THE EFFECT OF MICROWAVE PASTEURIZATION ON THE COMPOSITION OF MILK

DJELOVANJE MIKROVALNOG PASTERIZIRANJA NA SASTAV MLIJEKA

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SUMMARY

Free amino acid and total amino acid content, water soluble vitamin content (vitamin C, B_1, B_2, B_6 and B_{12}) and utilizable lysine, lysinoalanine and hydroxymethyl furfurol content of milk were examined after the samples were pasteurized using different heat treatment.

They analyzed the effect of microwave treatment on the amino acids, free amino acid content and biological value compared to the conventional heat treatment technology. In was established that the two applied heat treatments caused practically no change in the amino acid composition of the milk protein neither in essential nor in non-essential amino acids. The total free amino acid content of the raw milk (20.67 mg/100 g milk) decreased in the milk pasteurized in the traditional way to 8.02, whereas in the microwave pasteurized milk to 8.96 mg amino acid/100 g milk.

They established, that after mild pasteurization, vitamin C content of milk hardly changed while during microwave pasteurization it decreased to less than its third value. Comparing the composition of raw milk with that of milk pasteurized using the two heat treatment methods, there was no important differences between the four vitamins B. Raw milk and milk pasteurized traditionally and by microwave did not contain hydroxymethyl furfurol even in traces, and lysinoalanine content remained all the three samples below the quantification limit. The utilisable lysine content of the raw milk and the two pasteurized milks was almost the same.

Keywords: milk composition, mild pasteurization, microvawe pasteurization

INTRODUCTION

Prior to the human consumption with the exception of some special dairy products milk has to be pasteurized in order to kill the pathogenic microbes. Pasteurization should be carried out by minimizing the effect on the composition and organoleptic properties of the raw milk. Besides the conventional pasteurization procedures recently the microwave treatment has been used.

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In the food industriy practice one of the application fields of the microwave technique is the enhancement of the microbiological safety of the products by pasteurization. According to Pozar (1993), during the microwave processes mainly the frequency of 2450 MHz, and in some cases the frequency of 915 MHz have been used. The microwave pasteurization is a promising method as based on the experiences the foodstuffs are damaged less than during the conventional heat treatment, due to the short treatment and radiation time (Lau and Tang, 2002; Sieber et al., 1996; Sun et al., 2006; Wang et al., 2003). Sieber et al. (1999) when treating milk with microwaves could not detect health-damaging effects. Özilgen and Özilgen (1991) examined the kinetics of killing *Escherichia Coli* by heat during microwave pasteurization, and found that the microwave treatment was applicable at lower temperatures both for pasteurization and sterilization. One of the greatest advantages of the method over the conventional heat treatment is that the product can also be treated when it is already in a closed packaging and by this the product can be stored for a significantly longer time even without added preservatives.

The aim of our research was to investigate if there is a difference between the conventional and microwave pasteurization regarding their effect on the composition of milk.

MATERIAL AND METHODS

Milk samples examined

The examined raw milk was obtained from a dairy company in Hargita county, Romania. Normal (mildly) pasteurized milk was obtained by a heat treatment at 72 °C for 40 sec. For microwave pasteurized milk, samples were pre-heated to 63 °C in a plate heat-exchanger, and then heated to 68 °C by microwave treatment at 2.45 GHz frequency and kept at this temperature for 40 sec. The experimental pasteurization equipment consisted of three ALASCA household microwave ovens that were connected to form a cascade with the ovens placed above each other. Inside each oven a glass spiral was placed horizontally, that exited the instrument on the rear side. The spiral had an inner diameter of 18 cm, the glass tube had an ID of 20 mm. The three spiral tubes were connected into a cascade by flexible tubes. The microwave pasteurization equipment had a capacity of 200 dm^3/h.

The raw milk had a fat content of 3.65%, fat free dry matter content of 8.77%, density of 1.028 g/dm^3, total CFU of 2,600,000/cm^3, and E. coli number of 1,000/cm^3. After microwave pasteurization at 68 °C total CFU reduced to 1,200/cm^3, no E. coli was found, while all the other parameters remained unchanged. The experiments were repeated three times, and the three milk samples from each experiment were analysed.

