

THESIS OF DOCTORAL (Ph.D.) dissertation

**EXAMINATION OF INDIVIDUAL COMPONENTS OF THE RAW  
SHEEP'S MILK AND THE INFLUENCE OF PROTEIN FRACTIONS TO  
CHEESE MAKING**

**Ildikó Bajúsz**

Supervisors: Dr. András Jávor, university professor

Dr. József Fenyvessy, university professor



UNIVERSITY OF DEBRECEN

**DOCTORAL SCHOOL OF ANIMAL BREEDING SCIENCES**

Debrecen, 2009.

## 1. Objectives of the research

In our country the position of the sheep's milk processing can be considered as conservative. From sheep's milk there will not or only rarely be produced any fresh dairy products, rather cheeses. Unfortunately also the Hungarian sheep products are exposed to the extreme price-variations of the world market. It has often occurred that some cheeses were only marketable to a low price. It can be generally said about products made of sheep's milk, that they deviate from the average products in the internal content and the deliciousness value, they aim at a demanding and special consumer layer, but despite their high biological value their consumption does not reach a desirable level (FENYVESSY and CSANÁDI, 1999). Most of the products made of sheep's milk are considered as hungaricum, which additionally increases the importance of the branch. The products made of sheep's milk can play a prominent part in the development of tourism and in the marketing of the general food offer of the country.

The objective of my Ph.D. dissertation is to support the production of products made of sheep's milk in a manner, to provide information of scientific value, however also applicable in the practice on the following areas:

- Determination of the milk composition of three Tsigai strains of Milking, Jucu and Csóka kept in South-Hungarian stocks and of the Awassi R<sub>1</sub> breed, extension of the knowledge concerning milk processing,
- determination of the protein fractions, introduction their role in the development of the cheese yield, i.e. how can be reached the biggest cheese quantity the most efficiently,
- introduction of the fatty acids and conjugated linoleic acids in sheep's milk and their role in dietetics and physiology,
- analysis of the amino acids and the solid matter content of the Tsigai strains and the Awassi R<sub>1</sub> breed,
- examination of the clotting time and the features of the curd during the cheese production with the purpose, to be able to consider them during the production of the product appropriately.

With my examinations I would like to contribute to the enhancement of the favourable dietetic-physiological judgment of the sheep milk and the products made thereof and thereby to the wide popularization of it and to reduce and eliminate the ill-grounded beliefs and indispositions.

## 2. Antecedents of the research

Most of the sheep's milk will be produced and consumed in Europe, although its quantity is disadvantageously affected by the extent of the reduction of the stock. In our country the sheep's milk was raised partly from the ancient Hungarian uberous long-wool sheep, partly from the Tsigai indigenous in the Carpathian basin and from the sheep breeds of the settling, penetrating, stock-raising folks. The characteristic sheep's milk products were prepared by simple shepherds, smallholders by the middle of the last century hereditarily from generation to generation, with simple means. The activity exercised in this manner has often twinned with elementary hygienic default, which often caused the weak quality of the products (CSISZÁR and TOMKA, 1948).

For the subsistence of the sheep branch the improvement of the competitiveness is essentially required. For the determination of the optimum number of the Hungarian ovine stock the common assessment of the domestic grazing-lands, the market possibilities, the domestic genetic potential, the means of the market extension, the available workforce and the environmental tasks is required. For the increase of the production results of the domestic stock the livestock producing interbreeding with different ovidae shall be required (VERESS 1991; 1996; KUKOVICS et al, 1997). We have to deal with the increase of the number of the milking variant of the Tsigai indigenous in the Carpathian basin emphatically. Beyond the milk quantity the lacto protein and the milk solids and their lactation weight can be the basis of the further selection.

The milk-production indices of the interbred stocks of the Tsigai were already examined earlier (PÓCZOS, 1934; FEJÉR, 1942; GAÁL, 1956), however the Tsigai as a possible breed for the milk-producing sheep-farming has come to the examined breeds only in the recent years.

Several national and foreign authors have reported about the composition and characteristics of the sheep milk. Among the national authors the works of CSISZÁR (1928), SCHANDL (1937) and BALATONI (1963) can be considered as elementary, who provide valuable data about the composition of the milk of the botany merino breed. The solid matter content of the sheep's milk and besides its fat and protein content is substantially higher than that of the cow's milk. The higher solid matter content allows the consumption of more bioactive nutritive; at the same time its economic importance is outstanding, such as the bigger yield concerning cheeses. The exact values are affected by the genetic background, the environmental conditions, the twinning and the current lactation condition.

The sheep's milk proteins contain the essential amino acids in the sufficient quantity and proportion, so they can be considered as full protein for the human organism (GORDON and KALAN, 1978; SAWAYA and SAFI, 1984; ANIFANTAKIS, 1986). The sulphur-bearing and essential amino acids are present in the sheep's milk in higher proportion than in the cow's milk. This advantageous feature will be supplemented also with the better digestibility and more favourable utilisation ratio of the proteins of the sheep's milk. The proteins of the sheep's milk are - similar to the cow's milk - not uniform proteins; they can be divided into further fractions. Similar to cow's milk there are 6 main proteins in the sheep's milk as well. These protein fractions are as follows:  $\alpha$ -s<sub>1</sub> casein,  $\alpha$ -s<sub>2</sub> casein,  $\beta$ -casein,  $\kappa$ -casein and two whey-proteins,  $\alpha$ -lactalbumin and  $\beta$ -lactoglobulin. Some scientists report about 7 main proteins by differentiating A and B variants within the  $\beta$ -lactoglobulin (BORDIN, 2001).

