THE EFFECT OF BOILING ON THE VISCOSITY AND PROTEIN CONTENT OF COW MILK

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Abstract. *Due to their chemical composition and their high assimilation degree, milk and dairy products play an important part in rational human nutrition, being one of the most readily accessible sources of animal protein. More than 200 compounds have been found in milk, some in large quantities (water, fats, carbohydrates, and proteins), others in very small quantities, but all of them are interrelated and play a very important role in the technology of dairy products.The aim of the present paper is to highlight the effect of boiling on the correlation between viscosity and protein content, analysing fresh milk and boiled milk, respectively. Ten samples were analysed (5 samples of fresh milk and 5 samples of boiled milk), all taken from healthy cows.The chemical composition of milk was determined with a MilkoScan S54B, while the viscosity was determined with the help of Ostwald viscometer.The results were processed statistically with the ANOVA software programme and the differences to $p<0.05$were considered statistically significant.Viscosity is a biophysical parameter that can be used for assessing the protein content in milk. The results revealed positive correlation between these two parameters, both in fresh milk ($r=0.5148$), and in boiled milk ($r=0.5021$). The results also highlighted decreased dynamic viscosity in boiled milk.*

Key words: *cow milk, boiling, viscosity, protein content*

INTRODUCTION

Since the beginning of history, human beings have used the milk of other mammals as food source because it was recognized that the milk of some of the domesticated mammals was equally as satisfying in meeting the physiological demands for energy and nutrients as human milk [5, 6].

Due to their chemical composition and their high assimilation degree, milk and dairy products play an important part in rational human nutrition, being one of the most readily accessible sources of animal protein.

More than 200 compounds have been found in milk, some in large quantities (water, fats, carbohydrates, and proteins), others in very small quantities, but all of them are interrelated and play a very important role in the technology of dairy products.

In general, the gross composition of cow's milk is 87.4% water, 4.8% lactose (carbohydrate), 3.7% fat, 3.4% protein (2.8% casein and 0.7 % whey protein), and 0.7% minerals (or ash) [4, 7].

The viscosity of milk and cream creates the impression of "richness" to the consumer.

The casein micelles contribute more to the viscosity than any other constituent.

Viscosity varies not only with changes in the physical nature of fat but also with the hydration of proteins. Alterations in the size of any dispersed constituents result in viscosity changes. The viscosity of skim milk decreases on heating to 62°C, after which it increases, apparently due to changes in protein hydration. An increase of temperature causes a marked reduction of viscosity [7].

The aim of the present paper is to highlight the effect of boiling on the correlation between viscosity and protein content, analysing fresh milk and boiled milk, respectively.

MATERIAL AND METHODS

The research material was represented by 5 milk samples of 700 mL each, collected in milk containers from healthy cows raised in the University Farm, in March 2015.Immediately after milking, the samples were transported to the laboratory for analysis.

The milk was divided in two portions, the second portion was boiled. The first portion was analysed as fresh samples and for the boiled milk the analysis commenced after cooling.

Ten samples were analysed: 5 samples of fresh milk and 5 samples of boiled milk.

Evaluation of changes in the protein content of the milk samples was determined using the instrument MilkoScan S54B, which works in infrared spectrometry in the Cattle Breeding Technology Laboratory at Faculty of Animal Science of Banat's University of Agricultural Sciences and Veterinary Medicine "King Michael I of Romania" from Timisoara. The dynamic viscosity was determined using the standard method with Ostwald viscometerin the Biophysics laboratory [2].

The results were processed statistically with the ANOVA and XLSTAT 2015.1 software programme and t-Test was used for the statistical evaluation, $p<0.05$ was considered as significant.

RESULTS AND DISCUSSIONS

Viscosity is a biophysical parameter that can be used for assessing the protein content in milk. Dynamic viscosity at 25°C showed an interval from 1.4393 cP to 1.6234 cP for fresh milk and from 1.6929 cP to 1.7170 cP for boiled milk. Specific viscosity at 25°C showed an interval from 0.6105 to 0.8164 for fresh milk and 0.8943 to 0.9212 for boiled milk.

Table 1 shows the correlations between the physicochemical characteristics (protein and viscosity) of milk.

Table 1.

