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The technology of soft cheese with a vegetable component

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Abstract. In products with complex composition milk and vegetable raw materials are used in different combinations, which allow to give them certain functional properties. Increasing the production of biologically wholesome products is a highly topical issue. One of the possible solutions of the problem is combining milk basis with vegetable raw material. Studies have been conducted on the development of soft cheeses from goat's milk with chickpea flour. The aim of this research is to study the properties, consumer value and possibility of creation of soft cheese formulation with chickpea flour. In this field of study, an extruded chickpea flour is an innovative additive that had never been used before. Optimal proportion of ingredients was determined by nutritional, biological and energy value under the limitations arising from structural and parametrical models of adequate nutrition. The optimal concentration of bean filler in cheese mass that allows for the insignificant change in qualitative indicators of lacto–vegetarian product (taste, smell, consistency and color) was determined. During the experiments an effective fracture of bean component was selected and qualitative indicators of the developed soft cheese were determined. The paper gives scientific substantiation for the effectiveness of manufacture of soft goat cheese with chickpea flour.

Key words: goat milk, soft cheese, bean filler, chickpea flour, extruded chickpea.

INTRODUCTION

Nutrition is the factor of utmost importance that defines nation's health as a whole and health of the individuals in particular (Asafov, 1999).

The number of research conducted on development of new types of soft cheese due to their technological and economical superiority in comparison to hard and pickled cheese has increased recently (Heinlein & Caccese, 2014). In this regard, development of combined soft acid-rennet cheeses is highly promising. Production of functional products is a topical problem concerning contemporary food industry, particularly dairy industry.

In recent years, both qualitative and quantitative shortage of vegetable components in the structure of nation's nutrition has occurred, thus an increase in biologically wholesome food production has become rather actual (Gavrilova, 2004). One of the possible solutions to the problem is combining milk basis with vegetable raw materials (Gorlov et al., 2012).

Primary and most widespread type of raw material used in dairy product production industry is cow milk (Iakovchenko & Silantjeva, 2014). Cow milk is one of the most important food products of mankind (Vasilyev, 2001; Hennelly et al., 2006). However, it seems reasonable and advisable to use not only cow milk, but also goat milk due to its hypoallergenic and biological properties. It is well known that goat milk corresponds to physiological features of human organism better than cow milk. Goat milk contains mineral salts in certain proportion and balance. In comparison to cow milk, goat milk contains six times more cobalt, which is a part of B12 vitamin, a lot of calcium, ferrum, manganese and cuprum (Chechetkina et al., 2013). The percentage of goat milk of total milk consumption has significantly increased during recent decades in Russia. Therefore, more indepth knowledge about the composition and properties of goat milk is needed, especially in the context of dairy production (Haenlein, 2004; Sanz Ceballos et al., 2009). According to studies, carried out in different countries, fat content in goat milk ranges from 2.75% (Jandal, 1996) to 5.23% (Sanz Ceballos et al., 2009) and protein content from 2.98% to 3.66% (Strzałkowska et al., 2009). Depending on the stage of lactation and goat breeds, an average content of casein in goat milk varies from 1.06–3.01g $100g^{-1}$, lactose content from 3.85–5.46 g $100g^{-1}$, total solids from 9.8–15.9 g $100g^{-1}$ (Salem et al., 2004; Strzałkowski et al., 2009).

The paper considers the possibility of using chickpea filler as a resource–saving component and functional additive. A high–protein crop such as chickpea is a source of dietary fibers, vitamins, mineral elements, essential fatty acids and phospholipids. Chickpea rivals every other crop containing lysine, tryptophan and aliphatic sulfur–containing *α*–amino acid–methionine that participates in biosynthesis of adrenaline, choline and cysteine. In order to increase the amount of water-soluble antioxidants the chickpea had been previously sprouted. Sprouted chickpea was extruded. The extrusion allowed enhancing the product's taste due to cleavage of starch into simpler, sweeter components and dissipation of unpleasant smell typical for chickpea. In the process, a new structure appears in the form of biopolymer food foam that eases the product digestibility (Martinchik & Sharikov, 2015).

