MODELING THE MEASUREMENT OF COAGULATION TIME AND CURD FIRMING TIME OF GOAT MILK THROUGH ENZYMES WITH DIFFERENT CONCENTRATION

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Abstract: The aim of the present study is to investigate the possibilities of modeling the measurement of coagulation ability with a biosensor mechanical lactadinometer using different enzymes and concentrations.

Coagulation times and curd firming time were found in 420 whole goat milk samples. Four enzymes were tested with 4 concentrations each and one control group with standard chimosin recommended by the manufacturer. The analyzes were made using the Polo Trade-Computerized Renneting Meter.

There is a credible opportunity to considerably shorten the coagulation time of goat milk despite its specific rheological characteristics.

There is a credible possibility to shorten the curd firming time, albeit considerably less than the coagulation time - 0.55 min for the control group at 2.6 min in the experiments with the lowest values.

Differences in the effects of enzymes and concentrations were found in the two test parameters characterizing the coagulation ability of the milk.

Key words: measurement modeling, biosensors, coagulation properties of milk, goat milk

1. Introduction

The coagulation ability of milk is in a proven connection with the quality and yield of the cheese [9, 19, 21, 25, 1, 2]. The most important thing for goat cheese producers is to increase the curd firmness (CF), as this is the main coagulation parameter that affects the quality of the cheese and hence the yield and cost-effectiveness. The curd firmness improves the yield of goat milk cheese by retaining the milk composition [19, 20, 5, 17, 18, 22, 4].

According to [23] goat milk, there are substantial differences in the composition and technological characteristics of cow's milk and sheep's milk. Significant differences in the content and proportion of calcium sensitive caseins (αs- and β) as well as in calcium-non-sensitive k-caseins compared to sheep and cow's milk. These peculiarities also lead to significant differences in the cheeses of goat milk, which are significantly worse than cow's milk and sheep's milk. The weaker cheese qualities of goat milk, according to the same authors, are due to the lower casein content as well as differences in the composition of the casein micelle, its size and hydration. Milk cheesemade from goat's milk is more tender than that obtained from cows' milk. The kinetic coagulation of goat milk is characterized by a shorter coagulation time and a higher curd firming time.

The desire of goat's milk producers to improve its cheeseing qualities is covered by the research interest of a number of authors who investigate a number of genetic and non-genetic factors on the coagulation ability of goat milk [24].

[15] examined the relationship between the α1-casein content and the coagulation ability of goat's milk, of the Swedish white breed. The authors find that the coagulation ability of goat milk is strongly dependent on the αs1-casein content. If the content of this protein in the milk is higher, it is associated with a higher total protein content, a lower pH, a shorter coagulation time and a higher curd firmness.

[12] investigates the physical and chemical parameters of milk as well as its coagulation capacity in Albanian goat breeds. The authors found that the concentration of fat, raw protein and casein in cow's milk was twice as high as that in goat milk. Large differences were found between the parameters characterizing the coagulation ability of cow's milk and goat's milk. In this connection there are a number of studies on the factors that influence the process of coagulation of different types of milk.

The increased interest of scientists to investigate the coagulation ability of milk has led to the development of various scientific technologies to evaluate its coagulation ability. Three types of biosensors: mechanical and those based on a near-infrared spectrum can be presented as basic.

Studies on the use of the mechanical lactodinamograph to generate reference data for MIRS calibration [11] are of particular importance for the

practical applicability of the method to mass practice.

One of the problems of this method is that not all milk samples coagulate within 30 minutes and is considered uncoagulated [14, 10]. This problem is of great importance when investigating milk with slower coagulation in terms of statistical analysis of the measured samples [7, 8].

Another important problem is that the k20 parameter can not be evaluated in long-time coagulation samples where clamping of the coagulum does not allow for a flickering interval within 20 mm for 30 minutes. This indicator is important for the usefulness of measuring the germination ability of milk. In addition, k20 is characterized by a lower repeatability and reproducibility than the coagulation time leading to exclusion of the k20 estimates, despite the practical significance of this indicator, which is considered to be an indicator of the optimal cutting time of the curd. Last but not least, the parameter A30 is highly dependent on coagulation time, both phenotypically and genetically [13, 14, 6, 8].

Obviously, the longer the coagulation time, the shorter the time it takes to tighten the coagulum, and curd firmness will be lower. Although goat milk is characterized by relatively rapid coagulation and curd firming time for the coagulum, the curd firmness is unsatisfactory.

In our country no studies of the problems related to the measurement of coagulation properties of goat milk with biosensor - mechanical lactodinometer have been performed.

In the Bulgarian scientific literature, there is only one study [3; 16] to determine the variation in the individual coagulation capacity of milk in locally long-haired / goat-headed goats / and Kalofer long-haired goats.

