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Effects of Electromagnetic Waves on the Level of Fatty Acids in UHT Milk

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Abstract: The aim of this study was to determine whether long-term storage of UHT milk and its heating in a microwave has an impact on the fatty acid profile. Material consisted of 4 types of UHT milk from different manufacturers with a fat content 3.2%. Analyses conducted for 13 days. Milk stored in the original container in a refrigerator at 4°C. Milk samples after opening the package was heated for 1 and 2 minutes in a microwave. Estimated absolute density, acidity, freezing point, electrolytic conductivity and solid non fat, crude fat, lactose, total protein and minerals. Physical and chemical parameters of milk were carried out using ultrasonic analyzer Lactoscan MCC. The fatty acid composition was determined using a gas chromatograph. Fatty acid methyl esters identified by comparison with the standards (Supelco 37 Component FAME). UHT milk storage after opening at 4 °C and heating in microwave for 1 or 2 minutes (microwave power for 1100 W and power heater 750 W) did not result in the period of 13 days significant changes in the fatty acid profile. Also were not stated other significant changes in the values of physical and chemical parameters of milk during the experiment. Differences that occurred in the electrolytic conductivity may result from evaporation of water during storage of milk and heating, as indicated by its freezing point. On this basis, it can be concluded that storing milk in the fridge and reheat in the microwave does not have a significant impact on its physicochemical properties and fatty acid profile.

Keywords: UHT milk quality; microwave; fatty acid composition

1. Introduction

In countries with the longest average human life such as Denmark, Norway, Finland, Sweden, USA, Canada, UK, Ireland, the Netherlands, Greece, Switzerland, drinking milk is mostly pasteurized and not sterilized UHT. On the Polish dairy market is very strong position has UHT milk and its consumption is as high as 45% of the total amount of milk produced. This is probably due to the fact that this type of milk is suitable for long-term storage [1]. During a sterilization process occurs in the milk of certain physico-chemical changes [2]. Under the influence of heat escapes CO_2, which causes a slight reduction in titratable acidity of milk and at the same time increase its active acidity (reducing the level of pH) due to the release of hydrogen ions H^+. Heating also induces changes in the structure of casein micelles, which are enhanced by annealing the denatured whey protein, as well as the movement of calcium phosphate, which passes from the ionic forms an insoluble colloidal form. In the milk after instant sterilization (UHT 130-160 °C, 1 s) is formed epimer lactose - lactulose in an amount of 100-500 mg/cm^3, and after a conventional sterilization (UHT 135-150 °C 1-2s) - 900-1380 mg/cm^3. During instant sterilization of milk whey protein denaturing at 60-70%, and during the conventional at 70-80%. Preservation of milk by sterilization method causes a higher loss of vitamins than pasteurization [3]. Heat treatment does not cause physical or chemical changes that would reduce the nutritional value of the fat fraction of milk [4,5]. These treatments, however, can lead to the partial denaturation of the whey protein, casein micelle dissociation and disruption of milk fat globules shells [6,7] However, heat treatment changes the physical properties of the fat globules in whole milk and cream. Denaturation agglutinin that they clump decreases the ability of the

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accumulation of fat on the surface of the milk. There is also evidence that the milk heated at 60 °C for 30 minutes under a pressure of 200 MPa, increases the activity of the native lipase [8]. Rodriguez-Alcala et al., observed that the sterilization UHT (135 ° C, 30 s) and microwave pasteurization (650 W, 1.30 min), decreased in the milk total level of conjugated linoleic acid C18: 2 (CLA), but increased the percentage of both isomers t9t11 acid. The changes, however, were not statistically significant [4].

Microwave heating is a form of dielectric heating which is used in-dustrially for the processing of food and also used domestically for cooking or thawing of food [9]. MWs are elec-tromagnetic waves that are within a frequency band of 300 MHzto 300 GHz [10] however, MW-heating applications have been limited to a few narrow frequency bandsfor industrial, scientific, and medical use to avoid interference with the radio frequencies used for telecommunication purposes. The typical bands are 915±25 MHz and 2,450±50 MHz with penetration depths ranging from 8 to 22 cm at 915 MHz and from3 to 8 cm at 2,450 MHz depending on the moisture content. The domestic MW ovens operate at 2,450 MHz, whereas both frequencies are used ~~for~~ industrial purposes. It is worthwhile to note that outside of the United States, frequencies of 433.92,896, and 2375 MHz are also used for MW heating [11,12] UHT milk stored in the refrigerator after opening retains the freshness of a relatively long time. The development of microorganisms in the milk after each closing of the carton, from which it was sample collection occurs after 14 days [13]. Often the milk is consumed after being heated in the microwave. The most important structural and chemical changes that occur during MW heating are protein denaturation and aggregation, Maillard reactions, and lactose isomerization, which are mostly related to thermal effects of MW heating [14]. The Maillard reaction is also one of the most important causes of sensory quality and nutrient loss in heat-treated milk and dairy products, which is mainly caused by a significant loss of the essential amino acid lysine (2% to 3% in pasteurized and 7% to 10% in UHT milk) due to its non enzymatic reaction with lactose. Furthermore, it promotes the production of off-flavors and brown-colored pigments (melanoidins), as well the polymer-ization of milk protein [14–16].