Based on the foregoing, the aim of this research is to develop the innovative technology of soft cheese production using goat milk and chickpea flour, which is achieved by directed varying of proportions of the raw materials.

MATERIALS AND METHODS

Materials that used for the research are samples of soft cheese products with chickpea flour. The control sample was produced from fresh goat milk that meet the Russian national standard (2008).

Starters: CBL 6−CHEESE, Italy (direct vat set starter with combination of *Lactococcus lactis subsp. lactis/cremoris*, *Leuconostoc species* (type *L*) or *Lactococcus lactis subsp. diacetilactis* (type *LD*) cultures.

Ferment: calf rennet in the amount of 0.2% of milk volume (1% solution (w/v), obtained from Moscow factory of rennet (TS 10–02–824).

Vegetable component: finely ground extruded chickpea flour, obtained from Volga Research Institute of meat and dairy products of Russian Agricultural Academy, Volgograd.

Total-solids, total protein, fat content were measured using milk analyzer 'Klever−2M' (OOO NPP Biomer). The 'Klever−2M' milk analyzer is designed for measuring the mass contents of fat, protein, lactose and density in milk and dairy products.

Cheese manufacture

Raw whole goat milk was obtained from a local market. The process was carried out according to the conventional technology of soft fresh cheese manufacture. Raw goat milk was pasteurized at 72–75 °C for 20–25 seconds in a water bath, cooled to 28–30 °C and subjected to acid–rennet coagulation. The acid–rennet coagulation of proteins was conducted by using the following components: direct–set bacterial concentrate with a certain combination of *Lactococcus lactis subsp. lactis/cremoris*, *Leuconostoc species* (type *L*) or *Lactococcus lactis subsp. diacetilactis* (type *LD*) cultures in the amount of 1.0% of the mixture; rennet powder (TS 10–02–824) was added at concentration of 0.001 g 100 g^{-1} of milk; calcium chloride (TS 6–09–4711) based on the addition of 40 g of anhydrous salt per 100 kg of the mixture. The mixture was stirred and left for coagulation and acidification at a temperature of 35−40 °C for 90 minutes. After the complete coagulation, the curd was cut into cubes 1 x 1 cm and settled for 10 minutes. Curds were stirred carefully during the next 15 min and settled for 10 min. The chickpea flour was added after the partial whey drainage. Soft cheeses containing different amounts of chickpea flour were produced. The following formulations were produced, in triplicates (three different batches of the same formulation): the amount of chickpea flour varied from 1% to 7% with the increment of 2%. All samples were analyzed in 3 parallel replications. All results were expressed as mean values of three replicate trials. The control sample did not contain any chickpea flour. After that, the whey was drained and curds were transferred into perforated moulds for draining and held for self-pressing at 16–18 °C. The samples of cheese were turned upside-down three times during the first 5 h of draining and self-pressing.

Organoleptic evaluation

Samples were evaluated for organoleptic characteristics by a taste panel of 11 staff members and students of the Applied Biotechnology Department.

The participants were selected and trained in accordance with the ISO 8586-1 standard (1993). Requirements for the work of the group assessors were according to the ISO Standard 8589 (2007). Sensory evaluation of the soft cheese samples was carried out using a quantitative descriptive (profile) of the method for analytical evaluation of dairy products according to the ISO Standard 22935 (2009).

The aim of the organoleptic evaluation of soft cheese was to determine acceptable concentrations of chickpea flour used in soft cheese production. The quality of the cheese curds were evaluated for appearance (colour, colour homogeneity), consistency and texture (hardness, and flavour (odour and taste) using a 5-point scale (Pereira et al., 2011). The participants were asked to assess a number of specific attributes. The cheese curds were randomly coded with three-digit numbers.