Given that the goat's milk is distinguished by a more lean coagulum because of the quantity, nature and proportions of the milk protein fractions therein, the above mentioned problems with the measurement of the individual characteristics can be avoided by conducting research to use the activity of the enzymes used to improve the parameters characterizing the coagulation ability of the goat milk.

The aim of the present study is to investigate the possibilities of modeling the coagulation properties of goat milk with a biosensor mechanical lactadinometer using different enzymes and concentrations.

2. Materials and method

Coagulation times and curd firming time were found in 420 whole goat milk samples. Five enzymes were tested at 4 concentrations each and one control group with a standard chimosin recommended by the manufacturer. The analyzes were made using the Polo Trade-Computerized Renneting Meter biosensor. This technique of measurement is a monitoring of the viscosity behavior of milk samples placed at a constant temperature and coagulated by an added standard enzyme. Changes in viscosity are measured by vibrating pendulum immersed in coagulating milk. The device transforms the changes in the resistance of the pendulum movement as a result of the formation of the coagulum in a graphic image by means of a computer system.

The coagulation ability of milk is determined by three parameters:

- Rennet coagulation time (RCT)
- Curd firming time (k20)
- Curd firmness / a30 /

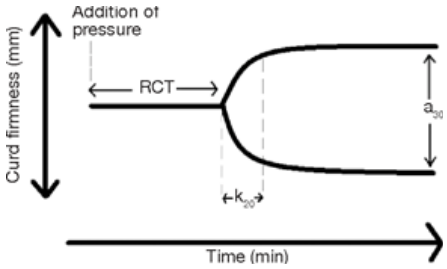

Fig. 1 Scheme

The analysis of the results was carried out using the SYSTAT statistical package.

3. Results and analysis obtained

Table 1 presents the descriptive statistical features for the coagulation time (RCT) indicator. The results obtained show possibilities for significant acceleration of coagulation time, despite the fact that goat milk is characterized by a relatively shorter coagulation time compared to cow and buffalo. Highly reliable ($P< 0.001$) were differences in the control group score versus experimental values, ranging from 2 to 4 times shorter coagulation time in the experimental groups.

Significant differences were found between both the individual enzymes and the different concentrations. It is noteworthy that in all cases, the trial groups have achieved a credible reduction in coagulation time. The shortest time has been achieved with the highest concentration of MAHIREN 600 /

0.25 ML enzymes, FROMASE 750 / 0.18 ML and OFASE 750 / 0.23 ML /. Fewer coagulation times were affected by low concentrations of the enzymes FROMASE 750 / 0.08 ML and 0.13 ML, MAXIREN PREM P / 0.22 ML and 0.27 ML and MAXIREN 180 /0.37-0.50 ML. Higher values of standard deviation and variation were also found at the lowest concentrations of the enzymes used. An exception is made by the experimental group with different concentrations of the MAXIREN 180 enzyme, which has a relatively weaker effect on coagulation rate of goat milk (7.33 to 8.58) while retaining comparatively constant and close to the control group values of standard deviation except for the highest concentration.

The results related to the curd firming time (Table 2) differ significantly from those found at coagulation time. It can be argued that curd firming time is definitely most strongly influenced by the MAHIREN XDS enzyme, where the most significant reduction in coagulation time (0.38 to 0.26) was achieved even at the lowest concentration. In the test groups with the lowest concentrations of MAHIREN 600 and FROMASE 750 enzymes, the values obtained were significantly higher than the control (0.55) group (0.64 and 0.71), respectively.

The MAXIREN 180 enzyme did not have a valid influence with values (0.50 to 0.51) close to the results of the control group (0.55).

With a few exceptions, standard deviations and variations are not significantly different.

The results obtained show that different signs are influenced differently by different enzymes and different concentrations. Although some common trends in enzymes and concentrations are observed, the highest RCT is achieved with the highest concentration of MAHIREN 600 / 0.25 ML (2.62 min) at the curd firming time at the shortest time was recorded at high doses of the MAHIREN XDS / 0.2 and o.25 ML enzyme (0.26 min). Different concentrations of the MAXIREN 180 enzyme accelerate almost two times the coagulation time but does not have a credible effect and has close to the control values for the k20.

Undoubtedly established by [13, 14,6,7] on the interconnection of the parameters of measuring the coagulation capacity of milk and the results obtained by us are an argument in favor of the methodological experimental approach chosen by us. The results obtained show that there is a dynamics in the influence of different enzymes and concentrations, which is not, in any case, logical and with a certain tendency. Obviously, it is necessary to deepen the statistical analysis and to study the interrelationships between the main factors influencing the process.

4. Conclusions

There is a credible opportunity to considerably shorten the coagulation time of goat milk despite its specific rheological characteristics.

