

**Thesis of doctoral (PhD) dissertation**

**OPPORTUNITIES FOR DEVELOPING FUNCTIONAL DAIRY  
FOODS**

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## **1. The background and objectives of the Doctoral Thesis**

In recent years not only in Hungary, but also in the world has increased the number of diseases that are correlated with bad lifestyle and irregular, unbalanced diet. There is a growing number of publications and literature dealing with health promotion and alternative therapies. Countless forums available where one can find information about the importance of a varied diet, good nutritioning and the sanitary role of certain foods and they functions in the body.

The consumers' expectations towards a food constantly shaping and changing with the growth of their knowledge which the food industry should follow. In order to satisfy the expectations of consumers and maintain competitiveness food producers need to develop and innovate. The trends of recent decades include whole grain products, foods with reduced carbohydrate content, the „light” and low-fat and sugar-containing products. Mineral substances and vitamin-enriched foods appeared thus creating the new group of functional foods.

Many defined the concept of functional foods (Bíró 1997, Schenker 1999, Szilvássy and Sáy 2008). The criterion is common in each definition: these foods must have proven positive and additional health effects on the body. The functional food market is leaded by dairy products within this the products enriched with probiotics. Several product development experiment launched with the aim to increase the value of milk and dairy product whether through production technology, enrichment or perhaps with the withdrawal of certain components.

Many examined and published the possibilities and effectiveness of in-process vitamin and mineral substance supplementation in yogurts and cheese and the value of goods produced by the addition of various oils. Ilic and Ashoor (1988) enriched a yogurt with vitamin A and C in a way that the product they made covered the daily requirements of vitamin A and C. Cueva and its co-workers examined the possibilities of vitamin B enrichment also in yogurt. Based on their results vitamin B content can effectively be increased in a way that the organoleptic characteristics of the product are not harmed. Banville and its co-workers analyzed the opportunities of increasing vitamin D content in cheese. According to their results 61.5 % of vitamin D added during the production retained in the cheese. Alzate and its co-workers (2010) examined the effects of various selenium concentrations on yogurt bacteria. They identified a significantly higher number of bacteria in the presence of selenium than in the control

samples. Nagy and its co-workers proved the physiological benefits of the consumption of selenium enriched yogurt.

Dhman and its co-workers (1999) studied the effects of oily seed supplementation. The CLA content of milk and cheese increased by 109% with the supplementation of soy, and by 77% with the supplementation of cotton seed. Zhang and its co-workers (2006) examined the effects of linseed supplementation on sheep milk and cheese. With the supplementation they reached a 73% higher CLA content in milk, which remained in the cheese too. Vargas and its co-workers (2013) made cheese out of milk derived from oil cake supplementation. According to their findings the quantity and proportion of fatty acids in milk remained in the product too.

There are fewer publications discussing that to what extent the vitamin content achieved naturally with various supplementation remains in yogurt and cheese, or how the fatty acid profile of milk – successfully modified by foraging - changes in the aforementioned products during processing, and which supplement provides a valuable dairy product.

Not everybody can enjoy the various physiological benefits of milk and dairy products. More and more people are becoming sensitive to certain components of milk. There are an increasing number of people suffering from digestive problems, the most common cases are lactose sensitiveness and lactose intolerance. Lactose malabsorption occurs when the body is unable to split the lactose into its monomers: glucose and galactose. In this case lactose gets into the small intestine unseparated and increases the osmotic pressure, due to its concentration absorbs water into the intestine which causes abdominal bloating. After this, the lactose gets into the colon, where intestinal bacteria ferments it thus creating organic acids with low molecular weight, gases and carbon dioxide, which increases the bloating, and then causes a very intense, spasmodic diarrhea. Lactose malabsorption is caused by the partial or total lack of lactase enzyme generating in the small intestine. This enzyme is very sensitive, it is the most vulnerable from all of our carbohydrate-degrading enzymes, thus the lactose digestive diseases are quite common (Csapó and Csapóné 2002). However it's just a matter of perspective that we view as a disease or as the natural order the reduction of lactase activity. For example milk produced by mammals serves as nourishment for the progenies for a certain amount of time which period differs amongst each species. This explains the fact that societies where adults do not consume milk, the production of lactase enzyme

decreases with 90% by the age of 4, and the enzyme-producing gene becomes inactivated by the time of adulthood (Bulhoes et al, 2007).