Product yield

Cheese yield was evaluated by weighing the samples of soft cheese with and without chickpea flour and presenting the difference in percentage. Experiments were repeated 5 times. Cheese yield from vat milk (CY_v) was calculated using Eq. 1.

$$CY_v = \frac{M_{ch} \cdot 100}{M_m}. \quad (1)$$

where: CY_v – cheese yield from vat milk, g 100 g^{-1} milk; M_{ch} – mass of cheese, kg; M_m – mass of vat milk, kg.

Qualitative properties

To minimize significant inaccuracy, there were 3 experiments for each sample. During the conducted research changes in the main qualitative indicators of cheese products stored at t = 4 ± 2 °C for 10 days were measured.

The titratable acidity was analyzed according to AOAC (1998). Moisture content was determined using standard methods according to the Official Methods of Analysis of AOAC International. These methods of moisture content and total solids determination are based on the sample heating at constant temperature and the loss of weight is used to calculate the moisture content of the sample according to AOAC method 948.12 (2002).

Microbiological indicators such as total viable counts of mesophilic aerobic and facultative anaerobic microorganisms were analyzed according to the AOAC International standard procedure as well. These indicators are the measure of product's quality and safety, its suitability for human consumption.

Microsructure studies of cheese

Freezing microtome (Microm) HM 525 with a freezer temperature at 30 °C below zero was used in the preparation of samples. The samples were strained according to the standard method using hematoxylin and eosin. A microscope AxioCam MRc 5 Imager Z2 was used for the examination of 20 mkm histological slice of the samples that was being held online with the use of the AxioVision computer program. Images of cheese product microstructure with chickpea flour additives were taken.

Statistical analysis of the data

All experiments were performed 3 times. The obtained data were processed by methods of mathematical statistics at theoretical frequency 0.95. The normal distribution and equality of standard deviations of variables were tested with Shapiro–Wilk test and Levene test, respectively. All tests were performed using Statistica 7.1 (StatSoft. Inc., Tulsa, USA) software.

RESULTS AND DISCUSSION

Studies on the regularities of biotechnology formation of cheese product manufacture using vegetable raw materials were conducted. Proportions of the product's composition were selected; the amount of chickpea flour was justified with regard to product being able to maintain necessary organoleptic, physical and chemical, microbiological and rheological indicators.

The main components of goat and cow milk are shown in Table 1. Fat content of the studied goat milk varied from 3.05% to 5.10%. The average fat content was 4.1%

(Table 1), which is somewhat higher than in a study conducted in the US (Park et al., 2007).

Table 1. Ranges in level, average fat and protein content of goat and cow milk

Component, %	Ranges in level, %		Average, %	
	goat	cow	goat	cow
Fat	3.05–5.10	3.80–5.0	4.1	4.4
Protein	2.69–3.95	3.13–3.81	3.32	3.47
Casein	2.61–2.71	2.6–2.7	2.66	2.65
Lactose	4.29–5.0	4.7–4.9	4.64	4.8
Solids	11.14–13.46	12.5–12.6	12.3	12.55
Solids non-fat	8.27–9.14	8.8–9.4	8.7	9.1

Protein content of goat milk ranged between 2.69% and 3.95%. The average protein content was 3.32%. Differences in the results can be attributed to regional peculiarities, breeding conditions, feeding, etc. (Salem et al., 2004; Park et al., 2007; Sanz Ceballos et al., 2009; Rewati Raman Bhattarai, 2012). When comparing the average fat and protein content of goat milk with corresponding parameters of cow milk, it turned out that the average fat and protein content of goat milk was slightly lower.

Organoleptic evaluation of the product

Organoleptic properties are a part of the complex of indicators that determine the nutritional value of cheese products. Table 2 presents samples of cheese produced in triplicates (three different batches of the same formulation): the amount of chickpea flour varied from 1% to 7% with the increment of 2%. All samples were analyzed in 3 parallel replications. All results were expressed as mean values of three replicates.