In the last century the fatty acid composition of the cow's milk was thoroughly studied, concerning the sheep's milk there is however substantially less publication issued, and they are very inconsistent. The main components of the sheep's milk fat are the triglycerides (97,8%), which contain more than two hundred different fatty acid, most of them however are only traces in milk. The phospholipids (0,8%), free fatty acids, sterols, carotenoids and the liposoluble vitamins amount to the remaining 2,8% (KURTZ, 1974; CHRISTIE, 1983; ALAIS, 1984).

Both the sheep's milk and the cow's milk will be processed typically with the same technological operations, in the most variable manner. From the products made of sheep milk the biggest market demand is for ewe-cheeses in the world. The selection of the cheeses made of sheep milk is very wide, the name of some of them is protected by the European Union and statutory regulations were prescribed about their use (FREITAS and MALCATA, 2000).

In order to determine the measure of the cheese yield, the values of the yield or the material demand shall be indicated. By cheese yield we mean the quantity of cheese made of milk with 100 kg known protein (casein) and fat content expressed in kilogram. The primal interest of the cheese producers is to attain the biggest possible result from unity material; with a more effective production their income can be increased.

### **3. Materials and methods**

#### **3.1. Sheep breeding, soiling, sampling**

The Tsigai breed of Csóka can be found in the training farm of the Centre of the Agrarian and Technical Sciences of the University of Debrecen, the ewes of Jucu and Milking are in Balmazújváros, on the farm of the breeder, Gábor Pál and the Awassi R<sub>1</sub> sheep can be found at the Bakonszegi Awassi Plc.

All three Tsigai strains were of free livestock breeding, they have spent only the nights in the sheepcote. Their soiling was based on grazing, typically extensive. The supplementation of their forage was composed identically. The method of the livestock of the Awassi R<sub>1</sub> breed is intensive, stabled, the forage technology consists of winter and summer forage. The ewes examined by us were 3-4 years old at the beginning of the sampling and they were with lamb with the third progeny generation.

The examination of the milk composition, the yield, the solid matter transfer and the sweet curd were carried out from bulk milk in case of the Tsigai strains, while the determination of the protein fraction and the required composition examinations, the complete fatty acid, KLS-content, amino acid analysis were performed from the individual milk samples of the Tsigai and Awassi R<sub>1</sub> breeds. The raw milk samples were taken from the animals according to the standard MSZ EN ISO 707:2000 in the works, with the help of the workers of the plant. The technology of milking was not uniform. In case of the Tsigai strains the milking was carried out manually, the first milk flow was separated and the udders were completely milked. In Bakonszeg we have applied mechanical milking, the sampling was performed with a 2x24 position milking machine type DeLaval.

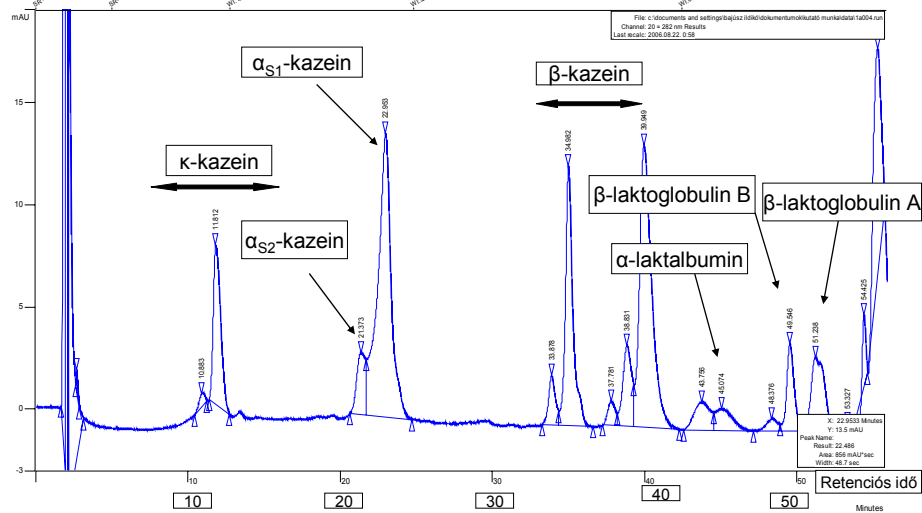
#### **3.2. Examination of the milk composition**

The milk composition examinations were performed for two lactation years from the bulk milk of Tsigai strains (100 of Csóka, 100 Jucu and 100 of Milking) and from 100 individual milk sample (25 Awassi R<sub>1</sub>, 25 Jucu, 25 of Milking and 25 of Csóka Tsigai strains) used for the determination of the protein fractions. The milk composition was examined in accordance with the IDF Standard 141B:1996.

### 3.3. Determination of the protein fractions of milk with HPLC

The determination of the protein fractions was performed for two years with the analysis of almost 3500 chromatograms run on HPLC from 100 individual milk samples of three Tsigai strains and the Awassi R<sub>1</sub> breed (Figure 1.).

Figure 1. Chromatogram from Tsigai sheep's individual milk sample



The examinations were carried out on the basis of the analytical method developed for BORDIN (2001) cow's milk, applicable also for sheep's milk.

