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TECHNOLOGICAL INDICATORS OF GOAT'S MILK AS A RAW MATERIAL FOR CHEESE PRODUCTION - SURVEY

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Abstract

Cheese is a product with a high nutritional value, compared to milk, because of its low water content, presence of lactic acid and cooking salt. The yield, composition and organoleptic qualities of cheese are influenced by production technology and milk composition, which varies depending on the breed, the season, the lactation stage, the type and proportion of fodder in the goat ration, and other factors. The quality of raw milk, along with the cheese preparation technology, have an impact on some physicochemical parameters and the proteolytic processes during cheese ripening. The casein fraction of the milk protein is a dominant factor affecting curd density, the syneresis rate, the moisture content and ultimately the cheese quality and yield. The technological characteristics of goat's milk coagulum differ from those of cow's milk, as the differences are mostly related to the genetic polymorphism of α_{s1}-casein. The purpose of this survey is to analyze the technological indicators of goat's milk and some factors related to the quality of the finished cheese product.

Key words: *cheese, goat’s milk, technological indicators.*

INTRODUCTION

Cheese is one of the ancient forms of manufactured food production, dating back to 5-6000 BC. Depending on the geographical location, the milk composition and the technologies used, a large assortment of goat cheese is produced in the world, ensuring high profitability for the producers. Nowadays, cheese is an essential food product and an integral part of a healthy diet, and its low levels of lactose make it suitable for people with digestive disorders. This shows its significance as a functional food, whose physiologically active components provide both nutritional and health benefits (Hasler, 2000).
In many countries, goat's milk is most often processed into cheese, alone or in a mixture with cow and sheep’s milk (Iliev & Michailova, 2014; Poveda et al., 2008; Janštová et al., 2010; Miloradovic et al., 2017). Over 400 types of goat cheese have been described with over 700 names of chese, which are produced by cow, sheep and buffalo’s milk in combination with goat’s milk (Park et al., 2017). France, Spain and Greece are the largest producers of goat’s milk in Europe (respectively 24.6%, 17.5% and 16.0%) and cheese from this raw material (France - 47.1%, Greece - 21, 3%, Spain - 20.3% (Medina and Nuñez, 2017). The quality of raw milk is determined by its chemical composition and sanitary-hygienic characteristics (Sharma et al., 2011; Petzer et al., 2017).
The criteria for milk quality and the threshold values of the indicators evolve depending on the development of science, production technologies and consumer preferences.
Casein genotype is the factor of greatest significance for the overall variation in curdling parameters (Lawrence, 1991; Albenzio et al., 2009).
Data from a number of studies show that goat’s milk high in αs1-casein has higher dry matter content, milk fat, protein, casein, phosphorus, lower pH and better curdling properties than that containing less αs1-casein (Ambrosoli et al., 1988; Barbieri et al., 1995).
The potential of milk to influence cheese yield is highly dependent on composition, particularly fat and protein content (Brito et al.,

2002; Guo et al., 2004).Cheese composition changes depending on the stage of lactation and corresponds to changes in milk composition (Soryal et al., 2005). The season of milk collection has an effect on the variation of chemical and coagulation characteristics of milk (Zullo et al., 2005), as well as farming systems, temperature treatment of milk, even the time of milking during the day (Zullo et al., 2005; Galina et al., 2007.

Cheese quality is related to the ripening process in terms of proteolysis, lipolysis and glycolysis. The purpose of ripening is to transform the fresh cheese into different types of cheese with specific organoleptic characteristics defining its type and quality. The composition and biochemical characteristics of raw milk, technological operations, the curdling process, the preparation of the curd and the ripening of the cheese directly or indirectly affect the quality of dairy products (Albenzio & Santillo, 2011), corresponding to the intensity of the ripening process from the point of view of lipolysis, proteolysis and glycolysis.

Hygiene control during milk production is also of great significance for the optimization of the hygienic and nutritional characteristics of goat cheese and the proteolysis occurring during the ripening process of the product.

RESULTS AND DISCUSSIONS

In the present survey, the technological indicators of goat's milk and some factors affecting the quality of the final cheese product are observed.