Table 2. Evaluation of experimental samples of cheese with different mass fraction of chickpea flour

A sample of soft cheese	The amount of chickpea flour, %	Consistency	The average rating
Control	0	gentle, elastic	4.8
Sample 1	1	uniform	3.9
Sample 2	3	moderately dense	4.5
Sample 3	5	gentle, connected	5.0
Sample 4	7	friable	4.4
Sample 5	10	crumbly	3.7

The scoring evaluation of experimental samples of cheese with different mass fraction of chickpea flour showed that all the samples had high ratings; however, the consistency of soft cheese with extruded chickpea in the amount of 5% received the highest score. Thus, taste of extruded chickpea flour in this product is felt softly.

According to the results of the experiments, in the case of using chickpea flour in concentration 5% the product with high organoleptic characteristics was obtained. With the addition of chickpea flour in the range of up to 5%, the consistency, color, taste and smell did not change significantly and were evaluated highly. While the increase of concentration of chickpea flour from 5% to 10% led to the decrease in average scores of mentioned indicators (Fig. 1).

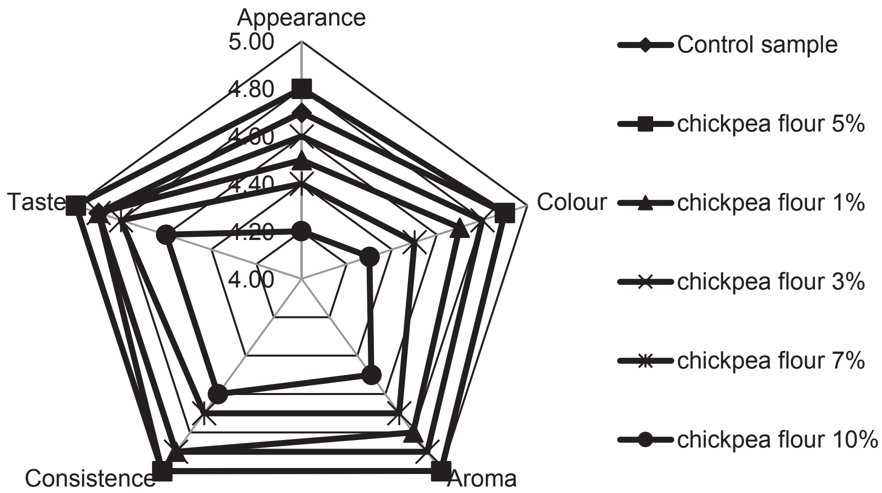

Figure 1. Dependency of point-based cheese product evaluation on mass fracture of the chickpea flour.

The data obtained from organoleptic analysis presented in Table 3. They demonstrate the differences of the experimental sample from control product.

Table 3. Organoleptic indicators of cheese product

Indicator	Control sample	Sample with bean filler
P	Pure diary sour, moderate salty without off-flavors; the surface is moist without mucus	Moderate salty typical for bean filler, weak smell of bean filler; the surface is moist without mucus
Consistency	Soft homogeneous; a little brittle, but not crumble	Homogenous, moderately dense, but not crumble
Pattern	No pattern. Some small round, oval or angular-shaped inclusions	No pattern. Some bean filler inclusions
Color	Uniform, from pure white to light yellow	Pure white, with uniform distribution of bean filler throughout the cheese body

The results of the sensory assessment of cheese quality are given (Fig. 1 & Table 3). It can be seen that appearance, taste and odour, consistency and texture of cheese were affected by the concentrations chickpea flour. The control cheese was a little firmer than cheese with increasing concentration of chickpea flour. The sensory attribute such as colour was found to be significantly different between control sample and samples with chickpea flour addition. The concentration increase up to 5% led to insignificant decrease in cheese firmness. The increase of concentrations of vegetable additive more than 5% led to a gradual decrease in organoleptic characteristics. The consistency of cheese became weaker, porous and even deliquescent. The taste and flavor of chickpea flour were strongly pronounced. All that makes these cheese curds the least acceptable for manufacture of cheese.