Pretreatment and analysis of the samples

Pretreatment of the samples

After sampling the milk samples were immediately cooled down to -25 °C. Sample preparation and analysis were carried out at the Department of Food Science of the Sapientia Hungarian University of Science of Transylvania, Csíkszereda Campus.

The samples were centrifuged at 8,000 g for 15 min in order to remove the cellular elements, then the milk was defatted. Subsequently, to 5 cm³ of the sample 5 cm³ of 50% trichloroacetic acid was added and left for 20 min. The precipitate was centrifuged for 10 min at 10,000 g (Csapó et al., 2007).

The supernatant was separated, and its vitamin, free amino acid and free D-amino acid content were determined.

Determination of the amino acid composition of milk samples

The total amino acid content was determined after protein hydrolysis (Moore and Stein, 1963). The amino acid analysis was carried out using an INGOS AAA400 amino acid analyzer, on an Ostion Lg ANB cation-exchange resin (35 cm x 0,37 cm sized glass column). Absorbance of the ninhydrin derivatives of the amino acids was measured at the wavelengths of 440 and 570 nm.

During the determination of the free amino acid and free D-amino acid content, derivatization and the analysis were performed using a Varian Pro Star HPLC apparatus. For data collection and evaluation Varian Star 6.0 software was used.

From the free amino acids cyclic derivatives were formed with *o*-phthaldialdehyde (OPA) and 2-mercaptoethanol (Dorresteijn et al., 1996). Separation was carried out on a 150 × 4 mm Supelcosil-C18 column using a two-component (methanol and sodium acetate buffer) gradient system.

From the amino acid enantiomers diastereomer pairs were formed with *o*-phthaldialdehyde (OPA) and 1-thio-β-D-glucose tetra acetate (TATG) (Einarsson et al., 1987). The separation was carried out on a 125 × 4 mm Superspher-C8 analytical column using a three-component (methanol, phosphate buffer and acetonitrile) gradient system.

Flow rate was 1 cm³/min in both cases. The derivatives were detected using a fluorescent detector (excitation wavelength: 325 nm, emission wavelength: 420 nm).

Determination of the vitamin content of milk samples

Separation of vitamins C and B was carried out by reversed-phase HPLC on a Supercosil (C18) column (150 × 4 mm id). The HPLC system consisted of 2 Varian ProStar 210 pumps, a Varian ProStar 320 UV detector and a Varian ProStar 363 fluorescent detector. Flow rate was 0,8 cm³/min.

Composition of the mobile phase:

For determination of vitamins B: 50:50% mixture of methanol and phosphate buffer was used.

For determination of vitamin C: 10:90% mixture of acetonitrile and acetic acid (0.4%) was used.

Isocratic analysis was performed with a 20 μl injection volume and detection at 254 nm. Before injection samples were filtrated on a 0.20 μm Millipore (Millipore, Milford, MA, USA) filter. The results were recorded and evaluated with a Varian ProStar 6.0. software.

HMF was also determined by HPLC, using the Varian Pro Star HPLC apparatus, on a Supelcosil C18 column (150 × 4.6 mm id) and the Pro Star 320 UV-VIS detector. A two-component eluent consisting of acetonitrile and water (5:95, v/v) was used. Flow rate was 1 cm³/min. HMF was detected at 284 nm.

Utilizable lysine content was determined after derivatization with 2,4-dinitro-1-fluorobenzene (DNFB). Dinitrophenyl-ε-amino-lysine (DNP lysine) was deter-

mined using amino acid analyzer (INGOS AAA). Lysinoalanine was determined by the INGOS AAA amino acid analyzer, under conditions similar to that of the normal amino acid analysis. Lysinoalanine eluted after tyrosine and phenylalanine, and before the basic amino acids.