The cooled, individual milk samples were degreased within 24 hours with centrifuging. The degreasing of the milk samples were performed with a Jouan CR422 centrifuge (8100 g, for 20 minutes at 37°C). The internal content values of the degreased individual milk samples were inspected with infrared spectrophotometer type Bentley 150.

Our inspections were carried out with a HPLC instrument of the system Varian LC Star. The device is controlled by a Varian Star 5.3 Software. During the examinations we have applied standard proteins, chemicals and eluents.

The injected sample volume was 20  $\mu$ l, the flow rate was 0,25 ml/minute. In order to increase the reliability of the measurement we have performed parallel measurements, so every single sample was run minimum four times, but in certain cases even eight times. Based on the chromatograms for the identification of the protein fractions we have read off the retention times and the size of the area under the belonging peak. The chromatograms were analysed on three wavelengths: 215 nm, 254 nm and 282 nm. For the quantitative determination of the protein fractions we have used the curves showing up during the

calibration of the cleaned proteins. From the data received knowing the protein content of the individual milk samples the data were corrected and afterwards we have determined the quantity of the total casein and the individual casein fractions respectively with mathematical calculations.

### **3.4. Determination of the complete fatty acid and the conjugated linoleic acid, amino acid analysis**

During our experiments we have performed a complete fatty acid analysis, KLS-content determination and amino acid analysis from the individual milk of the three Tsigai strains and the Awassi R<sub>1</sub> sheep. We have taken individual milk samples on the given plants in two months of the lactation for two times. For the inspections we have used the milk of totally 14 individuals milked during one day.

#### *Fatty acid analysis*

The samples were destructed with concentrated hydrochloric acid on hot-water bath and mixed with ethanol. Then we have extracted the lipids with ether, then with petroleum ether. After the combination of the organic phases we have removed the rennet with a rotational vacuum concentrator. The concentrated samples were boiled for approx. 5 minutes with 0,5 M methanol sodium-hydroxide solution, then for 3 minutes with 14% methanol boron solution. Afterwards we have fed dried hexane and boiled it for further 1 minute. The samples were cooled down and mixed with saturated water solution. After the precipitation of the phases the analysis was performed on a Chrompack CP 9000 gas chromatograph.

#### *Amino acid analysis*

The amino acid content of the samples was defined with ion-exchange column chromatography, with a device INGOS AAA 400. For the determination of the amino acid composition of the proteins as the first step the amino acids constituting a polypeptide chain shall be released from their bonds with hydrolysis. Afterwards the separation of the amino acid can follow with ion-exchange column chromatography. During the separation the acidic and hydrox amino acids separate from the ion-exchange column faster, while the basic amino acids more slowly and the neutral amino acids have a middle value between both extreme groups.

### **3.5. Examination of the yield after creaming and the solid matter transfer**

The examination of the yield after creaming and the solid matter transfer was carried out for two years from the bulk milk samples of Tsigai strains. The yield was defined on the basis of MELILLI's method prepared in 2002. The previously degreased 30°C milk of known composition was measured into the centrifuge tube with an analytical scale. The degrease of the milk was carried out with Janetzky T30 centrifugal machine with 3500 g for 10 minutes, then with 5500 g for further 10 minutes. Afterwards we have measured 150 cm<sup>3</sup> of fat-free milk, and then it was inoculated with rennet (MELILLI et al, 2002). For the inoculation we have applied the animal rennet with an inoculating strength of 14500, with the name "Caglio liquido" with a content of 50% chymosin and 50% beef pepsin of the company Caglifificio Clerici S.p.A. For 150 cm<sup>3</sup> milk we have used 37 µl rennet. The assessment of the transfer of the solid matter content into the cheese was performed from the available milk-analysis and quantity measuring results with a simple calculation.

### **3.6. Examination of the sweet curd with QTS 25 consistence testing device**

From the bulk milk of Tsigai strains of Csóka, Jucu and Milking we have examined the curdling process essential for the cheese production and its parameters as well for one lactation year. Upon preparation of the sample we have curdled 50 cm<sup>3</sup> bulk milk for 30 minutes at 30°C by adding 12,5 µl rennet. During the curdling of the bulk milk samples we have also measured the flocculation times with a Haake VT 500 rotational viscosity meter adjusted to 8,3 rotation/minute.

The examination of the developing curd was carried out with a QTS 25 (CNS Farnell, England) instrument, by repeating 3 parallel measurements for every single sample. For the selection of the most characteristic parameter of the curd we have performed pre-experiments, during which we have considered the stamp, the inspection temperature and the extent of compression as constant. As a result of the pre-experiments from the given characteristics we have decided for the examination of hardness, as comparing feature.

### **3.7. Mathematical, statistical methods**

For the evaluation of our examinations we have used the programs MS Excel and STATGRAPHICS 6.0. We have computed the average, the minimum and maximum values, the standard deviation and the relative standard deviation. For the proof of the coherence between the individual parameters we have prepared a correlation matrix. Upon analysis of the curd examinations and the determination of the protein fractions we have performed the

calculations on the basis of BYRKIT's (1987) method, with the program package STATISTICA for Windows 6.0. Among the statistical methods we have applied the one-way variance analysis (ANOVA), the Shapiro-Wilks, Kruskal-Wallis, Mann-Witney U, Hartley, Cochran and Bartlett test. We have laid special emphasis on the evaluation of our results with mathematical-statistical methods and in every case we have defined on the basis of the p values received by means of the Wilks-test, whether the visible changes are proven mathematically significant.

