Development of formulation for soft cheese based on milk from animals of different species

A S Shuvarikov, O N Pastukh, E V Zhukova, P A Korenevskaya

Department of Storage and Processing Technologies of Animal Origin Produce, Russian State Agrarian University – Moscow Timiryazev Agricultural Academy, 48, Timiryazevskaya st., Moscow, 127434, Russia

E-mail: tppj@rgau-msha.ru

Abstract. One of the core branches of the Russian farming industry is the dairy industry. Cheese has always ranked first in nutritional profile and calorie count. It is high in fat, protein, minerals and vitamins. All these components are in balanced proportions and are easily absorbed by the human body. In Russia, the most consumed is cow cheese; goat cheese is also gaining popularity; in the Caucasus – goat and sheep milk cheese. Cheese made from milk of different agricultural animals each has its own quality indicators. Hence, the paper provides data on using various types of milk – cow, goat, sheep and mixtures – to produce cheese. The paper describes the objects and methods of research, the results of research experience, benchmarking and evaluation of finished cheese, physical and chemical properties and sensory characteristics. The highest content of fat, SNF and protein was found to be present in goat milk. In cheese production, bryndza cheese made from sheep milk was distinguished by a large yield, cheese from a mixture of goat and sheep milk – by the highest fat content, and sheep cheese – by protein. Taste tests concluded that consumers preferred goat cheese. Cow and sheep cheese ranked low. The maximum number of points was given to bryndza cheese made from a mixture of goat and sheep milk.

1. Introduction

Milk is one of the most vital livestock products in Russia. This product is a source of the most valuable ingredients. Over the past several decades, the amount of milk and dairy products has been constantly increasing, although, of course, there are some occasional drops in production. Cheese is gaining popularity in all countries of the world. Each country has its own taste preferences and technical conditions of production process. Natural cheese is not only a tasty and healthy product, but one of the ways to preserve milk by producing milk products that have a longer shelf life [1].

Most of the cheese is made from cow milk, although goat and sheep cheese are starting to appear. Russia is striving to increase the production of its own cheese, and to reduce the amount of imported cheese. Unfortunately, there is a global problem – a shortage of high-quality raw milk. As evidenced by the results of a 30-year patent search, patents (about 60%) are mainly devoted to replacing milk components with other components including skim milk, whey proteins, cheese cream, etc. to reduce the cost and increase the cheese yield.

The results of the patent search showed that the issue of studying the properties of cheese based on goat and sheep milk has been understudied. Subsequent upon information and patent search, it was concluded that all scientific research in the field of cheese making does not rely on computers, and
cow milk is most often used as a raw material [2, 3].

2. Purpose of the Study
The paper aims to develop a formulation and assess the quality of soft cow, goat and sheep cheese as well as cheese made from mixtures of milk, using mathematical modeling. Scientific novelty lies in providing a comprehensive assessment of the quality of goat and sheep milk, being the least studied, a comparative assessment of both kinds with cow milk; developing recipes for soft cheese based on cow, goat and sheep milk using mathematical modeling; using, as an optimization criterion, a maximum yield of processed products; processing taste evaluation feedback about the taste of finished products through algebraic analysis and conclusions about a sustainable blending ratio of cow, goat and sheep milk for bryndza cheese manufacturing [4–6].

3. Material and Methods
To accomplish the tasks assigned, the employees of the Department of Storage and Processing Technologies of Animal Origin Produce, Russian State Agrarian University – Moscow Timiryazev Agricultural Academy, carried out a series of experiments.

The following indicators of milk were studied, including sensory characteristics in accordance with GOST R 52054-2003 “Raw cow milk. Specification” (with Amendments No. 1, 2), GOST 32940-2014 “Raw goat milk. Specification”; physical and chemical indicators: density, percentage of fat, protein and SNF using a “Laktan 1-4” milk quality analyzer; acidity – titrimetric methods in accordance with GOST 3624-92 “Milk and Dairy Products. Titrimetric Methods for Determination of Acidity” (as amended) [4, 7].