Thus, the most acceptable concentrations of chickpea flour for cheese manufacture are 5%. Further concentration increase leads to deterioration in the consistency of the cheese, which complicates soft cheeses obtaining, makes them unacceptable to the consumer.

The coagulation process of the mixture is one of the most important processes in cheese manufacture. Its success depends on a number of factors, as described by many authors (Smirnova & Ostroumova, 2006). The most indicative effect of chickpea flour on the acid accumulation process of samples can be demonstrated for the acid-rennet coagulation method of dairy mixture.

As a result of the research on soft cheese samples, it is shown in Fig. 2 that moisture–binding capacity of cheese with an addition of chickpea flour is higher than that of the control sample. These results demonstrated the efficiency of this additive for regulation of technological properties and quality of soft cheeses. During the cheese storage under constant temperature there was a decrease in moisture content. (Fig. 2).

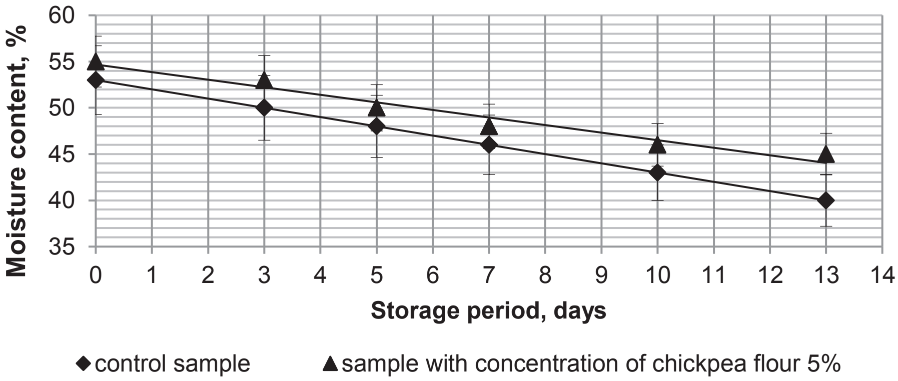

Figure 2. Changes in moisture content of cheese product during storage.

It can be caused by decrease in volume of the aqueous phase by addition of a chickpea flour to milk samples. Increased softness of cheeses made with a chickpea flour can be due to the filler and increased moisture level resulting from the high moisture – binding capacity of the chickpea flour. This can be explained by the positive influence of chickpea flour associated with an increase of hydrophobicity of proteins.

The ability of curds to whey separation during self-pressing process is important in the production of soft cheeses. It is obvious that samples with chickpea flour had a lower ability to separate whey. It was observed that the clots with chickpea flour have separated whey worse than the control sample. The varying water-holding capacities of curds influence the quality of finished products mainly the consistency of cheeses. The samples with chickpea flour were more similar to the control sample according to the ability to separate whey.

Data for titratable acidity changes throughout the storage period are illustrated in the Fig. 3. During the cheese product storage, an increase in acidity value depended on storage temperature and method. Cheese stored in our case at t = 4 ± 2 °C and relative humidity from 80 to 85%.

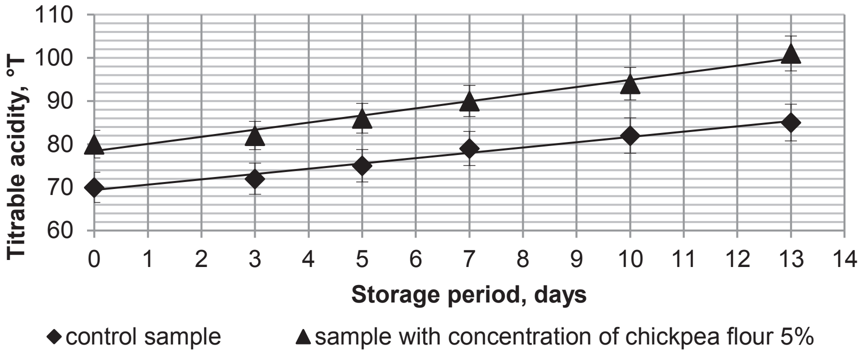

Figure 3. Changes titratable acidity of cheese product during storage.