RESULTS AND DISCUSSION

Total amino acid content of milk samples

Amino acid content of the raw milk, the conventionally pasteurized milk (normal milk) and microwave pasteurized milk (MW milk) is shown in Table 1.

After a statistical analysis of the results no significant difference could be established between the amino acid content of the raw milk and the milk pasteurized in the two manners (P≥0.05). Thus, it can be concluded that the two kinds of heat treatment practically did not cause any change in the amino acid content of the milk regarding the essential and non-essential amino acids. Change in the ammonia content was also minimal: it was 0.047% for the conventionally pasteurized milk and 0.048% for the microwave pasteurized milk, which was practically identical with the ammonia content of the control.

In Table 1 the results also can be seen in *g amino acid/100 g protein* unit which shows the proportion of the individual amino acids in percentage of the milk protein and gives information on the quality of the milk protein. As the amino acid composition was expressed in *g amino acid/100 g sample* hardly changed due to different treatments, and the total amount of amino acids was nearly equal to the crude protein content for all the three samples, therefore no difference was found in the amino acid protein composition between the three milk samples. It can be concluded that the heat treatment applied did not affect the amino acid content of the milk (g amino acid/100 g sample), and the amino acid protein composition (g amino acid/100 g protein) and the biological value of the protein. Calculating the biological value of milk protein according to Morup and Olesen (1976) 81.2 was obtained for the control milk sample, 80.9 for the conventionally pasteurized milk, while 80.8 for the microwave pasteurized milk. These results show that the heat treatment applied had no effect at all on the biological value of the milk protein.

Table 1.   Amino acid content of milk samples heat treated by different manner (n=5)

Tablica 1.   Sadržaj aminokiselina u uzorcima mlijeka tretiranih na različite načine

Amino acids Amino kiseline	Milk sample - Uzorak mlijeka					
	Raw milk - Sirovo mlijeko		Milk pasteurized - Pasterizirano mlijeko			
			by mild heat treatment blagim toplinskim tretiranjem		by microwave heat treatment mikrovalnim toplinskim tretiranjem	
	g AA / 100 g milk	g AA / 100 g protein	g AA / 100 g milk	g AA / 100 g protein	g AA / 100 g milk	g AA / 100 g protein
Asp.	0.216	6.8 ± 0.28	0.207	6.9 ± 0.35	0.212	6.8 ± 0.37
Thr.	0.124	3.9 ± 0.32	0.118	3.9 ± 0.29	0.123	4.0 ± 0.36
Ser.	0.165	5.2 ± 0.26	0.158	5.3 ± 0.25	0.159	5.1 ± 0.30
Glu.	0.694	21.8 ± 0.22	0.650	21.6 ± 0.28	0.669	21. 6 ± 0.24
Pro.	0.376	11.8 ± 0.31	0.343	11.4 ± 0.36	0.356	11.5 ± 0.33
Gly.	0.058	1.8 ± 0.29	0.055	1.8 ± 0.32	0.058	1.9 ± 0.26
Ala.	0.101	3.2 ± 0.36	0.098	3.3 ± 0.31	0.100	3.2 ± 0.34
Cys.	0.021	0.7 ± 0.20	0.022	0.7 ± 0.27	0.023	0.7 ± 0.24
Val.	0.185	5.8 ± 0.25	0.173	5.8 ± 0.32	0.180	5.8 ± 0.28
Met.	0.097	3.0 ± 0.30	0.090	3.0 ± 0.21	0.090	2.9 ± 0.26
Ile.	0.154	4.8 ± 0.23	0.146	4.9 ± 0.33	0.140	4.5 ± 0.28
Leu.	0.284	8.9 ± 0.28	0.265	9.0 ± 0.24	0.276	8.9 ± 0.31
Tyr.	0.130	4.1 ± 0.19	0.127	4.2 ± 0.25	0.132	4.3 ± 0.26
Phe.	0.140	4.4 ± 0.22	0.135	4.5 ± 0.28	0.139	4.5 ± 0.31
His.	0.086	2.7 ± 0.25	0.079	2.6 ± 0.21	0.080	2.6 ± 0.25
Lys.	0.232	7.3 ± 0.30	0.223	7.4 ± 0.24	0.236	7.6 ± 0.28
Arg.	0.073	2.3 ± 0.31	0.070	2.3 ± 0.25	0.078	2.5 ± 0.22

Free and free D-amino acid content of milk samples

Table 2 shows the free amino acid content of raw milk and the pasteurized milks in *mg amino acid/100 g milk*, as well as percentage of free amino acids.