The development of lactose-free dairy products is constant, several technological methods were developed in order to decrease, break down the lactose in milk and dairy products: Kosikowski (1978) was one of the first who applied ultrafiltration, Szigeti and Krász (1992) developed a two-step fermentation process, Ibarra and its co-workers (2012) developed an enzyme technology to produce lactose-free yogurt. Researchers of this field always make a note about the sweet flavor of lactose-free products, and recommend alternatives to treat this sweet flavor, however there is still relatively little information about how the consistency of lactose-free products, lactose-free yogurts differs from traditional yogurts. Consistency is critical not only for product manufacturing and product quality, but for consumers as well, who also have serious expectations regarding the subject. Consequently, every information relating to consistency is integrally contribute to the quality and competitive product development and product manufacturing.

The purpose of my research is the expansion of knowledge, experience and new scientific results in the following topics:

- processing of milk containing selenium and vitamin E increased by naturally with fodder supplementation, analyzing the nutritional values of the products produced
- the effects of rapeseed and sunflower - as a fodder supplementation for dairy cattle – on the fatty acid profile of dairy products, role of the products in the diet
- the effects of certain supplements on the organoleptic properties of dairy products
- consistency analysis of yogurts made from lactose-free milk
- analyzing the lactose-free yogurts tendency to syneresis

With the results of my examinations, I would like to contribute to the expansion of the literature on functional foods, to give useful and new information with applicable practical and scientific values for the food industry.

## **2. Materials and methods**

### **2.1. Milk used for product experiments**

The milk used for the research was provided by the Körös-Maros Biofarm Ltd., where the basic feed of the dairy cattle is complemented with vitamin E and selenium, in different combinations and doses (Sütő and Béri 2010). We took samples from the milk of those groups that received supplements and at the University of Szeged Engineering Faculty we made products such as cheese and yogurt in laboratory conditions.

We did the same thing with the milk originating from rape and sunflower supplements (Süli and Béri, 2009).

### **2.2. Production technologies of experimental milk products**

When making yogurt, we put the milk under heat treatment on 75 °C degrees for 5 minutes, and then homogenized it on 20MPa pressure. In 0.1/5 l quantity YoFast88 culture was added. (Ch., Hansens, Denmark) The milk was then poured into cups and was incubated on 45 °C degrees until reaching 4.6 pH. The yogurts were cooled and kept on 5 °C degrees for 24 hours. The difference in the production technology of the lactose-free yogurts was, that we added 2 ml/l lactase enzyme to the milk and incubated it on 40 °C degrees for an hour. At the end of the incubation, we checked that the lactose content is under 0.5 g/cm<sup>3</sup> in all cases, and then made yogurt from the milk with the above method. After adding YoFast 88 culture, we took samples in a 100 ml centrifuge pipe for later whey discharge experiments. We treated the samples the same way as the other products.

When making cheese, we kept the milk on 70 °C degrees for 5 minutes, then on 35 °C and added 0,2 g/l calcium chloride. After this, we mixed 0.02 g/l Lactobacillus casei starter (Ch, Hansens, Denmark) and 9 cm<sup>3</sup> rennet (Chy Max, Hansens) in the milk and coagulated it for 40 minutes. We cut the clots into 0.5 cm diameter nuggets to increase the surface of the whey discharge. We constantly moved the nuggets to avoid lumping, while slowly increasing the temperature (35-38 °C). We gradually leaved the whey away from the cheese vat. After reheating, we post extruded clot nuggets for about 40 minutes. They were put into a form and were pressed on 0.08 Mpa pressure for an hour. After this, we rubbed the cheese with salt and let it mature in a refrigerator for 5 days,

under 10 °C. After 5 days, we vacuum-packed it and for another 20 days, we post-matured it, again on 10 °C. At the end of the process, we were left with, semi-hard, Trappista-like cheese.

### **2.3. Examinations of chemical composition**

The chemical composition studies were made by the Food Analytica Ltd. The dry matter content was defined by the second chapter of the MSZ 2714-2:1989. The protein content was specified by the block destructive method, according to the MSZ 1385:1987 and the fat content according to the MSZ 9602:1984. The Röse-Gottlieb method was used throughout the examination. The vitamin E content was defined by the MSZ EN 12822:2000, with the help of HPLC. The MSZ EN 14627:2005 standard was used to define the selenium content. With hydride atomic absorption spectrometry, under pressure.

### **2.4. Instrumental gel assessment, measuring whey discharge**

The instrumental stock assessments were carried out with the QTS stock analyzer (CNS Farnell) and we used the Pro Texture software package for data processing. The machine is modelling the chewing mechanism. The instrument is measuring the forces occurring during intrusion and extrusion with a trial gadget, and it also records time. With moving the probe up and down, the force occurring in the cell is changing, due to the sample's resistance and substance. The machine measures and records the data and time change of this force. We examined the first fracture strength, stiffness, adhesion force and adhesiveness, which are the most important qualities regarding the product and the consumer.