The aim of the study was to demonstrate whether storing UHT milk after opening the package and heating it in a microwave has an impact on the fatty acid profile.

2. Materials and Methods

2.1. Material

Material consisted of 4 types of UHT milk from different manufacturers with a fat content of 3.2%. Each tested group consisted of 8 samples from different unit packages.

2.2. Procedures

The experiment was carried out for 13 days. Milk stored in the original container in a refrigerator at 4 °C. At this time, the milk sample was tested 4 times during the research 1 (0-control), 4, 8 and 13. To the vessel resistant to high temperatures was poured into 150 ml of milk and then subjected to the action of microwaves emitted by a microwave (Samsung, model GW73B, of microwave power up to 1100 W and 750 W power of the heater). In each of the four cartons of milk two samples were taken after 150 ml each, and heated for 1 and 2 minutes. Milk taken from the package (stored at 4 ° C) and the milk was preheated in a microwave to attain room temperature.

2.3. Methods

Marked physical parameters such as density, acidity, freezing point and electrolytic conductivity. Analyzed chemical components were solid non fat (SNF), fat, lactose, total protein (TP), and mineral matter (MM). The physicochemical parameters of milk was investigated by the ultrasonic analyzer Lactoscan MCC model (*Milktronic LTD*).

The fatty acid composition was determined using a gas chromatograph Trace GC Ultra (Thermo Electron Corp., Waltham, USA) with a flame ionization detector FID temp. 250 °C equipped with a column Stabilwax with dimensions of 30 m x 0.25 mm x 0.25 mm. It was used as carrier gas helium fed at a flow rate of 1 ml./min. and division (split flow) 10 ml / min. Injector and detector temperature

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were respectively 220 ° C and 250 °C. The column temperature was maintained at 60 ° C for 3 min, then raised at a rate of 7 °C / min. to 200 °C and held at this temperature for 20 minutes. To 5 mg fat obtained after extraction of milk with a solvent mixture of chloroform-methanol (2:1) was added 50 ml of toluene and esterified by adding 100 µl of 2N sodium hydroxide in methanol for 20 minutes at room temperature [33]. After addition of 0.5 ml 14% BF3 in methanol again reacted for 20 minutes at room temperature. The resulting esters extracted Hexane. On the chromatograph were injected 1 µl. Fatty acid methyl esters were identified by comparison with standards (Supelco 37 Component FAME Mix, Sigma-Aldrich Co.).

2.4. Statistical Analyses

Taken data were statistically analyzed in the program Statistica 9.1. The differences between the averages of individual parameters were examined using GLM procedure according to the following model: $Yijkl = \mu + Di + Pj + + (D\times P)_{ij} + Єij$,
where:

µ - average overall,
Di - the fixed effec of the i-th day after opening with milk (1, 4, 8, 13),
P_j - the fixed effec of the j-th time heating in the microwave in minutes. (1., 2),
$(D\times P)_{ij}$ - interaction between day after opening and time heating in the microwave
Єij - random error.
The significance of differences were tested by Scheffe.

3. Results and Discussion

According Pluta & Berthold, the advantages of heating foods using a microwave include a quick and direct heating of the product throughout the mass [17]. In addition, the food does not come into contact with the surface heating which prevents overheating of the product and blocking the flow. In the authors' research, the retentate after microfiltration of milk and cream (28% fat) were subjected to continuous microwave heating at a temperature of 110-138°C for 5 seconds. After sterilization, the samples were stored at 5±1°C and 25±1°C for up to 5 days. It was found that microwave heating of the cream and retentate at temperatures above 125 and 130°C for 5 seconds, respectively, was effective and did not cause any unfavorable changes in the taste and smell of the product.