Casein genotype

The technological characteristics of goat's milk rennet coagulum differ from those of cow's milk. The technological disadvantages of goat's milk arise from its low casein content, in particular α_{s1}-casein, and its high βcasein content. Differences in goat's milk casein content are associated with the α_{s1}-casein genetic polymorphism. Milk containing genetic variants A, B and C is distinguished by the highest amount of α_{s1}-casein, E - medium, D and F low, and 0 - does not contain it (Grosclaude et al., 1994). Goat' milk that is low in αs1-casein gives a less dense rennet coagulum (Ambrosoli et al., 1988), which is associated with greater whey casein losses and lower cheese yields (Pirisi et al., 1994).

These characteristics of the rennet coagulum in goat's milk limit the variety of cheese types from this milk, most of which fall into one of the following groups (Medina & Nuñez, 2017):

- Fresh (white) unrepented cheese with a low dry matter content, usually below 25%;
- Soft cheese produced mainly from lactic acid coagulum, small in size, cylindrical or pyramidal in shape, usually with mold growth on the surface;
- Semi-hard or hard cheese produced with a predominance of rennet coagulum, larger in size, with a flat cylindrical shape and a dry rind on the surface.

In dairy goats, casein fractions (αs1- and αs2-caseins) vary both between breeds and within individuals of the same breed and can affect cheese yield and rheological properties of the gel (Pirisi et al., 1994; Delacroix-Buchet et al., 1996).

Goat's milk from animals with strong alleles is associated with higher cheese yield and firmer curd than milk from animals with weak alleles (Albenzio et al., 2009; Clark and Sherbon, 2000; Tziboula-Clarke, 2003).

Total protein and αs1-casein content correlate with coagulation time (Clark & Sherbon, 2000; Mastewet et al 2012), which is highly dependent on milk pH values. Milk with a low as1-casein content has a higher pH and a significantly lower total protein content (Johansson et al., 2015).

In milk with a low concentration of as1 casein, the coagulation time ss 15% longer and the curd is 60% lower in density, compared to milk with a high content of as1 casein (Johansson 2015). Comparing the cheese yield from milk with and without as1 casein content, Pierre et al. (1998) found that the yield of milk containing casein was 26% higher than that of milk without casein. In addition, the organoleptic test on the 2nd and 13th day of ripening shows that the specific "goat smell" is significantly weaker in the cheese produced from milk containing as1 casein. A similar dependence between cheese yield and casein content in milk was found by Soryal et al. (2005), who indicated that the higher casein content in the milk of Nubian goats increased cheese yield by 60% compared to that of the milk of Alpine goats.

Effect of temperature treatment of milk

Miloradovic et al. (2017) studied the impact of temperature treatment of goat's milk at 80°C and 90°C with a delay of 5 min, instead of the traditional - 65°C/30 min on the composition, quality and yield of white brined cheese (0.005% - w/v *Lactococcus lactis* subsp. *lactis* and *L. lactis subsp. cremoris*). The higher temperature treatment of goat's milk significantly affects the composition and yield of cheese. It leads to binding of more water, fat and whey proteins in the curd mass and increasing the yield. For the studied period - 24 hours, 10, 20, 30 and 40 days of production, the content of dry matter in the goat's white brined cheese produced by the traditional technology (65°C/30 min) decreased from 44.27 to 40.34, 38.76, 39.82 and 38.16%.

The milk fat content and milk fat in dry matter of this batch of cheese changed from 18.50 to 17.67, 18.00, 18.83 and 17.50% and 41.14 to 43.75, 47.55, 45.89 and 45.86%, respectively, in contrast to the water content of the non-fat residue, which it gradually decreases during the ripening period of Feta goat cheese. Miloradovic et al. (2017) found an increase in this indicator for white brined cheese from the 24th hour to the 40th day of production - from 67.52 to 72.46% (10th day), 72.22% (20th day) 73.32% (30th day) and 74.92% (40th day). As a result of the high-temperature treatment of goat's milk, the water in the fat-free residue of the goat's cheese is higher already at the 24th hour of production (74.41% - 80°C/5 min and 75.81% - 90°C/5 min) and almost does not change until the 40th day (73.89 and 74.80%, respectively).

