS AND THE SOMATIC CELL COUNT

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Abstract. *Due to their chemical composition and high degree of assimilation, milk and dairy products play an important role in rational human nutrition and are some of the easiest assailable animal protein sources. They are foods with a particularly valuable plastic role in the nutrition of both children and adults and elderly. There are numerous studies and research showing that milk may undergo various changes during preparation (by boiling or microwaving) or during processing, heat treatment methods involving moderate or severe and can lead to undesirable changes. The goal of this paper is to point out the effect of boiling on density, surface tension, fat content, solids-non-fat content, dry matter and number of somatic cell for the evaluation of the correlations between these parameters by analysing fresh milk and boiled milk. The material used in the study was represented by five individual samples of milk, originated from clinically healthy cows. The milk was divided into two portions, the second being subject to heat treatment by boiling. Were analyzed a total of 10 samples (5 fresh milk and 5 boiled milk). The chemical composition of the milk was determined by means of the apparatus MilkoScan S54B, somatic cell count (NSC – number of somatic cell) by cell counter MT-02®, density by picnometric method and surface tension by stalagmometric method. To process experimental data and extract as much information from the results was used the technique of statistical principal component analysis (PCA), realizing all the necessary processing with software XLSTAT, Version 2015.1. Fresh milk fat ranged between 3.30 and 5.29 [g%], while for boiled milk between 3.51 and 5.16 [g%]. Fresh milk solids-not-fat ranged between 9.13 and 10.24 [g%], while for boiled milk was between 9.41 and 10.71 [g%]. NSC for fresh milk ranged between 100.000 and 310.000 cell/ml, for boiled milk between 50.000 and 115.000 cell/ml.*

Key words: *cow milk, somatic cell count, physico-chemical parameters*

INTRODUCTION

Due to their chemical composition and high degree of assimilation, milk and dairy products play an important role in rational human nutrition and are some of the easiest assailable animal protein sources. They are foods with a particularly valuable plastic role in the nutrition of both children and adults and elderly.

The over 200 components of milk – some present in large amounts (water, fats, carbohydrates, proteins) and others in small amounts – are linked and they play an extremely role in dairy product processing technologies.

Boiling milk has numerous benefits for human health – food safety – but there are numerous studies and researches showing that milk undergoes changes while being prepared (boiling or microwave exposure) or processed. Methods that suppose moderate or severe thermal treatment can result in unwanted changes [5,6,11,15].

Literature refers mainly to the effects of pasteurisation or UHT treatment on milk composition. The main effects of thermal treatment of nutritional importance are vitamin degradation, whey protein decay (they can be beneficial since they improve protein digestibility and decrease allergenic properties), Maillard reactions between reducing sugars and ε-amino groups of lysine residues in protein and lactose reactions [10].

There is increasing concern for consuming milk that also meets hygiene requirements (health state).

The goal of this paper is to point out the effect of boiling on density (ρ), surface tension (σ), fat content (Fat), solids-non-fat content (SNF), dry matter (SU) and number of somatic cells (NSC) for the evaluation of the correlations between these parameters by analysing fresh milk and boiled milk.

Biophysical measurements were made within the Laboratory of Biophysics of the Faculty of Medicine of the University of Medicine and Pharmacy from Timisoara (UMP), Romania, with standardised methods; chemical features and the number of somatic cells were determined within the Research Laboratory of the subject area Technology of Raising Bovines of the Faculty of Animal Science and Biotechnologies of the Banat's University of Agricultural Sciences and Veterinary Medicine "King Michael I of Romania" (BUASVM) from Timisoara, Romania.

MATERIAL AND METHODS

In March 2015, we sampled from clinically healthy cows of the BUASVM Farm 5 fresh milk samples 700 ml each. Right after milking, the samples were carried to the laboratory for analyses. The milk was divided into two, the latter of which was subjected to thermal treatment (boiling). The former was analysed as fresh milk, and the latter was analysed as boiled milk after cooling down. We analysed 10 samples (5 samples of fresh milk and 5 samples of boiled milk).

Part of the physico-chemical analyses were carried out in the Research Laboratory of the subject area Technology of Raising Bovines of the Faculty of Animal Science and Biotechnologies of BUASVM from Timisoara and the rest was carried out at the Laboratory of Biophysics of UMP from Timisoara.