Looking at the free amino acids different conclusions are obtained than in the case of the total amino acid content. Total free amino acid content of the raw milk was measured to be 20.67 mg/100 g milk. This value was reduced to 8.02 mg amino acid/100 g milk for the traditionally pasteurized milk and to 8.96 mg amino acid/100 g milk for the microwave pasteurized milk, res-

pectively. Among the amino acids the amount of phenylalanine, histidine, leucine, lysine, methionine, valine, aspartic acid, glutamic acid, proline and tyrosine decreased substantially and these differences could also be confirmed statistically. Though some differences were detected in the means of isoleucine, threonine, alanine, arginine, cystine, glycine and serine these differences did not proved to be significant.

The amount of phenylalanine, histidine, leucine, lysine, methionine, valine, aspartic acid, proline and tyrosine decreased considerably, while that of isoleucine, threonine, alanine, arginine, cystine decreased less, while some increase was obtained for glycine and serine.

Table 2.   Free amino acid content of differently treated milk samples (n=5)

Tablica 2.   Sadržaj slobodnih aminokiselina u uzorcima različito tretiranog mlijeka (n-5)

Amino acids Amino kiseline	Milk sample - Uzorak mlijeka					
	Raw milk - Sirovo mlijeko		Milk pasteurized - Pasterizirano mlijeko			
			by mild heat treatment blagim toplinskim tretiranjem		by microwave heat treatment mikrovalnim toplinskim tretiranjem	
	mg AA / 100 g milk	%	mg AA / 100 g milk	%	mg AA / 100 g milk	%
Asp.	1.66[a] ± 0,324	8.0	0.41[b] ± 0,182	5.1	0.46[b] ± 0,277	5.1
Thr.	0.14[a] ± 0,113	0.7	0.09[a] ± 0,125	1.1	0.07[a] ± 0,110	0.8
Ser.	0.07[a] ± 0,042	0.3	0.16[a] ± 0,037	2.0	0.08[a] ± 0,025	0.9
Glu.	7.07[a] ± 0,456	34.2	4.75[b] ± 0,315	59.2	5.15[b] ± 0,422	57.4
Pro.	4.23[a] ± 0,337	20.5	0.14[b] ± 0,091	1.7	0.23[b] ± 0,113	2.6
Gly.	0.33[a] ± 0,234	1.6	0.74[a] ± 0,421	9.2	1.01[a] ± 0,248	11.3
Ala.	0.50[a] ± 0,200	2.4	0.28[a] ± 0,112	3.5	0.37[a] ± 0,154	4.1
Cys.	0.06[a] ± 0,032	0.3	0.01[a] ± 0,014	0.1	0.02[a] ± 0,018	0.2
Val.	1.04[a] ± 0,066	5.0	0.14[b] ± 0,009	1.7	0.18[b] ± 0,011	2.0
Met.	0.27[a] ± 0,098	1.3	0.01[b] ± 0,008	0.1	0.03[b] ± 0,016	0.3
Ile.	0.14[a] ± 0,075	0.7	0.05[a] ± 0,030	0.6	0.04[a] ± 0,024	0.4
Leu.	0.54[a] ± 0,188	2.6	0.04[b] ± 0,022	0.5	0.06[b] ± 0,019	0.7
Tyr.	1.40[a] ± 0,323	6.8	0.07[b] ± 0,034	0.9	0.08[b] ± 0,038	0.9
Phe.	1.03[a] ± 0,218	5.0	0.08[b] ± 0,028	1.0	0.08[b] ± 0,021	0.9
His.	0.45[a] ± 0,107	2.2	0.14[b] ± 0,083	1.7	0.17[b] ± 0,075	1.9
Lys.	0.76[a] ± 0,026	3.7	0.20[b] ± 0,012	2.5	0.20[b] ± 0,017	2.2
Arg.	0.10[a] ± 0,051	0.5	0.10[a] ± 0,042	1.2	0.10[a] ± 0,063	1.1