Fig. 3 shows the increasing trend of titratable acidity of samples with chickpea flour during storage. The increase of acidity during storage was uneven. Acidity changes of the control sample were not significant during the first three days, then after 3 days of storage the acidity started to increase quickly and after 7 days it reached the acidity of the finished product (90°T), and after 13 days – the maximum 101°T. The increase of the titratable acidity of the finished product was more intense at the beginning of the storage period (first 3 days). It was observed that in a sample of cheese with chickpea flour the oxidation process proceeded more intensively. It can be seen from the data presented in Fig. 3, the addition of a chickpea flour slightly increased titratable acidity. Although, it had a tendency of acidity increase with the addition of a chickpea flour. Apparently, it can be due to bacteria, used the filler as a nutrient medium to produce lactic acid. Dynamics of accumulation of lactic acid in the experimental and control samples were similar.

During the product storage there was an increase in the quantity of mesophilic aerobic and facultative anaerobic microorganisms (QMAFAnM). The data presented in Fig. 4 show that the QMAFAnM increase is more intensive in the sample with the chickpea flour. This indicates that the added filler is an additional growth medium for microorganisms.

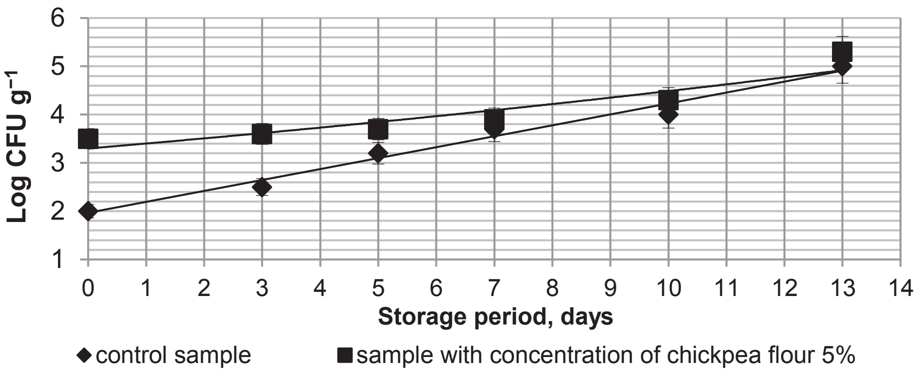

Figure 4. Microbiological changes in QMAFAnM during storage of cheese sample.

During the storage period, Escherichia coli bacteria, as well as potentially pathogenic and pathogenic microorganisms, fungus or yeasts were not detected in cheese samples.

Therefore, results of organoleptic, physical, chemical and microbiological analyses allowed to establish an expiration date of the product of 10 days under conditions of t = 4 ± 2 °C and relative humidity of 80 to 85%.

The output of each sample cheese from VAT milk (CY_v) was calculated using Eq. 1 (Heino et al., 2010). It is noted that with the increase of concentration of chickpea flour the product yield is also increased (Fig. 5), the difference between control sample and cheese product with chickpea flour yield is 12%. Hence, the product yield increases, at the same time gets functional properties, and is enriched with vegetable protein.