We measured the whey discharge with spinning and the discharged whey with analytical balance.

### **2.5. Sensory panel test of experimental products**

Sensory panel test was carried out by a 6 member jury, using 20 points for a total score. They took 4 standpoints into consideration: substance, color, scent and taste. These standpoints were graded on a 1-5 scale, where 5 was the very best and 1 the worst value. The grading was true to the 1-3/51-1 regulations of the Hungarian Food Book and the requirements of the sensory criticism of sour milk products.

## **2.6. Mathematical and statistical evaluation**

We created the charts, diagrams, images and calculated the average and standard deviation in MS Excel 2010. The statistical evaluation of data was carried out with the SPSS for Windows, version 13.0. The data homogeneity of variance was checked with the Levene test. The measurements of milk and products, originating from foraging experiments, as well as products from different supplements were compared by a one factor variance. When a homogeneous variance occurred we used the Turkey test, when a non-homogeneous variances appeared, we used the Tamhane test, to determine the significant differences between groups. The results of stock inquiry were evaluated with the T test in the case of homogeneous variances and with the Welch test when non homogeneous variances occurred. Results from the products originating from the antioxidant experiment were compared with the results of the original milk, using the t test. We worked with 5% significance in all cases.

### 3. Results

#### 3.1 Vitamin E and selenium supplementation of dairy produces

Significant proportion of the naturally increased vitamin E and selenium content can be preserved in dairy products. Although in each case vitamin content in milk was significantly reduced due to processing, decrease of vitamin content was lower in the presence of selenium.

In yogurts it was found that without the presence of selenium 62.58% of vitamin E remains after processing, while in the presence of selenium 88.59% of vitamin E in milk is retained (Table 1).

**Table 1:** Retention of vitamin E and selenium in dairy produces (n=6, %)

Supplement	milk	yogurt				cheese			
		vit. E content		Se content		vit. E content		Se content	
		mean	<i>S.D.</i>	mean	<i>S.D.</i>	mean	<i>S.D.</i>	mean	<i>S.D.</i>
vitamin E	100	62.58	$\pm 1.41$	-	-	<b>50.49</b>	$\pm 3.90$	-	-
vitamin E and organic Se	100	77.09	$\pm 15.88$	97.03	$\pm 1.69$	44.46	$\pm 6.02$	46.48	$\pm 1.67$
vitamin E and inorganic Se	100	<b>88.59</b>	$\pm 7.35$	96.04	$\pm 1.96$	47.99	$\pm 3.56$	49.30	$\pm 1.55$
organic Se	100	-	-	<b>98.87</b>	$\pm 0.86$	-	-	<b>51.08</b>	$\pm 2.02$
inorganic Se	100	-	-	96.26	$\pm 0.74$	-	-	47.74	$\pm 1.44$

Processing resulted in a significant difference between milk and yogurt vitamin content in case of each supplementation. In contrast, 98.87% of the selenium was detected in the produce, thus there was no significant difference between the selenium content of milk and yogurt made of it.

Vitamin losses in cheese were similar between groups, means are close to each other and there are no outlier values. On average, the vitamin loss ranged between 49.51 and 55.4%. The resulting values of fat-soluble vitamin D persistence investigations are in correspondence to the findings of Banville et al (2000).

During cheese making selenium content changed to greater extent, but in similar rates compared to the changes observed in the case of vitamins. On average, between 48.92 and 52.26% of the selenium was lost. From the similar trend it can be concluded

that most of the vitamins and selenium content is removed with the whey. However, closer examination of this is absolutely necessary.

Several factors can influence the vitamin loss in dairy products. One of the important ones is heat treatment (Molto et al, 2011), another one is lipid peroxidation. During oxidation free radicals arose which attack the molecular structure and disturb the chain of tocopherol (Burton et al 1985). The loss can be explained by microbial activity also. Lactic acid producing bacteria are capable of producing  $\beta$ -galactosidase, an enzyme which belongs to the group of lyases. Lyase enzymes are able to split C-C, C-O, C-N bonds without water absorption (Toth, 1984), thus to disturb the structure of tocopherol.

Despite the vitamin and selenium loss, the experimental dairy products contain significantly higher amount of vitamin E and selenium content compared to the control samples. Therefore supplementation - which had no impact on the cheese or yogurt organoleptic properties - can be regarded effective from the view point of the final produce. On the 1-5 point scale control yogurt received the highest, averaging 18.7, while yogurts with pure selenium supplementation received from 17.25 to 17.3 points. The judges explained the lower scores with the less distinctive flavor of the product, as they were not so fragrant and aromatic than other yogurts. In none of the cases was quality and sensory experience of the products criticized. The cheeses from pure selenium supplementation, just like yogurts, placed lowest in terms of total points (16.33 and 16.92). The judges explained it with the less pronounced flavors compared to other products.