Table 1. Effect of storage period of UHT milk since the opening of packaging and heating time on the physical parameters (means ± SD).

Factors		Physical parameters			
Day	**Heating min**	**Density g/cm³**	**Acidity pH**	**Freezing point °C**	**Electrolytic conductivity mS/cm**
0	0	1.0278 ± 0.0005	6.37 ± 0.07	-0.48 ± 0.01	3.98^{aA} ± 0.04
	1	1.0281 ± 0.0006	6.37 ± 0.07	-0.49 ± 0.01	4.02 ± 0.04
	2	1.0290 ± 0.0008	6.34 ± 0.07	-0.50 ± 0.01	4.11^{aC} ± 0.05
4	0	1.0287 ± 0.0005	6.34 ± 0.06	-0.48 ± 0.01	4.00^{b} ± 0.03
	1	1.0277 ± 0.0005	6.31 ± 0.04	-0.48 ± 0.01	4.05^{c} ± 0.04
	2	1.0278 ± 0.0005	6.26 ± 0.04	-0.50 ± 0.01	4.40^{AbBdDe} ± 0.04
8	0	1.0280 ± 0.0004	6.28 ± 0.10	-0.49 ± 0.01	4.09^{E} ± 0.04
	1	1.0279 ± 0.0004	6.36 ± 0.07	-0.48 ± 0.01	3.99^{B} ± 0.02
	2	1.0286 ± 0.0007	6.36 ± 0.05	-0.50 ± 0.01	4.10^{F} ± 0.03
13	0	1.0281 ± 0.0006	6.21 ± 0.15	-0.49 ± 0.01	4.00^{d} ± 0.05
	1	1.0281 ± 0.0007	6.30 ± 0.08	-0.49 ± 0.01	3.91^{CcDEF} ± 0.04
	2	1.0284 ± 0.0007	6.34 ± 0.05	-0.49 ± 0.01	4.00^{e} ± 0.03

Means in the rows marked with the same lowercase letters (a, b, c, d, e) vary significantly p≤ 0.05. Means in the rows marked with the same capital letters (A, B) vary significantly p≤ 0.01. Means in the rows marked with the same capital letters (C, D, E, F) vary significantly p≤ 0.001.

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During storage and heating UHT milk showed no statistically significant changes in its physical parameters. The density of the milk is the result the density of its components and is in the range from1.029 g/cm^3 to 1.033 g/cm^3. According to Albert *et al*., the density of the milk after heating in the microwave was 1.028 g/cm^3. In the studied milk samples, this value ranged from 1.0277 g/cm^3 to 1.0290 g/cm^3. Values obtained in the test are therefore comparable [18]. The acidity of the active (pH) in the first day of the experiment, after opening the milk was 6,34-6,37. There was an increase the acidity of the milk is not heated between day 0 and 13, an average of 0.08. These results are consistent with the results of Panfil-Kuncewicz & Kuncewicz [19]. It showed no effect of fat on the acidity of the milk. According to Kruk & Czerniewicz milk with high acidity below pH 6,4-6,7 is very sensitive to heating [20]. Constantin & Csatlos suppose that during the production and processing of milk small amounts of water can dilute milk [21]. This is probably due to the washing and sterilizing equipment or negligent to do so. Therefore, in practice, this translates into a change in the degree of freezing point and, consequently, increase in the threshold of tolerance by determining the water of foreign origin. The results showed that the freezing point ranged between -0.480 and -0.500 °C. It was observed significant differences in the values of electrolytic conductivity between milk heated and analyzed immediately after opening the package or not heated in the subsequent days of storage. Especially the milk after 13 days heated for 1 minute, differed highly significantly (<0.001) from the milk at day 0 heated for 2 min and milk at day 4 heated for 2 min and milk at day 8 heated by 0 and 2 minutes. MW heating of milk occurs at a faster rate than in water forthe same MW heating system due to the presence of ionic com-ponents in the milk [22]. Ahmed and Luciano have shown that the dielectricproperties of theβ-lactoglobulin dispersions were significantly in-fluenced by concentration and temperature and that the relative electrical permittivity and the loss factor increased at denaturation temperature of 80°C [23]. Mu ̃noz et al. identified that relative electrical permittivity of raw milk was slightly higher than skimmed milk. This difference was explained by the different compositions (water, fat, and ashcontent) of both types of milk [24]. Differences in the electrolytic conductivity of the examined samples of milk may have resulted from evaporation of the water during the heating and storage, as indicated somewhat freezing point [25].