[ab]Averages in one row with common superscript do not differ (P≥0.05)

In the non-essential amino acids the biggest decrease was experienced for proline and aspartic acid, at the same time in glutamic acid which is present in the highest amount, the change is relatively negligible. Summarized, it can be said that the essential amino acid content of the raw milk with the exception of arginine decreases considerably, as well as the non-essential amino acids – except for glycine and serine – decrease due to the heat treatment.

As the raw milk sample was immediately frozen along with the heat-treated samples, it could be excluded that the higher free amino acid content was due to the souring of the raw milk, the growth of lactobacilli. It can be assumed that this huge decrease in the amount of free amino acids is due to

the technological intervention only. There are two possibilities regarding the changes occuring during the heat treatment. As free amino acids are significantly more reactive than those bound in the peptide chain, it is possible that they reacted with milk sugar during the heat treatment resulting in Maillard reaction products. It is also supported by the fact that there was a decrease of 4 to 5% in the utilizable lysine content due to the heat treatment. This minimal decrease can be a result of the transformation of the free lysine and not of lysine bound in protein. For the rest of the amino acids there is no experimental evidence supporting this theory.

The other possibility may be that whey proteins coagulated during the heat treatment could absorb

the free amino acids on their surface so strongly that they could not be removed from the surface in the course of the determination. In fact, this possibility would be the most useful in practice since no free amino acids would remain in the whey but they would enhance the biological value of the dairy product by being bound on the surface of the protein.

In the course of the examination of the free D-amino acids we could detect D-aspartic acid, D-glutamic acid and D-alanine in the milk samples. Amino acids other than these could not be detected at the sensitivity level of our HPLC system. The amount of D-amino acids practically did not change due to different heat treatments. The amount of D-Asp varied from 0.016 mg/100 g milk in milk pasteurized conventionally to 0.017 mg/100 g milk, to 0.018 mg/100 g milk in the microwave pateurized milk, D-Glu changed from 0.053 mg/100 g milk to 0.052 and 0.054 mg/100 g milk, whereas D-Ala from 0.043 mg/100 g to 0.049 and 0.046 mg/100 g milk. Thus, it can be concluded that during pasteurization at the applied temperature and time combinations did not change the D-amino acid content of the raw milk. In this respect between the two heat treatment procedures cannot be distinguished.

Vitamin B and C content of milk

We chose these vitamins because both vitamin C and vitamins B are very sensitive to the technological interventions, especially to heat treatment. Ascorbic acid and vitamin B content of the raw milk and the differently heat treated milk are shown in the Table 3.

As can be seen vitamin C content hardly changed due to mild pasteurization, however, it decreased to less than its one-third. This is very surprising because the microwave pasteurization was carried out at a lower temperature (68 °C) than the conventional (72 °C) therefore it appears that in the microwave pasteurization not only the temperature but also the energy of the microwave could play a role in the deterioration of the vitamin C content.

Out of vitamins B we measured, vitamin B_1 is the most heat sensitive, while the other three have a higher resistance against heat impact. Accordingly, vitamin B_1 content decreased by approx. 33.3% due to both pasteurization procedures. In case of vitamins B_2, B_6 and B_{12} this decrease was around 10−11%, however, it did not prove to be a significant difference.

Hydroxymethyl furfurol content of milk

The quality of conventionally and microwave pasteurized milk is determined by measuring the hydroxymethyl furfurol (HMF) content. HMF is always present when foods with high protein and sugar content is heat-treated. Table 4 shows HMF content of the differently heat treated milk samples, sweetened condensed milk and milk powder in µg HMF/100 g sample.