The following indices were evaluated in bryndza cheese: sensory characteristics in accordance with GOST 33959-2016 “Pickled cheeses. Specification”; physical and chemical characteristics of cheese: acidity – titrimetric method in accordance with GOST 3624-92 “Milk and Dairy Products. Titrimetric Methods for Determination of Acidity” (as amended); percentage of fat – by sulfuric acid method in accordance with GOST 5867-90 “Milk and Dairy Products. Methods for Determination of Fat”; moisture – using a Chizhov device in accordance with GOST 3626-73 “Milk and Dairy Products. Methods for Determination of Moisture and Dry Matter” (with Amendments No. 1,2,3) [4, 8].

The following parameters were evaluated in whey: acidity – by titrimetric method in accordance with GOST 3624-92 “Milk and Dairy Products. Titrimetric Methods for Determination of Acidity” (as amended); percentage of protein – by form-molar titration; fat – by the sulfuric acid method in accordance with GOST 5867-90 “Milk and Dairy Products. Methods for Determination of Fat” [2, 9].

4. Results
Prior to bryndza cheese manufacture, the formulation was simulated using a computer. To formulate cheese, some methodological approaches were applied, designed on experimental statistical modeling, linear and non-linear programming. A set of methods involves identifying a key indicator and optimizing its quality. A computer-assisted computational experiment consists in eliciting a model-based response surface at different ratios over the entire surface. The mass fraction of each ingredient within the formulation was variables that needed to be calculated. The criterion for efficiency was the maximum cheese yield. The only constraint was a blending ratio [10].

4.1. Modelling cheese formula.
After drawing up necessary equations, this model was displayed in Excel: some source data (Table 1), criterion function, blending ratio, desired values of indicators were entered and solutions were searched.
Table 1. Data for enhanced formulation of cheese

| Nutritional value of ingredients | Ingredients | cow | goat | sheep | starter | enzymes |
|----------------------------------|-------------|-----|------|-------|---------|---------|
| Mass fraction, g/100 g: - water  | 88.22       | 87.67 | 81.58 | -      | -       | -       |
| - fat                            | 3.63        | 4.50  | 7.01  | -      | -       | -       |
| - protein                        | 2.76        | 3.02  | 5.72  | -      | -       | -       |
| - lactose                        | 4.69        | 4.70  | 4.77  | -      | -       | -       |
| - ash                            | 0.70        | 0.83  | 0.92  | -      | -       | -       |
| - whey fat                       | 0.04        | 0.44  | 0.21  | -      | -       | -       |

A “problem-solving” technique resulted in the proportional ratio of the mass of each ingredient in the formulation to be calculated (Table 2).

Table 2. “Problem-solving” results

| Bryndza cheese made from milk  | Amount of milk, % | Cheese yield, g |
|---------------------------------|-------------------|-----------------|
| Cow and goat                    | 50                | 50              | 159.61          |
| Cow and sheep                   | 50                | -               | 237.88          |
| Goat and sheep                  | -                 | 50              | 245.62          |
| Cow, goat and sheep             | 33                | 33              | 213.71          |

As per mathematical modeling, the maximum cheese yield should be elicited when manufacturing bryndza cheese from goat and sheep milk. As soon as the entire process was complete, including the development of a new product, and the evaluation of its sensory and chemical characteristics, the regulatory documentation was developed.

4.2. Raw milk quality.
The yield and quality of cheese depend on the sensory, chemical and technological parameters of the milk used. Before making cheese, raw milk was examined. The findings are presented in Table 3.