It can be concluded that it is possible to naturally increase the vitamin content of milk products so that 100 gram of it can cover the daily requirements (for instance 100 g cheese from vitamin E supplementation covers 7.4% of the required vitamin E, while cheese from vitamin E and selenium supplementation covers 100% of the recommended amount of selenium).

In our experience, in order to cover 50% of the daily vitamin E need with 100 g naturally vitamin E enriched yogurt, the raw milk of which the yogurt is produced of must contain at least 680  $\mu\text{g}$  / 100 g vitamin E.

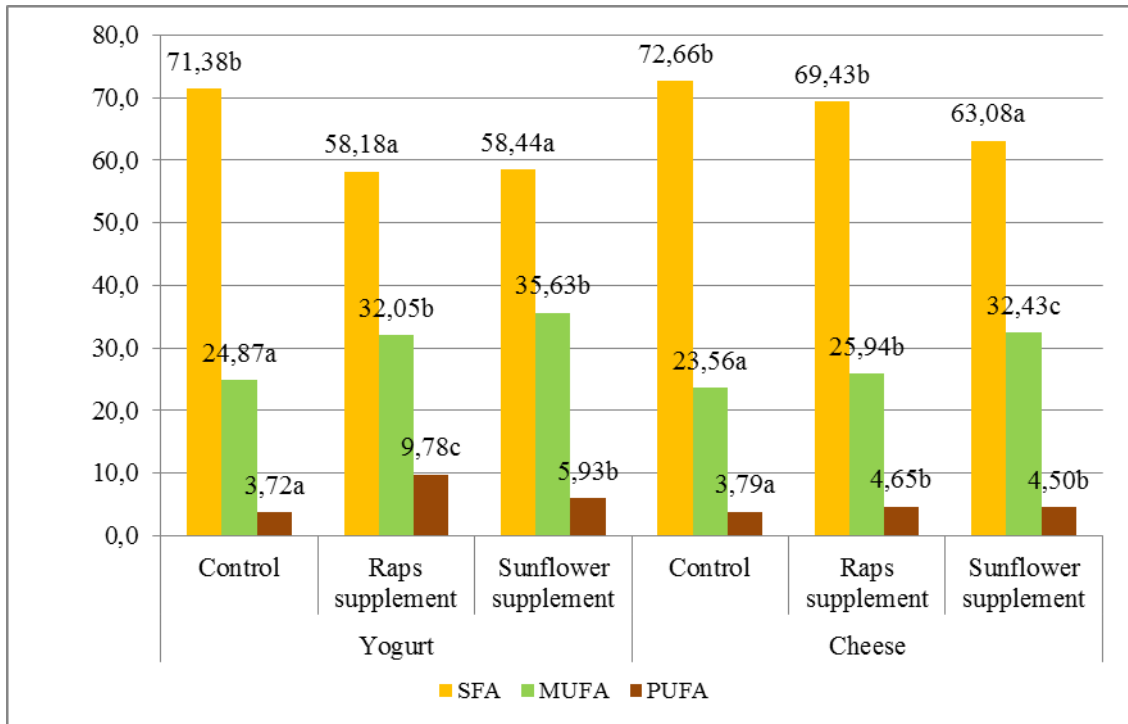
### **3.2 Fatty acid composition of dairy produces**

Due to feeding, fatty acid composition of milk was modified so that highly valuable fatty acids were present in much greater quantities, compared with conventional control milk. The type of fermentation during processing had significant but somewhat different impact on both yogurt and cheese fatty acid composition. Advantageous and disadvantageous changes compared to milk were detected (Figure 1).

Mono unsaturated fatty acids, which have high importance in controlling cholesterol levels, were present more abundantly when yogurt was made of milk produced with sunflower supplementation (35.63%) than when it was made of milk with rapeseed supplementation (32.05%).