The content of salt and salt in the water phase of the fresh cheese produced by the traditional method have higher values already at the 24th hour (1.24 and 2.24%, respectively) and gradually increase to 3.28 and 5.27% at the 40th day of production. The salt content of the experimental batches of fresh white brined cheese was lower (1.09% at 80°C/5 min and 90°C/5 min), reaching values of 3.09 and 3.39% on the 40th day of production. The salt content of the aqueous phase in the fresh cheese of the experimental batches was lower (1.76% at 80°C/5 min and 90°C/5 min), gradually increased to levels close to the control cheese during the 10th÷30th day and reaches 5.19 and 5.67% at the end of ripening (40th day). The authors found that a higher pasteurization temperature (80°C/5 min and 90°C/5 min) inhibited the degradation of α_s-casein but did not significantly affect that of β-casein fraction.

Barac et al. (2016) also investigated the physicochemical composition of white brined cheese produced from goat's milk at high temperature processing at 90°C/10 min. The cheese at 24th hours of production was 46.71% dry matter, 57.18% milk fat in dry matter, 36.58% protein in dry matter and pH 6.28. During ripening, the pH decreases to 4.6 on the 30th day, which practically does not change on the 40th and 50th days with pH 4.57. During the first 10 days of ripening, initial intensive degradation of αs-casein is established - over 50.70% till the 10th day and extremely slowly during the remaining 40 days. A slow and prolonged degradation of β-casein was observed, the residual amount of which (85.14%) was significantly higher than that of α_s-казеина (47.85%).

Impact of lactation phase and season on milk collection

Cheese produced from milk obtained at the end of lactation had a higher fat, protein and dry matter content, which corresponds to the higher values of these parameters in milk during that lactation phase (Soryal et al., 2005).

Higher cheese amount was registered from the milk of Alpine goats in October compared to July and September. The amount of cheese from Nubian goats increased as milk lactation progressed (Soryal et al., 2005). The total fatty acid content was high in the summer months (July, August, September). During the early lactation stages (May and June) and the last stage of lactation (October), the total concentration of fatty acids in the cheese was about half of that in August. This may be explained by the heat of the summer months, when there is an increase in fat consumption with the ration and a high level of lipolysis (Palmquist et al., 1993), leading to an increase in the relative proportion of long-chain fatty acids in milk. At the same time, the short-chain fatty acids (C4:0, C6:0 and C8:0) in the cheese did not show significant variation during lactation, which corresponded to a minor variation in organoleptic qualities.

López et al. (2012) also noted the season effect on cheese composition and fatty acid profile, especially during the summer months, despite the lack of reliable differences between individual proteolysis parameters. Cheese produced in spring had a better physicochemical composition, lower NaCl content and a better fatty acid profile. The pH values were lowest in autumn (5.44) compared to spring and summer (5.65). Dry matter was highest in cheese produced in summer (61.75 %) and lowest in cheese produced in spring (59.44 %). Season has no effect on the content of most fatty acids except C12:0, C14:0, C16:0, C18:0 and C18:1

The farming system corresponds to the composition of the milk and cheese because of the different composition of the ration. The cheese obtained from the milk of pasture-raised goats is characterized by a higher content of linoleic acid (163 mg/100 g vs. 142 mg/100 g cheese) and tocopherol (211 mg/100 g vs. 87 mg/100 g cheese) and lower fat content (12.3 mg/100 g vs. 16.9 mg/100 g cheese) and cholesterol (63.2 mg/100 g vs. 80.4 mg/100 g cheese), compared to cheese from goats raised in a barn (Galina et al., 2007).These results confirm that the components of nutritional and health interest are contained in significantly higher concentrations in cheese produced from pasture-raised animals compared to barn-raised ones. Cheese obtained from pasture-raised animals is characterized by a higher content of unsaturated fatty acids, antioxidants and aromatic compounds and a lower cholesterol content, compared to that from the milk of animals raised in a barn (Rubino & Chilliard, 2003; Chilliard et al., 2005; Luna et al., 2005; Nudda et al., 2005; Cabiddu et al., 2006).