There is a credible possibility to shorten the curd firming time, albeit considerably less than the coagulation time - 0.55 min for the control group at 2.6 min in the experiments with the lowest values.

Differences in the effects of enzymes and concentrations were found in the two test parameters characterizing the coagulation ability of the milk.

5. Literature

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Table 1. Descriptive statistical characteristics for the Rennet Coagulation Time(RCT)

Enzimes	Means	N	Std. Dev.	Variance	Std. Err.
Standart	**13,51a*** **	20	0,98	0,96	0,22
MAHIREN 600/0,1ML	**5,83c**	20	1,21	1,45	0,27
MAHIREN 600/ 0.15 ML	**5,98c**	20	0,40	0,16	0,09
MAHIREN 600/ 0.20 ML	**4,24d**	20	0,39	0,15	0,09
MAHIREN 600/ 0.25 ML	**2,62e**	20	0,35	0,13	0,08
FROMASE 750 / 0,08 ML	**7,33b**	20	0,70	0,49	0,16
FROMASE 750 / 0,13 ML	**7,04b**	20	0,97	0,95	0,22
FROMASE 750 / 0,18 ML	**2,91e**	20	0,33	0,11	0,07
FROMASE 750 / 0,23 ML	**2,71e**	20	0,35	0,12	0,08
MAHIREN XDS/ 0.1ML	**8,01b**	20	0,77	0,59	0,17
MAHIREN XDS/ 0.15ML	**4,47d**	20	0,33	0,09	0,07
MAHIREN XDS/ 0.2 ML	**3,14e**	20	0,65	0,42	0,15
MAHIREN XDS/ 0.25 ML	**3,19e**	20	0,57	0,33	0,13
MAXIREN PREM P/0.22 ML	**6,76c**	20	0,66	0,44	0,15
MAXIREN PREM P/0.27 ML	**6,21c**	20	0,48	0,23	0,11
MAXIREN PREM P/0.30 ML	**4,47d**	20	0,38	0,14	0,08
MAXIREN PREM P/0.35 ML	**4,66d**	20	0,39	0,15	0,09
MAXIREN 180 /0.37 ML	**8,58b**	20	0,86	0,73	0,19
MAXIREN 180 /0.40 ML	**7,93b**	20	0,60	0,36	0,13
MAXIREN 180 /0.45 ML	**7,55b**	20	0,93	0,86	0,21
MAXIREN 180 /0.50 ML	**7,33b**	20	0,48	0,23	0,11
Mean all groups	**5,93**	420	2,63	6,90	0,13

Table 2. Descriptive statistical characteristics for the curd firming time(K20)

Enzimes	Means	N	Std. Dev.	Variance	Std. Err.
standart	**0,55a**	20	0,38	0,14	0,08
MAHIREN 600/0,1ML	**0,64b**	20	0,29	0,66	0,03
MAHIREN 600/ 0.15 ML	**0,42a**	20	0,28	0,08	0,06
MAHIREN 600/ 0.20 ML	**0,33c**	20	0,09	0,01	0,02
MAHIREN 600/ 0.25 ML	**0,30c**	20	0,09	0,01	0,02
FROMASE 750 / 0,08 ML	**0,71b**	20	0,53	0,28	0,12
FROMASE 750 / 0,13 ML	**0,34c**	20	0,18	0,03	0,04
FROMASE 750 / 0,18 ML	**0,29c**	20	0,09	0,01	0,02
FROMASE 750 / 0,23 ML	**0,31c**	20	0,09	0,01	0,02
MAHIREN XDS/ 0.1ML	**0,38c**	20	0,25	0,06	0,06
MAHIREN XDS/ 0.15ML	**0,29c**	20	0,09	0,01	0,02
MAHIREN XDS/ 0.2 ML	**0,26c**	20	0,07	0,004	0,02
MAHIREN XDS/ 0.25 ML	**0,26c**	20	0,10	0,01	0,02
MAXIREN PREM P/0.22 ML	**0,48a**	20	0,37	0,13	0,08
MAXIREN PREM P/0.27 ML	**0,52a**	20	0,37	0,14	0,08
MAXIREN PREM P/0.30 ML	**0,42a**	20	0,31	0,10	0,07
MAXIREN PREM P/0.35 ML	**0,36c**	20	0,21	0,05	0,05
MAXIREN 180 /0.37 ML	**0,50a**	20	0,39	0,15	0,09
MAXIREN 180 /0.40 ML	**0,50a**	20	0,35	0,12	0,08
MAXIREN 180 /0.45 ML	**0,50a**	20	0,33	0,11	0,07
MAXIREN 180 /0.50 ML	**0,51a**	20	0,46	0,21	0,10
Mean all groups	**0,422**	420	0,41	0,17	0,02

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