During determinations SNF fluctuated in the range of 7.93% to 8.30%. Albert *et al*., believe that the average dry matter content of lean should be about 8.77% [18].

Table 2. Effect of storage period of UHT milk since the opening of packaging and heating time on the content of chemical components (means ± SD).

Factors		Physical parameters				
Day	Heating min	SNF %	Fat %	Lactose %	TP %	MM %
0	0	7.96 ± 0.13	3.55 ± 0.06	3.90 ± 0.07	2.69 ± 0.05	0.68 ± 0.01
	1	8.04 ± 0.16	3.56 ± 0.06	3.94 ± 0.08	2.72 ± 0.06	0.69 ± 0.01
	2	8.30 ± 0.21	3.66 ± 0.05	4.06 ± 0.10	2.81 ± 0.08	0.71 ± 0.02
4	0	7.93 ± 0.13	3.60 ± 0.06	3.88 ± 0.06	2.68 ± 0.05	0.68 ± 0.01
	1	7.96 ± 0.14	3.59 ± 0.06	3.89 ± 0.07	2.69 ± 0.06	0.68 ± 0.01
	2	8.22 ± 0.13	3.68 ± 0.08	4.02 ± 0.07	2.78 ± 0.05	0.70 ± 0.01
8	0	8.01 ± 0.11	3.64 ± 0.09	3.92 ±0.06	2.70 ± 0.05	0.69 ± 0.01
	1	8.00 ± 0.09	3.59 ± 0.06	3.91 ± 0.05	2.70 ± 0.04	0.67 ± 0.04
	2	8.17 ± 0.17	3.68 ± 0.06	3.99 ± 0.09	2.76 ± 0.07	0.70 ± 0.01
13	0	8.05 ± 0.17	3.66 ±0.03	3.94 ± 0.09	2.72 ± 0.06	0.69 ± 0.02
	1	8.06 ± 0.18	3.63 ± 0.09	3.94 ± 0.09	2.72 ± 0.08	0.69 ± 0.02
	2	8.12 ± 0.18	3.62 ± 0.06	3.97 ± 0.09	2.75 ± 0.07	0.70 ± 0.02

Investigated in the present study milk samples contained comparable value lactose, minerals and proteins at the beginning and end of the experiment. No significant differences in their content. You can, therefore, be concluded that both microwave heating and storage times and conditions do not significantly affect the content of the listed ingredients in the milk. Experiment of Constantin &

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Csatlos showed a slight change in the physicochemical parameters of cow's milk treated with the operation of the microwave [21]. These changes are visible only in the values of the three decimal places for the freezing point of milk and the second decimal place regarding protein and lactose. You can, therefore be concluded that heating the milk in the microwave does not have a significant impact on its chemical composition. According to Meiβner & Erbersdobler, the heating time and temperature are more significant factors causing negative changes in the food than the heat source [26].

The content of saturated fatty acids (SFA) in the test samples of milk were not statistically significant differences depending on the storage time and heating (Tables 3a and 3b).

Table 3a. Effect of storage period of UHT milk since the opening of packaging and heating time on the SFA profile (%; means ± SD).

Factors		SFA					
Day	**Heating min**	**4:0**	**6:0**	**8:0**	**10:0**	**12:0**	**14:0**
0	0	3.63 ± 0.09	2.54 ± 0.08	1.56 ± 0.05	3.44 ± 0.17	3.85 ± 0.23	12.55 ± 0.45
	1	3.64 ± 0.07	2.56 ± 0.05	1.57 ± 0.05	3.48 ± 0.17	3.86 ± 0.19	12.54 ± 0.44
	2	3.64 ± 0.13	2.56 ± 0.09	1.57 ± 0.05	3.47 ± 0.17	3.87 ± 0.23	12.57 ± 0.43
4	0	3.73 ± 0.08	2.60 ± 0.04	1.61 ± 0.04	3.57 ± 0.19	3.94 ± 0.24	12.75 ± 0.52
	1	3.65 ± 0.08	2.55 ± 0.04	1.58 ± 0.05	3.47 ± 0.21	3.85 ± 0.26	12.57 ± 0.49
	2	3.79 ± 0.12	2.65 ± 0.10	1.66 ± 0.09	3.67 ± 0.27	4.03 ± 0.34	12.89 ± 0.63
8	0	3.64 ± 0.12	2.60 ± 0.08	1.63 ± 0.09	3.59 ± 0.26	3.99 ± 0.30	12.81 ± 0.66
	1	3.50 ± 0.10	2.53 ± 0.03	1.60 ± 0.04	3.56 ± 0.20	3.98 ± 0.25	12.88 ± 0.55
	2	3.51 ± 0.03	2.51 ± 0.07	1.57 ± 0.06	3.52 ± 0.22	3.93 ± 0.24	12.85 ± 0.65
13	0	3.66 ± 0.19	2.59 ± 0.07	1.61 ± 0.06	3.55 ± 0.21	3.96 ± 0.27	12.73 ± 0.61
	1	3.69 ± 0.11	2.64 ± 0.19	1.64 ± 0.13	3.60 ± 0.37	4.01 ± 0.47	12.77 ± 0.92
	2	3.76 ± 0.23	2.68 ± 0.25	1.67 ± 0.16	3.69 ± 0.43	4.06 ± 0.47	12.98 ± 0.85