The increase of concentrated feed in the ration of goats from 10 to 40 % is accompanied by a reliable increase in milk productivity. The content of long-chain and polyunsaturated fatty acids, as well as conjugated linoleic acid and omega-3 fatty acids was significantly higher and the ratio of omega-6:omega-3 fatty acids was lower in cheese obtained from the milk of goats that received less concentrated feed (Volkmann et al., 2014).

Even the time of milking has an effect on the milk's cheese making potential. Milk obtained from morning milking is distinguished by better coagulation qualities, higher coagulation speed and better curd consistency (Zullo et al., 2005). The raising system of goats and the hygiene of the dairy also have an impact on the microflora and, accordingly, on the composition of goat's milk and cheese. (Albenzio et al., 2006).

Syneresis is one of the critical processes of great significance for cheese quality (Dejmek & Walstra, 2004), which can be defined as the separation of whey from the curd, stirring and heating. Coagulation and syneresis conditions determine the final characteristics of the cheese because of their impact on moisture and protein content. Dry matter content, whey composition and final product characteristics are determined to a significant extent by the control of the syneresis process and mechanical and physical whey separation during cheese processing (Garcia et al., 2014).

Milk coagulation, induced by yeast, is influenced by the type and concentration of culture and enzyme, incubation temperature and milk composition (Raynal & Remeuf, 2000). Curd density is the most significant indicator that determines the yield and quality of cheese and, accordingly, the economic efficiency of production (Clark & Sherbon, 2000). Better coagulant density reflects the formation of a denser network, which is related to the amount and composition of casein (Dimassi et al. 2005). Dense curd improves cheese yield by stimulating the retention of milk constituents (Martín-Hernández & Juarez, 1992).

Cheese yield, defined as the amount of cheese produced from a given amount of milk (Zeng et al., 2007), is one of the main factors determining the efficiency and profitability of cheese making (Emmons, 1993).

Cheese production corresponds to many genetic, physiological and production-technological factors such as milk characteristics, protein and fat content, genetic variants of proteins, somatic cells, conditions of cheese production, milk treatment, homogenization of fat, type of coagulation, the use of different starters, curd density, tub design, curd treatment (Fenelon & Guinee, 1999; Mona & Nawal, 2011).

Proteolysis and lipolysis are of greatest significance in the development of the organoleptic qualities of cheese and are controlled by the residual enzyme in the curd, milk proteinase and lipase, proteolytic and lipolytic enzymes from starter and non-starter bacteria, and lipases associated with certain coagulants (Collins et al., 2003; Visser, 1993). Enzymes naturally present in milk (plasmin system, cathepsin D, elastase and lipase) determine the biochemical processes during cheese ripening, and proteolytic and lipolytic enzymes are of greatest significance for cheese making.

Proteolysis is the most complex and significant biochemical process in cheese ripening that determines the texture, aroma and flavor of the products (Fox, 1996). Proteolysis in cheese can be divided into primary and secondary proteolysis. The main process in the first phase is the degradation of casein to polypeptides (McSweeney & Sousa, 2000; McSweeney et al., 2017). The following proteolytic processes (secondary proteolysis) lead to the formation of low-molecular polypeptides and free amino acids that determine the aroma and taste of the cheese.

The rennet from goat kids, often produced by the traditional method on the farms itself, contains chymosin as the main curdling agent and is the main source of lipolytic enzymes such as lipases and esterase (Bustamante et al., 2000) and the applied methods of its preparation can have an impact on the character and intensity of lipolysis. This yeast contains lipolytic enzymes including pregastric and gastric esterases responsible for the release of short- and medium-chain free fatty acids in the cheese (Jacob et al., 2010). The excessive content of these acids imparts a rancid, hot and unpleasant taste to the cheese, which repels consumers (Soryal et al., 2005).