We represent our results in every case in tabular forms, which contain the average of all of our data.

## **4. The main results of the thesis**

### **4.1. Examinations of the milk composition**

Based on our results concerning the milk composition of the Tsigai strains it can be declared, that they harmonize with the previous findings published in the literature (CSISZÁR, 1928; SCHANDL, 1937; BALATONI, 1963; CSAPÓ, 1992; FENYVESSY, 1990; JÁVOR, 1994; KUKOVICS, 2002; CSANÁDI, 2005; KUKOVICS és JÁVOR, 2006). During the time inspected by us the changes of the milk composition have developed according to the expectations and the literature (SCHANDL 1937; BALATONI 1963; FENYVESSY 1992; JÁVOR 1994; MUCSI 1997; BEDŐ et al, 1999), so the highest protein, fat and solid matter content values were measured at the end of the lactation. The highest value measured at the end of the lactation was 6,45% in the protein content, 8,99% in the fat content, 12,45% in the fat-free solid matter content and 20,19% in the solid matter content.

The fluctuation values indicating differences occurred in the internal content of the milk prove that the biggest deviation was observed in the fat content, while the smallest deviation was in the lactose content. The biggest difference in the protein content was 0,98%, in the fat content 2,89%, in the lactose content 0,23%, in the fat-free solid matter content 1,49%, in the solid matter content 3,78%.

During the inspection of the milk composition of the Tsigai strains for two years it can be summarized, that the biggest difference between both years was experienced in the fat content and the smallest deviation can be measured in the lactose content. Due to the relative constant value of the lactose and the minerals, the fat-free solid matter content has mainly depended on the protein content of the milk.

Both milk components – fat and protein content - most important from the aspect of the cheese yield represent 62-67% in our case according to the literature data. For cow's milk the proportion of the similar milk components is 55-57% (FENYVESSY, 1990).

Our findings for the milk composition of the Tsigai strains kept under extensive conditions in the training farm of the Centre of the Agrarian and Technical Sciences of the University of Debrecen and in Balmazújváros are as follows: although the solid matter content and the fat-free solid matter content of the bulk milk of the Tsigai strain of Csóka were lower than the Tsigai breed compared to the strains of Jucu and Milking, within this all three strains are of good milk production capability and recommendable for popularization.

## 4.2. Determination of protein fractions

Based on the differences in the total casein content we could unequivocally ascertain, that there was a significant difference between both breeds inspected by us (Tsigai and Awassi R<sub>1</sub>). The Awassi has a higher total casein quantity (83,95% on average) than the Tsigai strains (76,82% on average). Our results correspond with the literature data, according to which in case of the botany merino, Awassi, long-wool sheep and langhe the casein ratio varies between 77,6-82,2% among the total protein amount, while in case of the Tsigai and sarda it varies between 71,2-77,5% (BOYAZOGLU, 1991; CASPER, 1999; FENYVESSY, 1990; ARRANZ et al, 2001). The strain of Csóka had the lowest casein content. The deviation observable in the total casein quantity can cause differences in the yield. Because the main protein of the cheese production is the casein, the milk of higher casein ratio as experienced at the Awassi R<sub>1</sub> can be recommended rather for cheese production, while the milk of the Tsigai strains can be recommended rather for the production of sour products owing to its higher whey protein.

During the period inspected by us observing the periodically alteration of the total casein quantity it can be determined, that the total casein quantity has continuously increased in Tsigai strains and the highest values were measured in the 3<sup>rd</sup> and 4<sup>th</sup> month of the lactation. The periodical process of the total casein quantity of the Awassi R<sub>1</sub> breed differs from the Tsigai breed. The alteration of the casein content is not so uniform and it differs in its tendency from the observations of the Tsigai strains. At the Awassi R<sub>1</sub> breed the alteration is rather fluctuant, the highest values were measured in March, and similar to the Tsigai breed the total casein quantity has significantly increased at the end of our examinations compared to the start.

After the analysis of the most important casein fractions concerning cheese production, the  $\kappa$ -,  $\alpha$ - and  $\beta$ -casein quantities it can be ascertained, that the  $\kappa$ -casein content of the Tsigai of Jucu and Milking are almost identical also mathematically proven, the  $\kappa$ -casein content of the Tsigai breed of Csóka is however significantly higher. The  $\kappa$ -casein content of the Awassi R<sub>1</sub> breed is similar to the Tsigai of Csóka. The  $\alpha$ -casein content of the Tsigai of Jucu and Milking and the Awassi R<sub>1</sub> breed are almost identical, the  $\alpha$ -casein content of the Tsigai strain of Csóka is significantly lower. In case of the  $\beta$ -casein content we could detect also significant differences. The Awassi R<sub>1</sub> had the highest value; it was followed by the Jucu from the Tsigai strains. The Tsigai strains of Milking and Csóka had almost identical  $\beta$ -casein-quantity.