Table 3b. Effect of storage period of UHT milk since the opening of packaging and heating time on the SFA profile (%; means ± SD).

Factors		SFA				
Day	**Heating min**	**15:0**	**16:0**	**17:0**	**18:0**	**20:0**
0	0	1.22 ± 0.06	31.72 ± 1.69	0.48 ± 0.02	9.41 ± 0.53	0.13 ± 0.01
	1	1.22 ± 0.06	31.48 ± 1.95	0.48 ± 0.01	9.49 ± 0.58	0.13 ± 0.01
	2	1.22 ± 0.07	31.49 ± 1.73	0.48 ± 0.02	9.34 ± 0.57	0.13 ± 0.02
4	0	1.23 ± 0.07	31.25 ± 1.82	0.48 ± 0.01	9.47 ± 0.59	0.13 ± 0.01
	1	1.22 ± 0.06	31.35 ± 1.67	0.48 ± 0.02	9.57 ± 0.53	0.13 ± 0.01
	2	1.24 ± 0.06	31.15 ± 1.87	0.47 ± 0.02	9.30 ± 0.72	0.12 ± 0.01
8	0	1.25 ± 0.07	31.40 ± 1.59	0.49 ± 0.01	9.40 ± 0.60	0.11 ± 0.03
	1	1.25 ± 0.06	31.54 ± 1.72	0.48 ±0.02	9.39 ± 0.55	0.12 ± 0.01
	2	1.26 ± 0.05	31.54 ± 1.75	0.49 ± 0.03	9.45 ± 0.64	0.13 ± 0.01
13	0	1.24 ± 0.06	31.14 ± 1.92	0.49 ± 0.02	9.57 ± 0.64	0.13 ± 0.01
	1	1.24 ± 0.04	31.07 ± 1.60	0.48 ± 0.02	9.46 ± 0.91	0.12 ± 0.01
	2	1.25 ± 0.05	31.15 ± 1.46	0.48 ± 0.03	9.27 ± 0.89	0.13 ± 0.02

Milk fat contains up to 65% of saturated fatty acids. Monounsaturated fatty acids (MUFA) are found in milk fat at 35%. They have a dominant oleic acid (Table 4). The storage time and the heating of milk did not significantly change the MUFA profile. The results obtained in this experiment carried out on UHT milk confirm the findings Rodriguez-Alcala *et al.*, [4].

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Table 4. Effect of storage period of UHT milk since the opening of packaging and heating time on the MUFA profile (%; means ± SD).