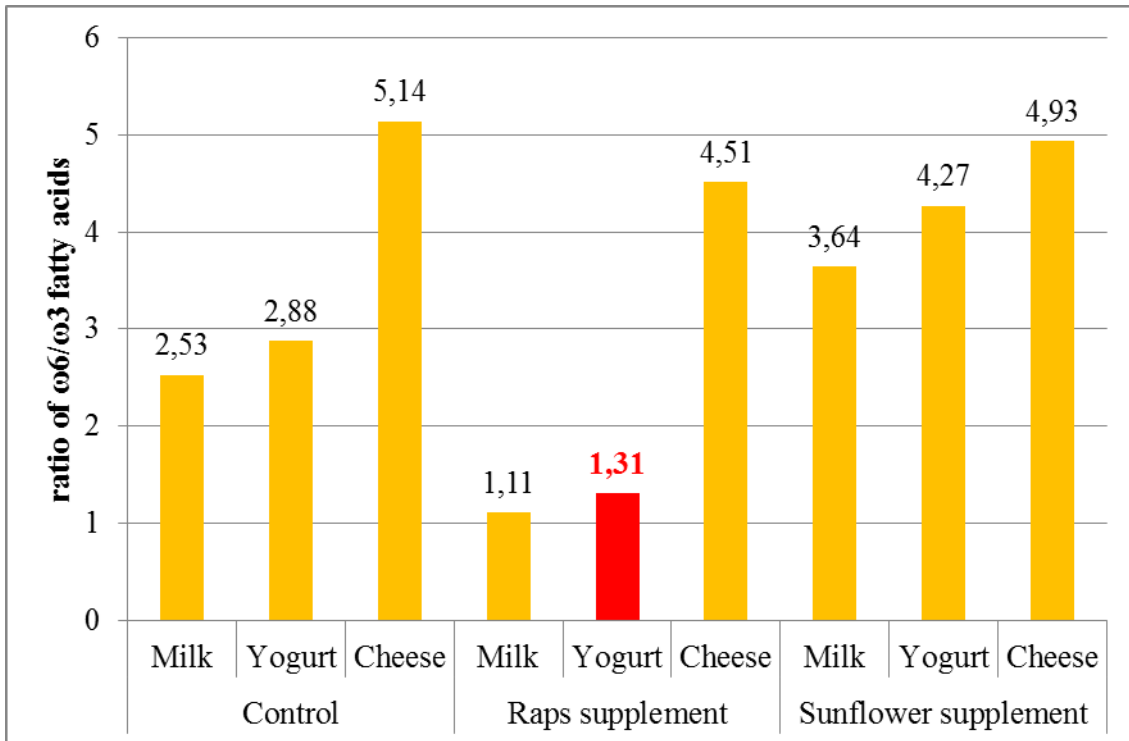
In terms of increasing essential polyunsaturated fatty acid content, rapeseed supplementation had higher impact on both cheese and yogurt. Through rapeseed and sunflower supplementation the essential fatty acid content of yogurt was 5.34% and 4.44%, and of the cheese was 3.02% and 3.01%, respectively.

Processing has increased the ratio of omega3 and omega6 fatty acids both in the cases of cheese and yogurt. In our studies we have found that omega 3:6 ratio can be preserved the most in yogurt. During cheese processing significant reductions in omega 3 fatty acids significantly increased the relative proportion of these fatty acids. Products made of rapeseed supplemented milk had better omega 6:3 ratio. The quotient of 1.31 in yogurts can be considered as therapeutic value, thus feeding rapeseed allows the production of very valuable functional produces (Figure 2).



**Figure 1** Changes in the physiologically different fatty acid groups of experimental samples  
Fatty acid content (in fatty acid methyl ester%)

a, b, c: indicate significant differences among the values (P<0.05)



**Figure 2** The  $\omega_6 / \omega_3$  fatty acid ratio of the experimental products

The highest CLA values were achieved in yogurts with sunflower (0.43%), in cheese with rapeseed supplementation (0.51%). For the healthy functioning of the body one needs 3g daily CLA intake (IP et al, 1994). Fourteen percent of this can be supplied with yogurt from 100g sunflower supplementation. Dhiman et al (1999) could achieve 0.6 to 0.73 g/100g, and Zhang et al (2006) obtained from 2.4 to 2.5 g/100g CLA content in cheese.

Different length carbon chains in milk changed minimally during yogurt production. In the experimental yogurts proportion of short and medium chain fatty acids increased, while the long chain fatty acids decreased. The only significant change occurred in short carbon chains in yogurt when rapeseed was fed. A similar trend has been published by Naydenova et al (2012); however, Florence et al (2012) recorded the decrease of short chain fatty acids.

Judges found inferior product firmness from both supplementations compared to control products. According to them, the yogurts had lower spoon-ability than the traditional ones. The control yogurt products received 19.3 points, while products from rapeseed and sunflower supplementation were given 17.2 and 16.8 points, respectively. There were no differences in color and flavor but regarding taste yogurt from rapeseed and sunflower feeding fall away because those were not found to be so aromatic and pleasantly acidic than the control sample. Cheese made with rapeseed feeding received 15.9 points, while feeding sunflower resulted in reaching 19.1 points on the sensory panel test. Judges found the structure of the cheese weak, fermentation holes were not regular and the product surface was not hard enough and the surface of the intersection was not clean since the cheese was easily fracturable.