Considering the periodical alteration of the casein fraction amounts it can be determined, that both in case of the Awassi R<sub>1</sub> breed and the Tsigai strains fluctuations could be

experienced within the examination period. The  $\kappa$ -casein quantity has increased only in case of the Tsigai strain of Csóka by the end of our measurement period in a mathematically proven manner. There was not any significant alteration in the Awassi R<sub>1</sub> and Tsigai of Milking, however in case of the Jucu Tsigai a significant reduction could be experienced. The  $\alpha$ -casein amount of all three Tsigai strains and the Awassi R<sub>1</sub> breed has increased by the end of our examinations. A significant difference in the alteration of the  $\beta$ -casein amount – in this case a reduction – could be experienced only in the strain of Milking. Since it is known that the casein fractions are responsible primarily for the cheese yield and the stock strength (MUIR et al, 1993), so these results can be considered informative anyway concerning cheese production.

#### **4.3. Determination of the crude fat and KLS-content**

After the examination of the individual milk samples of the Tsigai strains and the Awassi R<sub>1</sub> breed we have determined, that they did not differ significantly from the literature publications (SAWAYA and SAFI, 1984; FENYVESSY, 1990; VOIVODA and MIKHAILOVA, 2001, KUKOVICS et al, 2004; CSANÁDI, 2005).

The fatty acids of the examined milk fat samples discoverable in the biggest amount were according to the literature data (CSAPÓ et al, 2001/a) the myristic acid, the palmitic acid, the stearic acid and the oleic acid. The four fatty acids occurring in the biggest amount constitute 79,7% of the total fatty acid for the Jucu Tsigai, 76,1% of the Tsigai of Milking, 79,6% of the Tsigai of Csóka and 70,1% of the Awassi R<sub>1</sub>. Among the four „dominant” fatty acids the oleic acid had the biggest variation, the values of the stearic acid had the lowest variation; however a general conclusion could not be made due to the relative low number of the individual samples.

During our examinations concerning the fatty acid composition of sheep's milk it is considerable that the proportion of the unsaturated fatty acids of the Tsigai strains with extensive forage was between 33,49-38,22% on average and the proportion of the saturated fatty acids was between 61,74-66,39%. The proportion of the unsaturated fatty acids was more than 6% higher in case of the Tsigai strains compared to the data of SEVI et al (1998) concerning milk of the comisana sheep. Compared to the cow's milk (CSAPÓ, 1992) we have found the proportion of the unsaturated fatty acids approx. 4% higher. The fatty acid composition of the milk of the Tsigai sheep examined by us is close to the hypothetically ideal fat. In case of the Awassi R<sub>1</sub> breeds the proportion of the unsaturated fatty acids is almost 10% lower than in case of the Tsigai strains.

Almost 90% of the unsaturated fatty acids of the breeds consist of simply unsaturated fatty acids, among which the oleic acid occurs in the biggest amount. In case of the Tsigai strains the ratio of the oleic acid (27,48-30,83%) exceeds the highest value concerning the sheep's milk found in the literature with 3,5 % (SAWAYA and SAFI, 1984). Compared to the cow's milk the ratio of the oleic acid is almost 4% higher (CSAPÓ, 1992). From the milk samples of the Awassi R<sub>1</sub> sheep we could detect also in this case lower values. Also the proportion of the fatty acids containing two or more double bond is not negligible; we have observed a value of around 4% for all strains and the Awassi R<sub>1</sub> breed as well.

After the examination of the proportion of the physiologically extremely important omega-3/omega-6 fatty acids it can be declared, that our values received for the Tsigai strains close to the ideal value defined by CSAPÓ et al (2001/a). Examining the KLS-content, which has also positive features from nutrition scientific aspect it can be declared, that although the KLS-level of the raw milk shows a wide fluctuation, our data correspond with the values found in the literature (CSAPÓ et al, 2001/b; KUKOVICS et al, 2004). Among our data there can be especially attended to the KLS-content of the Tsigai of Csóka, because in this case, referred to 100g raw fat, we have received a value bigger than almost one and a half compared to the results of the other two Tsigai strains and the Awassi R<sub>1</sub> breed.

#### **4.4. Determination of the amino acid and solid content**

Our examination results confirm the opinions, according to which the amino acid set of the sheep's milk is biologically more valuable than that of the cow's milk (GORDON and KALAN, 1978; SAWAYA and SAFI, 1984; ANIFANTAKIS, 1986), which results of the bigger share of the essential amino acids.

FENYVESSY (1990) and CSAPÓ (1992) have defined the amino acid set of the botany merino sheep and examined the alterations occurred within the lactation respectively. The results received for the amino acid amounts and the values of the essential and non-essential amino acid proportions measured by us harmonized with the results received by the mentioned authors concerning the botany merino sheep.

In case of the examination of the amino acid content the Tsigai strains can be considered as one group from the aspect of comparison, and the total amino acid content of their milk is almost 15% lower than that of the Awassi R<sub>1</sub> breed.

Upon examination of the proportion of the essential and non-essential amino acids, comparing our results with the essential amino acid demand determined by FAO/WHO and the amino acid composition of the sheep's milk protein it can be ascertained, that the essential

amino acid content of the milk of the Tsigai strains and the Awassi R<sub>1</sub> breed significantly exceed the demand, so the amino acid demand of the developing organism can be completely satisfied.

Based on our results received during the solid matter content examination, which plays an important role from the point of view of cheese yield, it can be declared, that there is a difference also in the solid matter content between the Tsigai strains and the Awassi R<sub>1</sub> breed. The values of the Tsigai strains of Milking, Jucu and Csóka are similar, so they have constituted a homogeneous group. In case of the Awassi R<sub>1</sub> breed we have measured higher values significantly deviating from these strains.