Factors		MUFA							
Day	Heating min	10:1	14:1	16:1n-9	16:1n-7	17:1	18:1n-7	18:1n-9	20:1
0	0	0.38 ± 0.04	1.14 ± 0.05	0.35 ± 0.02	1.47 ± 0.54	0.27 ± 0.01	2.28 ± 0.61	20.50 ± 1.01	0.10 ± 0.02
	1	0.38 ± 0.02	1.15 ± 0.05	0.33 ± 0.06	1.77 ± 0.04	0.27 ± 0.01	2.33 ± 0.66	20.61 ± 1.06	0.10 ± 0.02
	2	0.38 ± 0.02	1.15 ± 0.06	0.35 ± 0.02	1.73 ± 0.05	0.26 ± 0.02	2.32 ± 0.63	20.58 ± 0.94	0.11 ± 0.02
4	0	0.39 ± 0.01	1.16 ± 0.06	0.34 ± 0.03	1.70 ± 0.03	0.26 ± 0.01	2.34 ± 0.64	20.41 ± 1.14	0.10 ± 0.02
	1	0.38 ± 0.01	1.14 ± 0.05	0.33 ± 0.04	1.71 ± 0.01	0.26 ± 0.01	2.39 ± 0.64	20.65 ± 1.01	0.10 ± 0.01
	2	0.40 ± 0.02	1.19 ± 0.07	0.32 ± 0.03	1.70 ± 0.04	0.25 ± 0.02	2.30 ± 0.65	20.12 ± 1.40	0.10 ± 0.02
8	0	0.39 ± 0.02	1.17 ± 0.07	0.34 ± 0.02	1.73 ± 0.04	0.26 ± 0.02	2.32 ± 0.63	20.23 ± 1.13	0.11 ± 0.02
	1	0.38 ± 0.02	1.18 ± 0.07	0.33 ± 0.04	1.73 ± 0.04	0.26 ± 0.02	2.31 ± 0.65	20.31 ± 1.05	0.10 ± 0.02
	2	0.37 ± 0.02	1.17 ± 0.07	0.34 ± 0.06	1.73 ± 0.06	0.26 ± 0.02	2.27 ± 0.65	20.40 ± 1.11	0.10 ± 0.02
13	0	0.38 ± 0.03	1.17 ± 0.09	0.30 ± 0.03	1.70 ± 0.06	0.26 ± 0.02	2.31 ± 0.68	20.55 ± 1.13	0.11 ± 0.02
	1	0.39 ± 0.03	1.17 ± 0.11	0.34 ± 0.03	1.71 ± 0.05	0.27 ± 0.03	2.31 ± 0.71	20.41 ± 1.75	0.11 ± 0.02
	2	0.39 ± 0.04	1.19 ± 0.11	0.33 ± 0.07	1.70 ± 0.03	0.27 ± 0.02	2.26 ± 0.69	20.09 ± 1.62	0.10 ± 0.02

Polyunsaturated fatty acids (PUFA) present in the milk fat represented linoleic acid, n-6 and n-3 linolenic acid are present in small amounts up to 5% but provide very important for biological functions of the human body. Determine, among others, the structure of cell membranes, regulate the secretion of insulin, they are also a source of tissue hormones, eicosanoids [27]. The tested samples of UHT milk the total PUFA content was 17%. The results presented in Table 5 clearly show that the storage and heating did not affect the percentage of identified polyunsaturated fatty acids in the milk. Herzallah et al. conducted a study focused on pasteurized, UHT, boiled, and microwaved milk, reporting no changes in the concentrations of total SFA, MUFA, and PUFA [28]. Those authors concluded that the continuous aqueous phase of milk acts as an oxygen barrier that hinders the oxidation reactions, and therefore triglycerides are not altered during processing. In further studies from other authors, cow milk naturally enriched in RA was assayed in the elaboration of UHT milk [29]. The provided FA composition also showed absence of variations after processing. According Rodríguez-Alcalá research, the total concentration of SFA, MUFA, and PUF remained stable when milk batches were processed to obtain pasteurized, HTST, UHT, STR, HP, and microwave pasteurized milks [30]. Furthermore, when the detailed FA composition was examined, stability was found for most of the compounds in all samples. Analyzing the results of Rodriguez-Alcala *et al*., as well as your own results, it can be concluded that if the process of pasteurization, sterilization and heating of raw milk in the microwave does not significantly affect the fatty acid profile, the heating UHT milk in the microwave will not change this state [30]. Research also indicates that HP treatment does not significantly affect the composi-tion of triacylglycerols in milk fat, and in the fatty acid profile, the exception is anincrease in branched-chain fatty acids [32]. Nevertheless, HP-treated samples exhibit minoryet noteworthy alterations in milk fat crystallization curves in comparison to untreatedsamples [32].

According to research of Wroński *et al*., long-term storage of UHT milk has little effect on the fatty acid content [1]. The results of the experiment also proved that the UHT milk stored in the refrigerator for 2 weeks after opening the package are not significantly affected the physical and chemical influencing the fatty acid profile.

4. Conclusion

UHT milk storage after opening at 4 °C and heating in microwave for 1 or 2 minutes (microwaves to 1100 W and 750 W heater power) did not result in the period of 13 days significant changes in the fatty acid profile. There was no further significant changes in the values of physical and chemical parameters of milk during the experiment. The differences that occurred in the electrolytic

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conductivity may result from evaporation of water during storage of milk and heating, as indicated by its freezing point. On this basis, it can be concluded that the storage milk in the fridge and reheat in the microwave does not have a significant effect on its physicochemical properties and fatty acid profile.

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Data Availability Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Competing Interests: The authors declare that they have no competing interests.

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