Overall it can be stated that products with additional beneficial health effects can be produced when fatty acid profile is modified through feeding. Fatty acid composition of milk and the quantity of the valuable fatty acids can be preserved in the most amounts in yogurts. Products carrying the most physiological benefits are from rapeseed supplementation which proves rapeseed to be suitable to the production and development of functional foods.

However, supplementations had negative impact on the organoleptic properties of yogurt and cheese. Due to the high unsaturated fatty acid content, experimental yogurts had objectionable taste and aroma and cheese firmness was lower compared to control samples.

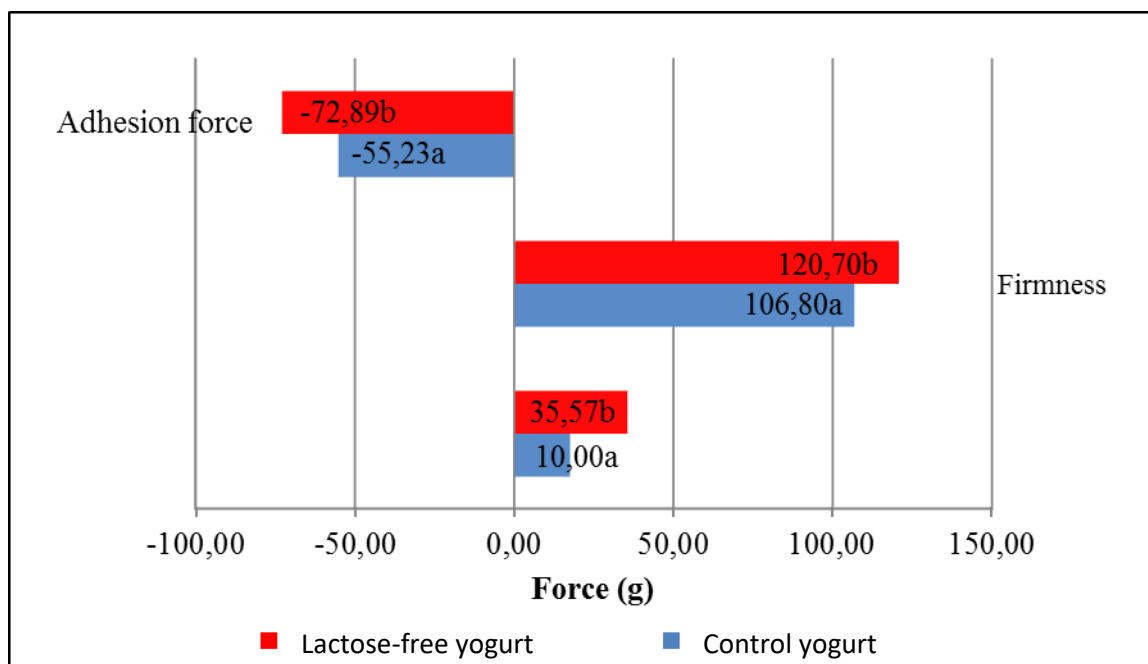
Based on our experiments, supplementing cattle feed with rapeseed results physiologically better products than that of sunflower supplement.

### 3.3. Lactose free yogurt produces

Several authors addressed the property improvement of yogurt. Jacek (2006) improved the firmness and structure by adding trans-glutaminase enzyme. Jaros et al (2002) studied the effects of exopolysaccharide-producing cultures on gel aging. Karsheva et al (2013) produced yogurt with firmer texture by adding *Lactobacillus salvarius* to the traditional culture.

There are several possibilities (enzymatic breakdown, ultrafiltration, multi-stage fermentation) to produce lactose-free products including lactose-free yogurt but published data on the properties is very scarce.

In our experiments, the breakdown of lactose in the milk has resulted in significant differences in firmness and whey separation of yogurt.



**Figure 3** Forces during the texture tests of yogurt

a, b: indicate significant differences among the values within group (P<0.05)

Based on test data, strength of the set gel structure of yogurt made of lactose-free milk is significantly higher than of yogurt made of control milk.

The first refractive power that is needed for the probe to penetrate into the yogurt has increased to 255.7% compared to the control.

Firmness, showing the forces needed to break up the gel structure of the product is 13% higher in the lactose-free products. This is the force necessary to dip the spoon into the yogurt.

Adhesion force is sensory counterpart: the force that is needed to remove the spoon from the yogurt. It is 31.9% higher in lactose-free products than it is in control samples.