#### **4.5. Examination of yield after creaming and solid matter transfer**

The effects of the internal content values of the bulk milk samples received from Tsigai strains to yield were developed according to the expectations, the increase of the solid, protein and casein content has raised the significant increase of the yield. Based on the R<sup>2</sup> values received during the solid matter and protein transfer the effect of the protein content has proven the tightest, because the protein content plays a more significant role in yield than the mineral and lactose content. The R<sup>2</sup> value received for the casein content has indicated the closest coherence, so the casein quantity in the protein content is the most determinative concerning the cheese yield.

Upon examination of the strains the percentage of the yield was the highest of the Jucu Tsigai, because the Jucu strain had the highest protein content. Although the Tsigai of Csóka had the lowest protein content, but if we have examined the relative yield referred to 1% protein content, we did not find any big difference anymore, compared to the Tsigai strains of Milking and Jucu. The reason for this is that in this case we have considered the casein ratio within the protein, which mainly affects the yield.

During our measurements we have ascertained, that from the higher solid content of the Jucu Tsigai strain a higher percentage has come into the cheeses. Concerning the solid matter transfer there was not any significant difference between the Tsigai strains of Milking and Csóka.

Based on the data of our examinations it can be summarized, that we have to use 4,9 liter of the milk of the Tsigai of Milking, 5,4 liter from the milk of the Tsigai of Csóka, 4,6 liter from the milk of the Jucu Tsigai for the production of 1 kg cheese. Based on above among the bulk milk samples received from the Tsigai strains drawn into the yield examinations –

considering the milk composition – the milk of the Tsigai of Jucu and Milking would be the most appropriate for cheese production.

#### **4.6. Examination of sweet curd**

Based on our results it was clearly proven, that the flocculation time is affected by the ratio of the  $\beta$ - and  $\alpha$ -casein fractions in case of a curd performed under identical conditions. During our measurements we have experienced that according to the literature (MUIR et al, 1993) the milk samples of the Tsigai strains of Milking and Jucu with the higher  $\beta$ - and  $\alpha$ -casein ratio have shown the first signs of the curd earlier than experienced at the Tsigai of Csóka.

From the hardness results of the instrumental consistency inspections we have come to the conclusion, that the hardness of the curd of the Tsigai strains of Milking and Jucu deviates from the strain of Csóka, it is significantly lower. The reason of this can also account for the difference between the casein fractions, the strength of the curd will be defined by the amount of the  $\kappa$ -casein among the protein fractions. According to our measurements the curd of the Tsigai of Csóka with the higher  $\kappa$ -casein content has become the hardest accordingly.

After the development of the curds it can be summarized, that the curd of all three Tsigai strains is appropriate concerning the cheese production. Although we did not experience any difference between the curds of the three Tsigai strains with sense perception, the results of the QTS stock examination have shown, that the Tsigai strains of Jucu and Milking behaved identically concerning the curd strength, the hardness of their curd has shown a result less than almost 8-10% than the values of the Tsigai breeds of Csóka.

## **5. New scientific results**

1. For the analysis of the protein fractions we have chosen a method, which – according to the literature references - was applied until now only for cow's milk. The comparative analysis of the quantity alterations of the casein fractions for these Tsigai strains and the Awassi R<sub>1</sub> breed still was not performed in Hungary. With this method we could carry out comparative analysis of the content of the total casein and casein fractions of the Tsigai strains and the Awassi R<sub>1</sub> breed and the periodic alteration of their amounts as well.
2. We have ascertained that in case of the Tsigai strains the ratio of the oleic acid exceeds the highest value referred to sheep's milk found in the literature with 3,5%. The KLS-content of the Tsigai of Csóka referring to 100g raw fat is almost one and a half higher than the results of the Tsigai of Milking, Jucu and the Awassi R<sub>1</sub> breed.
3. Based on our examinations the total amino acid content of the milk of the Awassi R<sub>1</sub> breed is approx. 15% higher than that of the Tsigai strains.
4. We have ascertained that from the bulk milk samples deriving from the Tsigai strains the milk of the Tsigai of Jucu and Milking would be the most appropriate for cheese production.
5. During the curd examinations we have determined, that the ratio of the  $\beta$ - and  $\alpha$ -casein amounts within the protein fractions affects the flocculation time and the amount of the  $\kappa$ -casein affects the curd strength. The milk samples of the Tsigai strains of Jucu and Milking have shown the first signs of curding faster, their curds were however less solid as experienced for the Tsigai strain of Csóka.

## **6. The practical usability of the results**

1. With the milk composition examinations we have proven, that the keeping and milking of the Tsigai ewes can significantly increase the proceeds from sale, so sheep-stock can be made profitable easier.
2. The attention of the industrial plants processing sheep's milk concentrates first of all to the composition of sheep's milk and the quantity alterations of the individual milk components, so it is important anyway, that the two components – fat and protein content -, which are the most important from the aspect of cheese yield, represent together 62-67% in accordance with the literature data. Based on the data of the yield examinations it can be ascertained, that 4,9 liter from the milk of the Tsigai of Milking, 5,4 liter from the

milk of the Tsigai of Csóka and 4,6 liter from the milk of the Jucu Tsigai shall be used to prepare 1 kg of cheese. Based on this – considering the milk composition – the milk of the Tsigai of Jucu and Milking would be the most appropriate for cheese production.