The fat content of brined goat's milk cheese increased from 50.67 at the beginning to 54.87 g/100 g at 60th day, whereas the total protein in the ripening process decreased from 45.2 g/100 g at the beginning to 36.9 g /100 g at the end of the period, as the decrease was most significant during the first 10 days (Miroljub et al., 2013). The degree of proteolysis increased from 3.47% at the beginning of ripening to 11.61% on the 60th day. The water-soluble protein increased from 9.77 to 17.88 g/100 g of cheese on the 60th day of ripening. Both casein fractions (αs-1 and β-casein) are exposed to proteolysis but to different extents. In the ripening process, αs1 casein disappears, while on the 60th day of ripening, the contents of αs2 and β casein decrease by 38.90% and 30.72%, respectively. As the ripening takes place in a salt brine, the decrease in total protein is probably also related to the diffusion of loosely bound proteins and/or partly of partially hydrolysed proteins in the cheese. Analogous changes in the cheese composition were also observed by Mas et al. (2002), noting a continuous increase in dry matter, with values at 3, 15, 30 and 60 days of ripening being 51.96%, 55.28%, 56.19% and 58.90%. The NaCl content gradually increased from 1.46% on the 3rd day to 2.50% on the 60th day of ripening. The fat content also increased from 51.74% at the beginning to 52.64% on the 60th day of ripening. Proteolysis products also increase with cheese ripening. The pH values decreased sharply after the 30th day of ripening and increased gradually until the 60th day. Most of the lactose in the milk passes into the whey, and the remaining lactose is rapidly metabolized in the early ripening stage by the starter and non-starter microflora of the cheese (Jeleva, 2005).

Mallatou et al. (2004) investigated the proteolytic processes in Teleme cheese from sheep, goat and a 1:1 mixture of both. The cheese was produced after standardization of sheep's milk to 6.1, goat's milk to 4.4 and the mixed one to 4.7% fat content. The casein/fat ratio (C/F) in processed milks is in the range of 0.72÷0.75, 0.62÷0.64 and 0.68÷0.69, respectively. A significantly lower degradation of αs-casein was found in goat's milk cheese than in sheep's or a 1:1 mixture of them at all stages of ripening at 20th, 60th, 180th and 360th days of production. No significant differences were found in free fatty acids among the three types of cheese.

Water-soluble components, such as mineral substances, water-soluble vitamins, amino acids, lactose, etc., are dissolved in water and all microbiological, chemical and enzyme-chemical processes take place in it during the production, ripening and storage of different types of cheese, therefore the water content is decisive factor for product consistency (Kojev, 2000b).

Proteolysis in brined cheese in the ripening process is significantly influenced by the temperature, related to the general development of lactic acid bacteria and biochemical processes in cheese. In buffalo cheese ripening at a temperature of 9°C, the proteolytic processes are significantly slowed down. The ripening regime at 12°C allows a moderate proteolytic process, with the cheese reaching the indicators for the desired degree of maturity by the 60th day. The high temperature regime of 15°C contributes to the acceleration of proteolytic processes and reaching a desired level of maturity already on the 45th day of ripening (Balabanova et al., 2014).

Hygiene control during milk production affects proteolytic processes. Processing of milk with a high somatic cell count is associated with an increase in the level of proteolysis and a change in the proteolytic pattern in cheese (Coulon et al., 2004). An increased number of somatic cells can impair the cheese making qualities of milk by causing a prolongation of coagulation time, a decrease in coagulum density, an increase in moisture content and, accordingly, a decrease in cheese yield and fat content (Albenzio et al., 2006). The flavor is determined by its taste and aroma, which are the result of the appropriate balance and concentration of numerous aromatic components perceived during cheese consumption. Excessive proteolysis and lipolysis can deteriorate cheese quality and to cause unpleasant nuance due to the high content of bitter peptides and volatile free fatty acids that have an impact directly or as precursors other ingredients (Broadbent et al., 2002; Pinho et al., 2004).

CONCLUSIONS

The technological indicators of goat's milk directly affect the quality and organoleptic properties of the finished cheese product. Rennet coagulum is influenced by casein genotype. The composition of raw milk corresponds to various factors and, along with the production technology, has an effect on the cheese yield. Establishing the relationship between the technological processes and the composition of the milk makes it possible to optimize the production and to achieve better economic results, and from there for a higher profitability of the producers.

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