Adhesion capacity: describing the area under the curve of the probe penetration cycle. The force which is required to remove the material from the surface. It is 22.36% higher in lactose-free products.

On average, control products had 21.47% and lactose-free products had 14.63% whey syneresis. The syneresis difference between the products is significant (Table 2).

Decrease in syneresis in yogurt production is desirable; both because of the aesthetics of the product, on the other hand, with the whey valuable components are leaving from the product. Hindering syneresis can increase the nutritional value of sour milk products.

**Table 2** Whey syneresis in control and lactose-free products (n=15)

<b>Control yogurt</b>		
	Gel as % of milk	Whey % of milk
<b>Mean</b>	<b>74,76</b>	<b>25,24<sup>b</sup></b>
Minimum	63,15	19,01
Maximum	80,99	36,85
S.D.	6,48	6,48
CV%	8,66	25,67
<b>Lactose-free yogurt</b>		
	Gel as % of milk	Whey % of milk
<b>Mean</b>	<b>85,60</b>	<b>14,40<sup>a</sup></b>
Minimum	83,79	12,17
Maximum	87,83	16,21
S.D.	1,27	1,27
CV%	1,48	8,81

a, b: indicate significant differences between the values within column (P<0.05)

Judges in the sensory analysis of the control products gave 19.2 points, while the lactose-free products gained 18.5. Regarding external properties such as odor and smell,

no difference was found between the two products. Both products had perfect, discoloration-free evenly bone white color which came with a pleasantly sour smell typical to yogurt. Lactose-free products tasted less juicy, sweet flavor dominated, which was strange compared to conventional natural yogurts. Results of penetration tests, stating that lactose-free yogurts have firmer structure were confirmed with sensory panel tests. Significant difference was detected between the control and the lactose-free yogurt concerning the taste and firmness of yogurts.

The breakdown of lactose not only improves structural properties but also reduces whey separation in the final product by 32%.

This change in the gel properties may come from the small size and molecular weight of monosaccharides. It is known that milk fat adversely affects the properties of yogurt gel because the fat globules do not fit into the sensitive network of proteins rather making it unstable. Lactose might have similar properties. After lysis, torn into parts, it is possible that the smaller molecules can better fit into the protein matrix thus making it stronger and more stable.

The above-mentioned differences and the results may originate not only in structural stability, but also in the higher water retention abilities. Degradation of lactose results in the formation of monomers which bond to water molecules with their free electrons. Basically lactose molecule is monohydrate, it is able to bind one water molecule. As glucose and galactose decomposes, the oxygen bridge binding the two monosaccharide breaks up and highly reactive free ends are formed so that both the molecules are able to bind 1-1 water molecules. The strong bond formed between water molecules and monosaccharide may explain the significantly lower whey separation in yogurts. However, the enzyme used in the breakdown of lactose is not necessarily cleaves into only monomers the lactose. Due to the  $\beta$ -galactosidase enzyme transgalactosidation can take place, whereby galacto-oligosaccharides, larger molecules than monomers, can be generated (Wallnefels and Malhorta, 1960). The galacto-oligosaccharides possess extremely high water binding capacity, equal to that of sucrose, which is used as a wetting agent and also as a stabilizer.

The results may not only be beneficial for lactose sensitive or lactose intolerant but also for those consuming conventional products. For instance, in case of flavored fermented sour milk products the quantity of sugar added can be significantly reduced or even be omitted. Hence the product may achieve favorable perception and healthier

product can be manufactured and even more, structural properties can be improved without additives.

#### 4. New scientific results

1. Vitamin retention in yogurt made from milk of cows fed with vitamin E supplemented feed is well higher when selenium is also added to feeding stuffs. Feeding stuffs' vitamin E content has no impact on Se content of yogurt.
2. When cows are fed vitamin E and Se supplementation, vitamin E not exceeding 102,67  $\mu\text{g}/100\text{ g}$  in yogurt and 890  $\mu\text{g}/100\text{ g}$  in cheese and selenium not exceeding 13,55  $\mu\text{g}/100\text{ g}$  in yogurt and 70,45  $\mu\text{g}/100\text{ g}$  in cheese, there is no considerable change in the organoleptic properties of products. However, in cheese, when milk is solely Se supplemented it may result minor sensory deterioration.
3. Rapeseed supplementation results notably better omega 6-omega 3 ratio as the feeding of sunflower. This also substantially increase the amount of polyunsaturated fatty acids in yogurt. Most of the fatty acid composition of milk, altered through feeding (rape and sunflower seed), can be preserved in yogurt products.
4. Beneficial fatty acid composition of milk - developed as a result of feeding rape and sunflower seeds –can be more effectively retained in yogurts than in cheese.
5. Breaking down lactose has favorable effect on gel properties, resulting in firmer, denser gel with higher adhesion. Overall gel denseness increases 13% due to lactose hydrolysis.
6. Amount of whey separating in yogurt –made after lactose hydrolysis procedure– can greatly be reduced.