Pearson correlation matrix between protein and viscosity (dynamic specific and relative) of milk

Correlation matrix (Pearson (n)):								
Variables	η	η_{rel}	η_{sp}	Protein	η boiled	η_{rel} boiled	η_{sp} boiled	Protein boiled
η [cP]	**1**							
η_{rel}	**1.0000**	**1**						
η_{sp}	**1.0000**	**1.0000**	**1**					
Protein [g%]	0.5148	0.5146	0.5146	**1**				
η boiled [cP]	0.6641	0.6642	0.6642	0.6529	**1**			
η_{rel} boiled	0.6639	0.6639	0.6639	0.6527	**1.0000**	**1**		
η_{sp} boiled	0.6639	0.6639	0.6639	0.6527	**1.0000**	**1.0000**	**1**	
Protein boiled [g%]	0.3650	0.3648	0.3648	**0.9755**	0.5021	0.5018	0.5018	**1**
Values in bold are different from 0 with a significance level alpha=0.05								

The results revealed positive correlation between these two parameters, both in fresh milk (r=0.5148), and in boiled milk (r=0.5021).

A PCA was conducted to evaluate the global effect of boiling on the physicochemical properties of cow milk, from a descriptive point of view. It was found that two principal components (PCs) explain 100% of the variations in the data set.

Figure 1 presents the PCA analysis of the physicochemical parameters of milk samples. Figure 1 and table 2 present the parameters loadings; it can be observed that the major influence on the descriptive view is represented by protein and viscosity.

Table 3 shows the PCA analysis from the point of view of the correlations between variables and factors, contribution of the variables (%) and squared cosines of the variables.

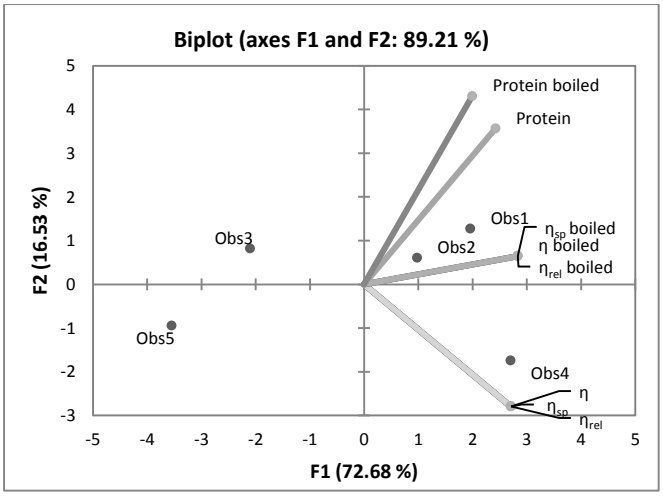

Figure 1.PCA analysis of the protein and viscosity of milk samples

Principal component analysis (PCA), presented in Figure 1, grouped the studied variables. The viscosity and protein of fresh and boiled milk are grouped in the fourth quadrant by highly significant correlations.

Table2.

Factor loadings with major influence on the description of viscosity and protein

	Factor loadings	
	F1	F2
η	0.873	-0.430
η_{rel}	0.873	-0.430
η_{sp}	0.873	-0.430
Protein	0.782	0.548
η boiled	0.914	0.099
η_{rel} boiled	0.914	0.099
η_{sp} boiled	0.914	0.099
Protein boiled	0.643	0.662

Table 3.

Correlations between variables and factors, contribution of the variables (%) and squared cosines of the variables

Correlations between variables and factors:			Contribution of the variables (%):		Squared cosines of the variables:	
	F1	F2	F1	F2	F1	F2
η	0.873	-0.430	13.105	13.974	**0.762**	0.185
η_{rel}	0.873	-0.430	13.105	13.983	**0.762**	0.185
η_{sp}	0.873	-0.430	13.105	13.983	**0.762**	0.185
Protein	0.782	0.548	10.511	22.685	**0.611**	0.300
η boiled	0.914	0.099	14.361	0.747	**0.835**	0.010
η_{rel} boiled	0.914	0.099	14.356	0.747	**0.835**	0.010
η_{sp} boiled	0.914	0.099	14.356	0.747	**0.835**	0.010
Protein boiled	0.643	0.662	7.102	33.134	0.413	**0.438**
Values in bold correspond for each variable to the factor for which the squared cosine is the largest						

Milk proteins are part of the complex protein group that contain all the essential amino acids not only in sufficient quantities, but also in an optimal correlation for rational nutrition; consumption of 0.5 kg of milk fully meets the needs of the body in the essential amino acids for 24 hours [3]. Protein content showed an interval from 3.00 g% to 4.19 g% for fresh milk and from 3.16 g% to 4.33 g% for boiled milk.

CONCLUSIONS

This work confirms the existence of significant differences as a result of boiling on protein and viscosity of cow milk (η – p-value (two-tailed) =0.026 and protein p-value (two-tailed) =0.007). The results also highlighted decreased dynamic viscosity in boiled milk.

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