The chemical composition of the milk was determined with a MilkoScan S54B apparatus, the number of somatic cells (NSC) was determined with the somatic cell counter MT-02®, density through the picnometric method and surface tension through the stalagmometric method.

With the MilkoScan S54B apparatus, one can determine the fat percentage and the skimmed dry matter percentage; by adding the two, one can get the total dry matter percentage in milk. We calculated dry matter (SU) by adding milk fat to not-fat solids. Measurements of the chemical composition of milk and dairy products are done through infrared spectrometry. Infrared rays are sent through the sample in the recipient and then the sample is read by an analyser; results are compared with pre-set curves determining the chemical composition of the sample.

Physico-chemical measurements were made in the Laboratory of Biophysics through standardised methods [3,17].

Milk density, together with pH, acidity and dry matter are criteria for milk quality and marketing value assessment upon delivery.

Milk surface tension is 53-54 dyn/cm. The low value of milk surface tension compared to that of water can be explained by the fact that fats are emulsified and proteins are dispersed colloidally [4].

Recent studies show that microwave treatment or boiling of milk reduces significantly the number of somatic cells [7,8].

To process experimental data and get as many information as possible from the results, we used the statistical technique of principal component analysis (PCA); all processing was done with the software XLSTAT, Version 2015.1. Principal component analysis (PCA) is a particular case of a statistical analysis technique known as factor analysis, whose final goal is to point out pre-existing structures within a multitude of multivariable data. These structures, in general, are expressed through variable variance, covariance, similarities, and dissimilarities between objects [12,16]. The values of the parameters were expressed as means (±standard deviation) of the confidence coefficient of 95%.

To check the correlation relationship between physico-chemical features and NSC, we used the method of interpreting Pearson correlation coefficients [13]: very strong association of coefficient correlation 0.7 or above; significant association for coefficients 0.5 or above; moderate correlation for coefficients 0.3 or above; low correlation for coefficients 0.1 or above.

RESULTS AND DISCUSSION

In assessing milk quality upon collection for industrial processing, density is used as an indicator of integrity and, according to standards, it should be at least 1.027 g/cm^3.

Between the value of density and content of total skimmed substance, there is a strong correlation. It allows using density in different formulas to calculate the content of these constituents.

The number of somatic cells is nowadays one of the main indices of milk quality; in Norway, it was introduced as a criterion in pricing milk [1,2,9].

Data in literature shows that viscosity is a biophysical parameter that can be used in assessing protein content in milk [14]. It was also found that there are significant correlations between milk viscosity and NSC in both fresh and boiled milk [7].

Table 1 below presents a summary of descriptive statistics of physico-chemical features in assessing milk nutritive quality.

Table 1.

Descriptive statistics of physico-chemical features of milk

Descriptive statistics (abstract)					
Variable	Number of samples	Minimum	Maximum	Media	Standard deviation
Fat p	5	3,300	5,290	4,488	0,728
SNF p	5	9,130	10,240	9,560	0,442
SU p	5	12,560	14,950	14,048	0,956
σ p	5	56,460	58,780	57,496	0,836
ρ p	5	1,028	1,033	1,030	0,002
ρr p	5	1,025	1,030	1,028	0,002
NSC p	5	100.000,00	310.000,00	209.000,00	75.531,45
Fat f	5	3,510	5,160	4,554	0,636
SNF f	5	9,410	10,710	9,876	0,495
SU f	5	13,340	15,580	14,430	0,800
σ f	5	58,390	62,980	60,346	1,787
ρ f	5	1,027	1,031	1,029	0,002
ρr f	5	1,024	1,028	1,026	0,002
NSC f	5	50.000,00	150.000,00	115.000,00	38.405,72
(**p** index – for fresh milk and **f** index -for boiled milk)					

Fat varied between 3,30 and 5.29 [g%] in fresh milk and between 3.51 and 5.16 [g%] in boiled milk. Non-fat substances varied between 9.13 and 10.24 [g%] in fresh milk and between 9.41 and 10.71 [g%] in boiled milk.