Table 3. **Vitamin C and B content of raw milk, and milk samples after mild and microwave pasteurization (n=5)**
Tablica 3. **Sadržaj vitamina C i B u sirovom mlijeku i uzorcima mlijeka nakon blagog i mikrovalnog tretiranja**

Vitamin content Sadržaj vitamina mg/dm³	Milk sample - Uzorak mlijeka		
	Raw milk - Sirovo mlijeko	Milk pasteurized by mild heat treatment Pasterizirano blagim topl. tretiranjem	Milk pasteurized by microwave Pasterizirano mikrovalno
Vitamin C	22.71[a] ± 1.273	22.11[a] ± 1.106	6.25[b] ± 0.825
Vitamin B_1	0.39[a] ± 0.083	0.27[a] ± 0.075	0.26[a] ± 0.062
Vitamin B_2	1.81[a] ± 0.324	1.63[a] ± 0.193	1.65[a] ± 0.215
Vitamin B_6	0.52[a] ± 0.153	0.48[a] ± 0.162	0.46[a] ± 0.144
Vitamin B_{12}	0.004[a] ± 0.0021	0.004[a] ± 0.0014	0.003[a] ± 0.0012

[ab]Averages in one row with common superscript do not differ (P≥0.05)

Table 4.   HMF (hydroxymethyl furfurol) content of milk sample with different heat treatment, sweetened condensed milk and milk powder (µg HMF/100 g sample)

Tablica 4.   Sadržaj HMF (hidroksimetilni furfurol) u uzorku mlijeka različitog toplinskog tretiranja, zaslađenog kondenziranog mlijeka i mlijeka u prahu (uzorak ng HMF/100 g)

Sample - Uzorak		HMF content µg HMF/100 g sample Sadržaj HMF/100 g
Raw milk - Sirovo mlijeko		-
Milk pasteurized by mild heat treatment - Mlijeko pasterizirao blagim toplinskim tretiranjem		-
Milk pasteurized by microwave - Mlijeko pasterizirano mikrovalno		-
Sweetened condensed milk - Zaslađeno kondenzirano mlijeko	Mean - Prosjek	127
Milk powder - Mlijeko u prahu	Mean - Prosjek	684

Based upon the results it can be said that the raw milk, the conventionally pasteurized and microwave pasteurized milk did not contain HMF even in traces, thus, in this respect the two pasteurization procedures are equal. In order to check the suitability of the analytical method, determined the HMF content of a commercially obtainable sweetened condensed milk and milk powder was in three repetitions.

It was established that the sweetened condensed milk contained on the average 127 µg HMF/100 g, while the milk powder contained on the average 684 µg HMF/100 g sample. Comparing these values, it was found that the milk powder contains more HMF than the condensed milk. The reason for this is that milk powder is produced at a higher temperature than the condensed milk, and the formation of the products of the Maillard reaction accelerates at a higher temperature. In the milk powder 600–700 µg HMF /100 g was found.

Utilizable lysine and lysinoalanine content of milk

Parallelly with the analysis of the HMF content of milk samples we examined the utilizable lysine and the lysinoalanine content of milk samples heat-treated differently. The results are shown in *Table 5*.

No lysinoalanine could be detected above the level of the sensitivity of the measurement either in the raw milk or the two heat-treated milk samples. This means that neither threonine (perhaps serine) that is very sensitive to heat treatment, nor cysteine and cystine that are sensitive to heat treatment and oxidation, decomposed considerably, as these two amino acids are the main precursors of lysinoalanine.