3. With the examination of the curdling of the milk of the Tsigai strains and the curd stock during the practical application we can contribute to the attainment of the profitability during the production processes and the appropriate quality of the product, so the required stock of the curd.
4. From the aspect of practice the most possible accurate knowledge of the protein fractions is all-important for the dairy industry. Because it is known, that the casein fractions are primarily responsible for the cheese yield and the stock strength (MUIR et al, 1993), so our results can be considered informative anyway from the point of view of cheese production.
5. Due to nutrition scientific aspects it can be informative, that the fatty acid composition of our milk samples is very close to the hypothetically ideal fat. The KLS-content of the Tsigai of Csóka referred to 100g raw fat is almost one and a half higher than the results of the Tsigai of Milking and Jucu and the Awassi R<sub>1</sub> breed.
6. Based on the essential content of the milk samples inspected by us their consumption can be recommended for the developing organism.

## 7. Publications in the topic of the thesis

### *Articles in the topic of the thesis*

1. **Bajúsz I. (2005):** Rheological measurements of cheeses. Scientific and Technical Bulletin for 2005 Nagyvárad Analele Universitatii in Oradea. In: Fascicula: Ecotoxicologie, zootehniei tehnologii de industrie alimentara. p. 411-417.
2. **Bajúsz I., Bajúsz-Kabók K., Fenyvessy J., Záhonyi-Racs P. (2006):** Substance analysis of spreadable poured cheeses. Journal of Food Physics. Budapesti Corvinus Egyetem. p. 85-93.
3. **Bajúsz I., Kukovics S. (2006):** Method of conservation (based on phenotypic and/or genetic traits) in the case of multipurpose Tsigai and other indigenous sheep breeds in Central, Eastern and South-Eastern European countries. In: Kukovics S., Kume K.: Possible way of conservation the multipurpose Tsigai and other indigenous sheep breeds in Central, Eastern European and Balkan countries, European Regional Focal Point for Animal Genetic Resources. Roma, Italy. p.81-91.
4. **Bajúsz I., Csanádi J. (2007):** The examination of Tsigai ewe milk. Review of Faculty of Engineering, Analecta Technica Szegediensia. p.1-6.
5. Csanádi J., Fenyvessy J., **Bajúsz I. (2007):** The breeding of tsigai sheep as a possibility towards the profitability I. Milking performance, production indexes. Review of Faculty of Engineering, Analecta Technica Szegediensia. p.23-30.
6. Csanádi J., Fenyvessy J., **Bajúsz I. (2008):** The breeding of tsigai sheep as a possibility towards the profitability II. Fatty acid composition of milk. Review of Faculty of Engineering, Analecta Technica Szegediensia. p.13-19.
7. Csanádi J., H. Horváth Zs., Fenyvessy J., Hodúr C., **Bajúsz I. (2008):** Zsírgolyócskák méreteloszlása tehén-, és kecsketejben. Tejgazdaság LXVIII. (1-2). p.77-83.
8. **Bajúsz I. (2008):** Három cigája fajtaváltozat tejének beltartalmi vizsgálata és a juhtej kazein frakcióinak elválasztása RP-HPLC módszerrel. Agrártudományi Közlemények 31. p.13-22.
9. **Bajúsz I., Csanádi J. (2009):** Cigája fajtaváltozatok tejösszetételének vizsgálata. Tejgazdaság, in press.

### *Articles*

1. Csanádi J., Jávora A., Fenyvessy J., Szabó G., Eszes F., **Bajúsz I. (2003):** Changes in the D-Amino Acid content of sheep milk related technologies. The environment resources and sustainable development. International Scientific Session. Oradea. p. 9-12.
2. **Bajúsz I. (2005):** HACCP rendszer kidolgozása egy tejipari termékre. Szeged (dokumentált szakma specifikus alkotás). p.1-52.
3. **Bajúsz I. (2006):** Juh és kecsketej szerepe a táplálkozásban. Magyar juhászat 15. (3). In: A magyar mezőgazdaság 61. (13). p.10-14.
4. **Bajúsz I. (2007):** Beszámoló a Szegedi Tudományegyetem (SZTE) Mérnöki Karán 2007-ben megvédett tejgazdasági témájú szakdolgozatokról. Tejgazdaság LXVII. (1). p.31-37.

### *Conference lectures in the topic of the thesis*

1. **Bajúsz I.,** Bajúsz-Kabók K., Csanádi J., Záhonyi-Racs P. (2004): Tejföl és joghurt állományának vizsgálata. Matematika, Fizika, Számítástechnika Főiskolai Oktatók XXVIII. Konferenciája. Nyíregyháza.
2. Fenyvessy J., Csanádi J., **Bajúsz I. (2004):** A magyar juhtejgazdaság helyzetelemzése. VI. Nemzetközi Élelmiszertudományi Konferencia, Szeged.
3. **Bajúsz I.,** Bajúsz-Kabók K., Csanádi J., Záhonyi-Racs P. (2004): Savanyú tejtermékek állományának vizsgálata. Al Il-Lea Simpozion International „Resurse De Mediu Si Dezvoltarea Durabila”. Oradea.
4. **Bajúsz I. (2005):** Minőségbiztosítás egy tejipari termék esetében. X. F fiatal Műszakiak Tudományos Ülésszaka, Kolozsvár.
5. **Bajúsz I.,** Kukovics S. (2005): Method of conservation (based on phenotypic and/or genotypic traits). Possible way of conservation the multipurpose tsiagi and other indigenous sheep breeds in Central-, Eastern-, and South-eastern European countries. Budapest.
6. **Bajúsz I. (2005):** Matematikai, statisztikai módszerek alkalmazása a kísérleti eredmények kiértékelésében. Erdei Ferenc III. Tudományos konferencia. Kecskemét.
7. **Bajúsz I.,** Bajúsz-Kabók K., Huhn E. (2005): Juhtej állományjellemezőinek összehasonlító vizsgálata matematikai statisztika módszereivel. Matematika, Fizika, Számítástechnika Főiskolai Oktatók XXIX. Konferenciája. Szeged.