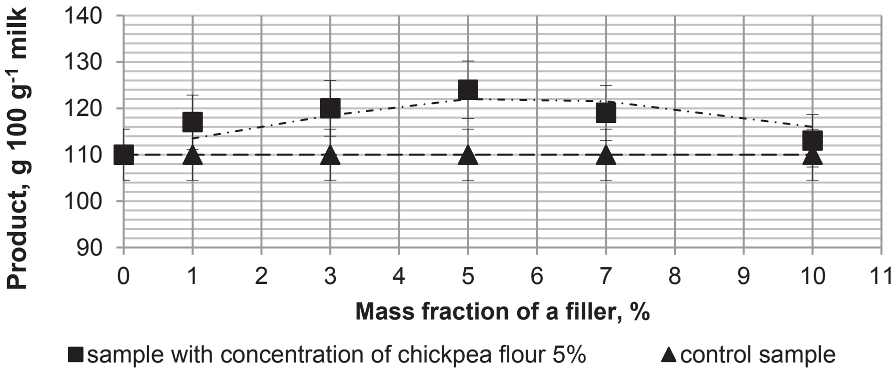

Figure 5. Effect of chickpea concentration on cheese yield.

It is well known that casein micelles in bulk milk are from 40 to 200 nm in size (Fig. 6, a), submicelle size is 12–20 nm, while the size of casein molecules of which submicelles consist of, as well as whey proteins, is in the range between 3 and 6 nm.

Fig. 6 shows the electron microscopic image of the rennet curd structure with the addition of chickpea flour.

a) b)

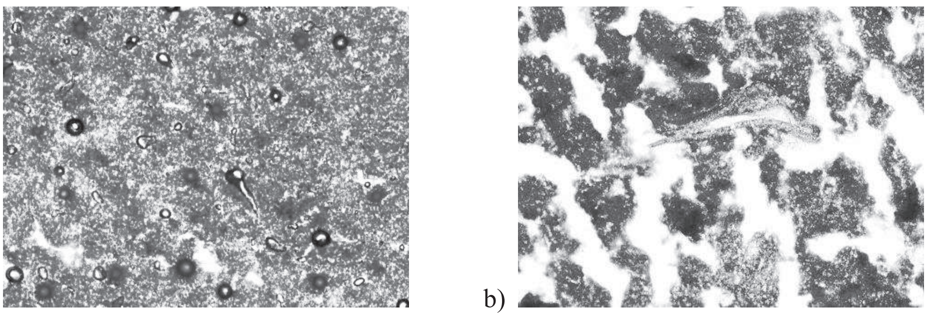

Figure 6. a) Histological slice of the product; b) Histological slice of the product with addition of chickpea flour in the amount of 5%.

During the experimental research, it was discovered that particles of chickpea flour slightly retard the process of gel syneresis; partially block the influence of the ferment on kappa-casein; physical and chemical processes of enzymatic formation of milk gel with flour particles run differently than with calcium chloride; particles of chickpea flour contribute to the binding of whey protein; it is probable that particles of chickpea flour also contribute to the binding of lactose.

CONCLUSIONS

Goats produce only approximately 2% of the world total annual milk supply. Goat milk differs from cow milk due its higher digestibility, alkalinity, buffering capacity, and certain nutritional and therapeutic properties.

A possibility of using chickpea flour in the soft cheese production was scientifically substantiated and proven practically, which allows enrichment of the product with vegetable protein and also increase product yield as well as to expand the assortment of dairy food products.

The optimal level of chickpea flour that maintains high technological properties of the cheese, consumer properties and nutritional value of the product was determined. The desired level of chickpea flour is 5% of weight of the mixture.

It is established that the introduction of chickpea flour into the soft cheese product has a positive influence on its organoleptic evaluation, vastly improves its nutritional and physiological values by means of enrichment with physiologically functional ingredients: phospholipids, polyunsaturated fatty acids, dietary fibers, vitamins, macro- and microelements, contributes to an increase in water retention capability of the product, increases product yield by 12% comparing to the control sample.

In addition, considering the almost complete absence of scientific works on the production of such cheeses, the obtained results could give a greater understanding of the characteristics of these products.

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