NSC varied between 100.000 and 310.000 (per ml) in fresh milk and between 50.000 and 115.000 (per ml) in boiled milk. Relative density varied between 1.025 and 1.030 in fresh milk and between 1.024 and 1.028 in boiled milk.

The matrix of Pearson correlation coefficients (table 2) shows that there is a significant positive correlation between fat and dry matter (r=0.897). Likewise, there is a significant positive correlation between fat and NSC in both fresh (r=0.964) and boiled (r=0.918) milk.

Table 2.

Matrix of Pearson correlation between fat, non-fat substances (SNF), dry matter (SU), density (ρ), surface tension(σ) and NSC in fresh and boiled milk

Matrix of Pearson correlation (n):														
Variables	Fat p	SNF p	SU p	σ p	ρ p	ρr p	NSC p	Fat f	SNF f	SU f	σ f	ρ f	ρr f	NSC f
Fat p	**1**	0,294	**0,897**	-0,022	-0,427	-0,549	**0,964**	**0,979**	-0,114	0,708	-0,813	-0,475	-0,474	**0,967**
SNF p	0,294	**1**	0,686	0,495	0,675	0,549	0,292	0,303	0,834	0,757	-0,332	0,610	0,620	0,294
SU p	**0,897**	0,686	**1**	0,212	-0,013	-0,164	0,869	**0,885**	0,299	**0,889**	-0,772	-0,080	-0,074	0,872
σ p	-0,022	0,495	0,212	**1**	0,607	0,547	-0,132	0,137	0,772	0,587	0,454	0,685	0,681	-0,210
ρ p	-0,427	0,675	-0,013	0,607	**1**	**0,986**	-0,364	-0,400	0,811	0,184	0,385	0,844	0,856	-0,478
ρr p	-0,549	0,549	-0,164	0,547	**0,986**	**1**	-0,468	-0,530	0,722	0,026	0,488	0,809	0,822	-0,600
NSC p	**0,964**	0,292	0,869	-0,132	-0,364	-0,468	**1**	**0,898**	-0,197	0,592	-0,851	-0,551	-0,544	**0,939**
Fat f	**0,979**	0,303	**0,885**	0,137	-0,400	-0,530	**0,898**	**1**	-0,015	0,786	-0,701	-0,373	-0,376	**0,918**
SNF f	-0,114	0,834	0,299	0,772	0,811	0,722	-0,197	-0,015	**1**	0,607	0,190	**0,926**	**0,927**	-0,156
SU f	0,708	0,757	**0,889**	0,587	0,184	0,026	0,592	0,786	0,607	**1**	-0,439	0,276	0,275	0,633
σ f	-0,813	-0,332	-0,772	0,454	0,385	0,488	-0,851	-0,701	0,190	-0,439	**1**	0,474	0,467	**-0,923**
ρ f	-0,475	0,610	-0,080	0,685	0,844	0,809	-0,551	-0,373	**0,926**	0,276	0,474	**1**	**1,000**	-0,495
ρr f	-0,474	0,620	-0,074	0,681	0,856	0,822	-0,544	-0,376	**0,927**	0,275	0,467	**1,000**	**1**	-0,494
NSC f	0,967	0,294	0,872	-0,210	-0,478	-0,600	0,939	0,918	**-0,156**	0,633	-0,923	**-0,495**	**-0,494**	1
Values in bold are different from 0 with a significance level alpha=0,05 **(p index – for fresh milk and f index -for boiled milk)**														

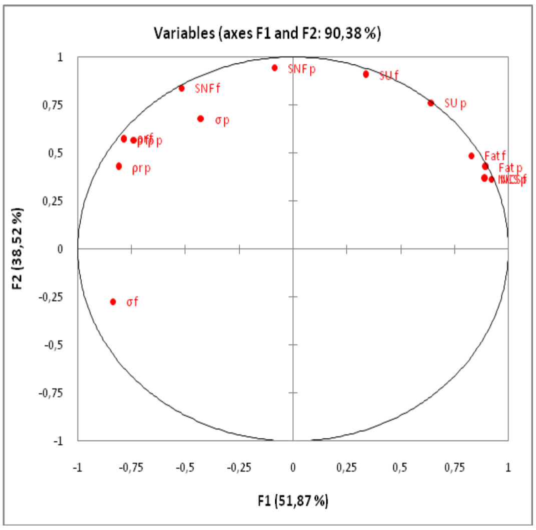

Figure 1. PCA analysis of physico-chemical features of the milk samples

PCA was determined to assess the comprehensive effect of boiling on physico-chemical features of cow milk from a descriptive perspective. We see that two principal components (PCs) explain 90.38% of the variations in the data set.