## 5. Practical utilization of the results

1. Vitamin and selenium retention can be assumed to much greater extent in yogurt than in cheese. Therefore it is worth to enrich the milk with vitamin E and selenium through feed supplementation since it can be preserved to greater extent in yogurts (vitamin E to 88.59%, selenium to 96.04%). Since vitamin E is a fat soluble vitamin, it is assumed that other fat-soluble vitamins can be retained with similar potency in yogurt.

The significance of this, in addition to being natural and accessible source of vitamins, is that it eliminates the risk of infection from additives in the course of production.

It is possible to make such cheese from vitamin E and selenium supplementation so that 100g of it covers the recommended daily amount of selenium.

2. Rape and sunflower seed supplementation significantly increases unsaturated and essential fatty acid ratios in milk. These changes have effect on the organoleptic characteristics of the cheese and yogurt. Yogurt clot formation is sluggish, cheese structure is weaker, flavor and fragrance formation is not so intensive and their flavor is emptier compared to control products. These faults can be solved and avoided with modification of technology, use of different cultures (e.g. exopolysaccharide producing bacteria).
3. The breakdown of lactose in milk yields tougher and denser curd than of traditional yogurt. The current need that favors creamy texture and full flavor yogurts (e.g. Greek yogurt) can be supplied effectively without the addition of fat by lactose breakdown.
4. Lactose-free yogurts beyond being beneficial for lactose sensitive may be physiologically advantageous also. Separation of whey is not only an aesthetic problem but also causes nutrient losses. Such losses can be decreased by 32%.

## 6. Scientific publication list



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Candidate: Zsuzsanna Kárnyáczi  
Neptun ID: EEVDR9  
Doctoral School: Doctoral School of Animal Husbandry  
MTMT ID: 10048685

### List of publications related to the dissertation

#### Hungarian scientific articles in Hungarian journals (5)

1. **Kárnyáczi, Z.**, Csanádi, J., Fenyvessy, J., Béri, B.: Kísérleti tejtermékek E-vitamin tartalmának vizsgálata.  
*Agrártud. Közl.* 65, 49-52, 2015. ISSN: 1587-1282.
2. **Kárnyáczi, Z.**, Óré-Sütő, B. V.: Tejtermékfejlesztés zsírsavösszetétel-módosítással.  
*Élelmvizsg. Közl.* 60 (1), 58-67, 2014. ISSN: 0422-9576.
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Funkcionális élelmiszerek fejlesztése: Háttér és eredmények.  
*Élelm. Tud. Technol.* 2, 6-14, 2012. ISSN: 2061-3954.
4. Lendvai, E., Krisch, J., **Kárnyáczi, Z.**, Fenyvessy, J., Tóth, Z., Csanádi, J.: Új szimbiotikus joghurt fejlesztésének értékelése.  
*Tejgazdaság.* 72 (1-2), 37-45, 2012. ISSN: 1219-3224.
5. **Kárnyáczi, Z.**, Béri, B., Fenyvessy, J., Csanádi, J.: Funkcionális tejtermékek kifejlesztésének lehetőségei.  
*Agrártud. Közl.* 40, 33-36, 2010. ISSN: 1587-1282.

#### Foreign language scientific articles in Hungarian journals (1)

6. **Kárnyáczi, Z.**, Csanádi, J.: Texture profile properties, sensory evaluation, and susceptibility to syneresis of yoghurt prepared from lactose-free milk.  
*Acta Aliment.* 46 (4), 403-410, 2017. ISSN: 0139-3006.  
DOI: <http://dx.doi.org/10.1556/066.2016.0018>  
IF: 0.384





Foreign language scientific articles in international journals (1)

7. Sütő, B. V., **Kárnyáczi, Z.**, Béri, B.: Effect of vitamin E and Selenium supplementation on the antioxidant content of milk and dairy products in dairy cows.  
*J. Agric. Sci.* 44, 9-12, 2011. ISSN: 0021-8596.  
IF: 2.041

Hungarian conference proceedings (1)

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9. Csanádi, J., **Kárnyáczi, Z.**, Bajusz, I., Baráné Herczegh, O., Fenyvessy, J.: Effect of Lactose hydrolysis on milk fermentation and some properties of curd.  
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**Total IF of journals (all publications): 2,425**

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