The utilizable lysine content of the raw milk was 0.229%, that of the conventionally pasteurized milk was 0.217%, whears that of microwave pasteurized milk was 0.219%, which is not a significant

Table 5.   Utilisable lysine and lysinoalanine content of milk samples with different heat treatment (n=5)

Tablica 5.   Sadržaj iskoristivog lizina i lizinoalanina u toplinski različito tretiranim uzorcima mlijeka

Component examined Ispitana komponenta	Milk sample - Uzorak mlijeka		
	Raw milk Sirovo mlijeko	Milk pasteurized by mild heat treatment Blago toplinski pasterizirano	Milk pasteurized by microwave Mikrovalno pasterizirano
Utilisable lysine content Sadržaj iskoristivog lizina, %	0.229±0.075	0.217±0.093	0.219±0.104
Lysinoalanine content Sadržaj lizinoalanina, mg/dm^3	< 5	< 5	< 5

difference (P≥0.05). It can be concluded that during the heat treatment we applied the ε-amino group of lysine which is very sensitive to the reducing sugars and heat did not convert to such an extent that could influence its biological utilizability. The difference around 4−5% in the utilizable lysine content indicates that some Maillard reaction product was formed.

From our examinations it can be concluded that the two heat treatment methods can be considered as equal in this respect, and neither of them decreased substantially the utilizability of lysine, one of the most important essential amino acids, and neither of them resulted in a considerable lysinoalanine content.

SUMMARY

In the course of the experiment we examined pasteurized milk samples using different heat treatment procedures at a dairy company in Hargita County, Romania. We analyzed the effect of the microwave treatment on the components, and compared the data with those obtained in case of the traditional heat treatment.

The two heat treatments applied practically did not cause any change in the amino acid composition of the milk protein. For the free amino acids a considerable difference was obtained between the raw milk and the milk samples heat-treated differently, but between the two heat treatment methods no difference can be distinguished in the respect of free amino acids.

Due to mild pasteurization the vitamin C content of the milk hardly changed, while during the microwave pasteurization it decreased to less than its one-third, compared to the raw milk. In the case of vitamin B_1 it was established that a loss of 30−40% can be expected, while for the other three vitamins B this decrease was only around 10%.

During the examinations we could not detect hydroxymethyl furfurol and lysinoalanine in any of the milk samples, and we could not establish a significant decrease in the utilizable lysine content due to the pasteurization procedures.

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SAŽETAK

Ispitivani su sadržaj aminokiselina i ukupan sadržaj aminokiselina, vitamina topivih u vodi (vitamini C, B_1, B_2, B_6 i B_{12}) te iskoristivog lizina, lizinoalanina i hidroksimetilnog furfurola u mlijeku nakon što su uzorci pasterizirani različitim toplinskim tretiranjem.

Analizirano je djelovanje mikrovalnog tretiranja na aminokiseline, slobodne aminokiseline i biološku vrijednost u usporedbi s konvencionalnim toplinskim tretiranjem. Utvrđeno je da ova dva primijenjena toplinska tretiranja nisu prouzročila gotovo nikakvu promjenu u sastavu amino-kiselina bjelančevina u mlijeku, niti esencijalnih niti neesencijalnih. Ukupan sadržaj aminokiselina sirovog mlijeka (20,67 mg/100 g mlijeka) smanjio se u mlijeku pasteriziranom na konvencionalan način na 8,02, dok se u mikrovalno pasteriziranom mlijeku smanjio na 8,96 mg amino kiselina/ 100 g mlijeka.

Utvrđeno je da se nakon blagog pasteriziranja sadržaj vitamina C u mlijeku jedva promijenio dok se za vrijeme mikrovalnog pasteriziranja smanjio na manje od trećine svoje vrijednosti. Uspoređujući sastav sirovog mlijeka s pasteriziranim mlijekom primjenom dvaju toplinskih tretiranja nije bilo većih razlika između četiriju vitamina B. Sirovo mlijeko i mlijeko pasterizirano na tradicionalan način i mikrovalno nije sadržavalo hidroksi-metilni furfurol niti u tragovima a sadržaj lizinoalanina ostao je u sva tri uzorka ispod kvantifikacijske granice. Sadržaj iskoristivog lizina u sirovom mlijeku i dva pasterizirana mlijeka bio je gotovo isti.

Ključne riječi: sastav mlijeka, blago pasteriziranje, mikrovalno pasteri-ziranje

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Potpis