Table 3. Average values of physical and chemical parameters of milk

| Index                             | Milk               |
|-----------------------------------|--------------------|
| Mass fraction, %: - dry matter    | cow                |
|                                   | goat               |
|                                   | sheep              |
| SNF                               | 12.13±0.70         | 14.37±0.41        | 18.10±0.12      |
| fat                               | 8.51±0.98          | 9.19±0.27         | 10.45±0.14      |
| protein                           | 3.62±0.41          | 5.18±0.55         | 7.65±0.10       |
| lactose                           | 2.97±0.19          | 3.38±0.36         | 3.86±0.07       |
| minerals                          | 4.43±0.22          | 4.78±0.14         | 5.44±0.18       |
| Calorie count, kcal/g             | 0.68±0.04          | 0.74±0.03         | 0.84±0.04       |
| Density, g/cm³                    | 64.01±4.26         | 81.63±7.13        | 109.28±5.26     |
|                                  | 1.0276±0.02        | 1.0303±0.01       | 1.0331±0.01     |

Being benchmarked against indicators of different types of milk, sheep milk has a higher content of SNF, dry matter, lactose, protein, fat and minerals. Higher dry matter content is associated with higher fat and protein content. Accordingly, the calorie count in sheep milk will be higher than that in the rest. In terms of chemical indicators goat milk goes second, while cow milk exhibits the lowest indicators and calorie count.

Bryndza cheese was produced not only from a certain type of milk, but also from a mixture of...
different types. Chemical indicators of a mixture of cow, goat and sheep milk are presented in Table 4.

| Index                  | Milk mixture                  |
|------------------------|-------------------------------|
|                        | cow+goat | cow+goat+sheep | goat+sheep | cow+goat+sheep |
| Mass fraction, %:       |          |                |            |                |
| - dry matter            | 13.92±0.55 | 15.81±0.42    | 16.21±0.21 | 15.26±0.35     |
| - SNF                   | 8.86±0.100 | 9.51±0.005    | 9.81±0.001 | 9.38±0.010     |
| - fat                   | 5.06±0.005 | 6.30±0.001    | 6.40±0.005 | 5.88±0.010     |
| - protein               | 3.27±0.011 | 3.51±0.01     | 3.62±0.01  | 3.47±0.001     |
| - lactose               | 4.63±0.12 | 4.95±0.02     | 5.10±0.01 | 4.88±0.04     |
| - minerals              | 0.71±0.04 | 0.76±0.007    | 0.79±0.004 | 0.75±0.02     |
| Calorie count, kcal/g   | 79.33±0.21 | 93.28±0.16    | 95.27±0.37 | 88.92±0.28     |
| Density, g/cm³          | 1.029    | 1.0305        | 1.0317     | 1.0304        |

The highest indicators of SNF, fat, protein, lactose and minerals were found to be present in mixtures containing sheep milk. A mixture of goat and sheep milk contained the maximum physical and chemical indicators, which was due to the fact that this mixture had no cow milk that has minimum indicators.

4.3. Quality and yield of cheese.

Bryndza cheese made from milk of different species significantly differs when it comes to the quality indicators and yield (Table 5).

| Index                  | Bryndza cheese made from                      |
|------------------------|----------------------------------------------|
|                        | cow | goat | sheep |
| Mass fraction, %:       |          |      |       |
| - moisture              | 60.0±2.00 | 60.0±1.00 | 58.0±0.08 |
| - fat                   | 16.5±0.59 | 16.23±0.83 | 15.95±0.47 |
| - protein               | 15.24±2.16 | 17.4±1.21 | 18.93±1.55 |
| Milk consumed to make 1 kg of cheese, kg | 3.90±0.71 | 3.65±0.44 | 2.72±0.29 |

The yield and indicators of bryndza cheese made from milk of different species are not the same. Cheese made from sheep milk is distinguished by the highest yield. Sheep milk cheese is distinguished by a higher fat amount, a higher mass fraction of protein. The mass fraction of moisture in all cheese samples is almost the same. As with raw materials, goat milk cheese is medium indicators and cow milk cheese – the least.

The quality indicators and yield of bryndza cheese made from mixtures of milk of different species are presented in Table 6.

| Index                  | Bryndza cheese made from mixtures             |
|------------------------|----------------------------------------------|
|                        | cow+goat | cow+goat+sheep | goat+sheep | cow+goat+sheep |
| Mass fraction, %:       |          |                |            |                |
| - moisture              | 56.04±2.00 | 52.05±1.00    | 58.02±0.08 | 54.10±0.16     |
| - fat                   | 17.88±0.59 | 17.33±0.63    | 22.04±0.47 | 16.78±0.56     |
| - protein               | 15.82±2.16 | 17.76±1.21    | 18.10±1.10 | 18.57±1.35     |
| Milk consumed to make 1 kg of cheese, kg | 4.09±1.07 | 3.21±0.87     | 3.63±0.75  | 3.45±0.84     |
A mixture of cow and sheep milk is reported to yield most cheese with least milk consumed, since this milk mixture includes sheep milk that has the best chemical characteristics.