According to factor distribution, we see that the variables “Fat”, “NSC”, “ρr” correlate strongly with the first factor and the variables “SNF”, “SU”, “σ” with the second factor. The other variables correlate only moderately with the factors, and two of them correlate approximately the same way with both factors.

The first factor reflects the size of **the nutritive value** (density, fat percentage, NSC) to be successful on the food market, and the second factor reflects **the physico-chemical context** to be successful on the food market (dry matter, non-fat substances, surface tension coefficient).

Figure 1 presents the PCA analysis of the physico-chemical features investigated in the milk samples; from a descriptive perspective, the highest induction is in fat and NSC.

Principal component analysis (PCA) presented in figure 2 groups the studied variables. Fat, dry matter and NSC of fresh and boiled milk are grouped in the fourth case, which points out the existence of a significant correlation also confirmed by table 1 presenting Pearson correlation coefficients.

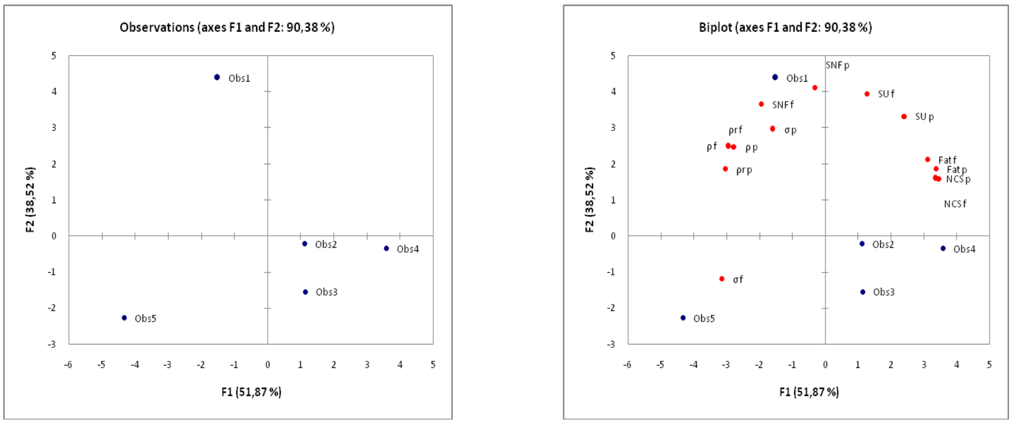

Figure 2. PCA presented through variables

Using the principal component analysis aimed at getting results that are easy to interpret, more suggestive and supplying large amounts of information. For good reasons and to ease the work, we only used one image to incorporate about 90-95% of the information in the N measurements. At the same time, principal component analysis allowed information for the quality assessment of cow milk (nutritive value) through completely non-invasive methods of physico-chemical analysis.

CONCLUSIONS

NSC varied between 100.000 and 310.000 cel/ml ranging within maximum limit of 400.000 cel/ml for fresh milk and between 50.000 and 115.000 cel/ml in boiled milk.

Fat varied between 3.30 and 5.29 [g%] in fresh milk and between 3.51 and 5.16 [g%] in boiled milk.

Non-fat substances varied between 9.13 and 10.24 [g%] in fresh milk and between 9.41 and 10.71 [g%] in boiled milk.

Relative density varied between 1.025 and 1.030 in fresh milk and between 1.024 and 1.028 in boiled milk.

The matrix of Pearson correlation coefficients shows that there is a significantly positive relationship between fat and dry matter (r=0.897). Between fat and NSC there is a significant positive correlation in both fresh (r=0.964) and boiled (r=0.918) milk.

PCA was determined to assess the comprehensive effect of boiling on physico-chemical features in cow milk from a descriptive perspective. Two principal components (PCs) explain 90.38% of the variations of the data set.

The values of different physical features are conditioned by the content of the principal components of milk and reflect the character of mutual correlations, which allows their use in assessing milk quality.

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