8. **Bajúsz I.**, Bajúsz-Kabók K., Fenyvessy J., P. Záhonyi-Racs P. (2005): Substance analysis of cheeses. Innovation and Utility in the Visegrad Fours. International Scientific Conference. Nyíregyháza.
9. **Bajúsz I.** (2005): Juhtej beltartalmi értékeinek összehasonlító vizsgálata a tehéntejjel. Bácska Expo, I. Élelmiszeripari és Mezőgazdasági Kiállítás és Vásár. Baja.
10. **Bajúsz I.** (2005): Juhtej beltartalmi értékeinek vizsgálata. Magyar Tudomány Hónapja. Szeged.
11. Csanádi J., Fenyvessy J., **Bajúsz I.** (2006): Cigája anyajuhok tejtermelésének és a tej összetételének vizsgálata. X. Agrárökönómiai Tudományos Napok. Gyöngyös.
12. **Bajúsz I.**, Kukovics S. (2006): Possible way of conservation the Tsigai and other sheep breeds. Within the European Union. III. International Conference. Mosonmagyaróvár.
13. **Bajúsz I.**, Fenyvessy J., Csanádi J, Jávör A. (2006): Nutrition evaluation of components of small ruminants milk. Within the European Union. III. International Conference. Mosonmagyaróvár.
14. **Bajúsz I.** (2006): Juhtej állományának vizsgálata. VII. Nemzetközi Élelmiszertudományi Konferencia. Szeged.
15. **Bajúsz I.**, Smehák Gy., Záhonyi Racs P. (2006): Substance analysis of spreadable poured cheeses. Matematika, Fizika, Számítástechnika Főiskolai Oktatók XXX. Konferenciája. Pécs.
16. **Bajúsz I.**, Fenyvessy J., Szabó G. (2006): Substance analysis of cheeses with rotational viscosimeter. 4th international scientific symposium. Natural resources and sustainable development. Oradea.
17. Csanádi J., **Bajúsz I.** (2006): Milk production and composition of Tsigai sheep in Hungary. I-st International Symposium. "Ecological approaches towards the production of safety food". Plovdiv, Bulgária.
18. **Bajúsz I.**, Bara-Herczegh O. (2006): A kappa-kazein elválasztása RP-HPLC módszerrel. A Tudomány Ünnepe. Szeged.
19. Csanádi J., Fenyvessy J., **Bajúsz I.** (2007): Fatty acid composition of Tsigai sheep milk as a physiological advantage. 5th International symposium on the challenge to sheep and goats milk sectors. Alghero, Italy.
20. **Bajúsz I.** (2007): Juhtej kazein frakcióinak elválasztása RP-HPLC módszerrel. „A jövő tudósai, a vidék jövője,, Ph.D. konferencia. Debrecen.

21. **Bajúsz I. (2008):** A nyers juhtej összetételének és minőségének hatása a sajtkihozatalra. "Fiatal kutatók az élhető földért". MTA Magyar Tudomány Ünnepe, FVM központi rendezvény. Budapest

### *Conference lectures*

1. Fenyvessy J., Csanádi J., **Bajúsz I.**, Kiss T. (2005): Alternatív vajkrém-receptúrák kidolgozása az új piaci kihívások ismeretében. XLVII. Georgikon Napok és 15. ÖGA éves találkozó. Keszthely.
2. Csanádi J., Fenyvessy J., **Bajúsz I.** (2005): A juhtej és juhtejtermékek D-aminosav tartalma. Lippai J.- Ormos I.- Vas K. Tudományos Ülésszak. Corvinus Egyetem Budai Campus.
3. Fenyvessy J., Csanádi J., **Bajúsz I.** (2006): The effect of SCC on the texture properties of yoghurt from sheep milk. LMC International Food Congress. Dánia.
4. **Bajúsz I.**, Fenyvessy J., Sipőcz Zs. (2006): A porlasztva szárított sovány tejpör minőségi követelményei. XV. Élelmiszer Minőségellenőrzési Tudományos Konferencia. Debrecen.
5. Csanádi J., Fenyvessy J., **Bajúsz I.**, Bara-Hercegh O. (2006): Juhtej szomatikus sejszámának hatása a joghurt állománytulajdonságaira VII. Nemzetközi Élelmiszertudományi Konferencia. Szeged.
6. **Bajúsz I.**, Kiss T. (2007): Alternatív vajkrém összetétele és állománya. Matematika, Fizika, Számítástechnika Főiskolai Oktatók XXXI. Konferenciája. Dunaújváros.