### 4.4. Taste assessment of cheese.

One of the key indicators of product quality is sensory evaluation. All produced cheese samples were tangy and had dense or slightly loose texture. RSAU employees and students were involved in the taste tests (Table 7). The following samples were evaluated: Sample I – bryndza cheese from cow milk; Sample II – bryndza cheese from goat milk; Sample III – sheep milk cheese; 1 sample – bryndza cheese from a mixture of cow and goat milk; 2 sample – bryndza cheese from a mixture of cow and sheep milk; 3 sample – bryndza cheese from a mixture of goat and sheep milk; 4 sample – bryndza cheese from a mixture of cow, goat and sheep milk.

### Table 7. Taste assessment of cheese

| Sample | Taste assessment (5 points) | Points total | Average | Geometric mean | Fuzzy similarity |
|--------|-----------------------------|--------------|---------|----------------|-----------------|
|        | Flavour | Taste | Texture | Colour |               |                 |               |               |
| I      | 4.56±0.59 | 4.78±0.35 | 4.22±0.86 | 5.0±0.0 | 18.56 | 4.64 | 4.61 | 0.38 |
| II     | 3.89±0.39 | 4.61±0.43 | 4.17±0.63 | 5.0±0.0 | 17.67 | 4.42 | 4.34 | 0.17 |
| III    | 3.17±0.63 | 4.56±0.49 | 4.28±0.37 | 5.0±0.0 | 16.45 | 4.11 | 3.17 | 0.00 |
| 1      | 4.02±0.89 | 4.73±0.37 | 3.89±0.79 | 5.0±0.0 | 17.62 | 4.41 | 4.31 | 0.15 |
| 2      | 4.04±0.44 | 4.67±0.44 | 4.05±0.52 | 5.0±0.0 | 17.72 | 4.43 | 4.36 | 0.18 |
| 3      | 4.33±0.44 | 4.22±0.52 | 4.44±0.49 | 5.0±0.0 | 17.99 | 4.50 | 4.47 | 0.24 |
| 4      | 3.95±0.42 | 4.44±0.74 | 4.39±0.57 | 5.0±0.0 | 17.78 | 4.45 | 4.40 | 0.20 |

Using the methods of comparative analysis, the sensory characteristics of the finished product were evaluated. For this, the following indicators were calculated, including the average, geometric mean and fuzzy similarity.

Based on the results of sensory evaluation, the cheese made from cow milk has the best consumer characteristics, since its geometric mean and fuzzy similarity have maximum values – 4.61 and 0.38, respectively.

### 5. Conclusion

Cow, goat and sheep milk used for the production of bryndza cheese, met the requirements of the technical regulations stipulated by the Customs Union “On the safety of milk and dairy products” (TR CU 033/2013). The largest mass fraction of SNF, fat and protein was found in goat milk (10.45%, 7.65% and 3.86%, respectively). Bryndza cheese made from sheep milk was distinguished by the highest yield, cheese from a mixture of goat and sheep milk – the highest amount of fat (22.0%) and cheese from sheep milk – protein (18.93%). The taste tests showed that the consumers liked the cow milk cheese more that was more common for the consumers (~ 18.56 points). Goat and sheep milk cheeses received lower ratings. Of the cheeses made from mixtures of milk, the highest number of points was given to sheep and goat milk cheese (17.99 points).

When developing formulations for new products, it is possible to recommend mathematical modeling to be used to create a product with a given profile and properties. To expand the range and increase nutritional profile and calorie count of cheese, it is possible to use goat and sheep milk for making soft cheeses.

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