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EFFECT OF GAMMA STERILIZATION ON THE FATTY ACID PROFILE OF LYOPHILIZED BUFFALO CHEESE

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Abstract

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The changes in the fatty acid profile of buffalo cheese after lyophilization and gamma rays treatment at 2 kGy and 4 kGy doses have been studied with the objective of its shelf-live prolongation. The results of the experiments show a decrease of the content of the saturated fatty acids after irradiation at the aforesaid gamma rays doses. A favorable effect on human organism has the decrease of the quantity of the short-chain fatty acids – by 13.16 % on irradiation at 2 kGy and by 18.73% on irradiation at 4 kGy, compared to the control sample. A satisfactory correlation between the essential fatty acids omega-6/omega3 has been observed in the lyophilized buffalo cheese. In the process of irradiation this balanced correlation changes and increases up to 7.32 and 8.31 at 2 kGy and 4 kGy respectively.

Key words: buffalo cheese, fatty acid profile, fatty acids, lyophilization, gamma sterilization

Introduction

Cheese is a valued food that was known yet by the ancient peoples and nowadays still enriches and varies our table. Cheese is a traditional product in Bulgarian cuisine with high nutritional value and physiological sufficiency which are determined by the high content of proteins and fats, by the presence of well assimilable by the human organism peptides and free amino acids, vitamins and microelements. It is obtained as a result of the inoculation or curdling of the milk, cutting of the whey, adding of salt and a process of lactic acid fermentation. During ripening its proteins undergo qualitative changes and become more easily digestible and better assimilable by the organism.

Cheese has an important complementing function in the normal rational nutrition which is not always provided with wholesome proteins of animal origin as well as with sufficient calcium salts. One of the important characteristics of the quality of dairy products is the determining of the fatty acid profile. In the process of the cheese ripening changes in the quantity of fatty acids take place (Dimitrov et al., 2008). Mihailova et al. (2003) and Mihailova et al. (2004) have established a decrease of the quantity of the saturated fatty acids in the process of cheese production and have noted an increase during the ripening process. According to Prandini et al. (2001), the microorganisms in milk and the rennet (starter) used for producing of dairy products have an effect on the fatty

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acid profile. The characteristic qualities of cheeses are revealed after a 45-days ripening. The caproic, caprylic and capric fatty acids have an effect on the organoleptic characteristics of cheeses (Mihailova et al., 2004). They participate in the formation of the aroma and flavor of the diary products. The butyric and caprylic acids give an unpleasant taste and aroma of some hard cheese brands. The polyunsaturated fatty acids are used for treatment of a number of diseases and for immunostimulation. In the recent decades of scientific interest has been the conjugated linoleic acid which has anticarcinogenic and antioxidant properties and reduces the body mass (Herzallah et al., 2005; Parodi, 1999). The trans-fatty acids in diary products are in comparatively low quantities. They are obtained as a result of biohydrogeneration during the vital activity of the microorganisms, inhabiting the ruminant's stomach.

Cheese is rarely prescribed as a dietetic means but it is usually given to diseased with poor appetite, exhaustion, anemia, hypovitaminosis, hypoproteinemia, gastritis with reduced secretion (Nacheva et al., 2007). Cheese is an inappropriate foodstuff for people with increased gastric secretion in cases of ulcers, nephritis, cardiac decompression, obesity. Its consumption is not recommended in cases of endemic of renal and cardiac origin because of the high quantity of sodium chloride – 4% to 8% (Mermerski, 2008).

The reliable preservation of perishable products, including dairy products necessitates the application of efficient conservation methods in order to prolong the shelf live with maximal preservation of their consumer's qualities. A modern, alternative method for overcoming of the unfavorable changes in foods, related to their technological processing, as well as during their long-term storage, is freeze-drying where the end products are known for their preserved colour, aroma, nutritional value, unchanged initial volume and fast rehydratation (Tsvetkov, 1979).

Another modern technology for safe food preservation is the so called cold (gamma) sterilization where foods are subjected to a controlled dose radiant energy where pathogenic and putrefactive microorganisms are eliminated, parasites associated with them are inactivated, and the shelf-live is prolonged. In case of a correctly carried out radiation processing the nutritional qualities of the products are preserved, the same as when applying the traditional methods of food conservation (Miteva et al., 2008). On combining of the two technologies – lyophilization and treatment with low doses gamma rays, unfavorable changes in the technological and qualitative characteristics of the buffalo cheese don't occur and a prolongation of its preservation term is achieved.

Objective: Study of the changes in the fatty acid composition of buffalo cheese after lyophilization and gamma ray treatment; prolongation of the shelf-life by combining of the two technological approaches.

Material and Methods

The investigations were carried out on buffalo cheese supplied from of shops and lyophilized in ICFT. The analyzed samples were divided in three groups: control – non-irradiated cheese, irradiated with 2kGy and irradiated with 4 kGy.

Two technological approaches were used in the experimental process: freeze-drying and gamma ray irradiation.

The freeze-drying was carried out in a vacuum freeze-drying installation TG 16.50 of "Hochvacuum" company – Germany, with contact plates heating, at the following parameters – drying temperatures – (-40)^{o} C, temperature of the condenser – (-65)^{o} C, total pressure in the sublimation chamber 0.20-0.35 mm/Hg and secondary drying temperature up to +30^{o}C.

The irradiation at doses of 2kGy and 4kGy was realized on a gamma-irradiation installation – "Gamma-1300", with radiation source Cs^{137} and dose power 1.5 kGy/min.

The extraction of total lipids was made by the method of Roese-Gottlieb (Roese –Gottlieb, 1975), by using of diethyl and petroleum ether. The transesterification of the fatty acid was realized with the aid of sodium methylate (CH_3ONa, Merck, Darmstadt) and a subsequent drying with $NaHSO_4.H_2O$.

The fatty acids methyl esters (FAME) was analyzed with the aid of a gas chromatograph Shimadzu-2010 (Kyoto, Japan), completed with flame-ionizing detector and automatic injection system (AOC-2010i). The analysis was done on a capillary column CP7420 (100m x 0.25mm i.d., 0.2 µm films, Varian Inc., Palo Alto, CA). Hydrogen was used as carrying gas and as make-up gas – nitrogen. A five-step regime of the furnace was programmed – initial temperature of the column – 51°C, maintained for 8 min, after which it was increased by 10°C/min up to 170°C and was maintained for 20 min, a new increase followed by 4°C/min up to 186°C for 10 min, then the temperature was again increase by 4°C/min up to 220°C and by 2°C/min up to 240°C until the completion of the process.

The obtained data were statistically processed with the software product Statistic for Windows.

Results and Discussion

The fatty acid profile of lyophilized buffalo cheeses is presented in Tables 1, 2, 3, 4 and 5.

The total content of saturated fatty acids in the control sample is 70.42 and as a result of the gamma irradiation a decrease up to 67.60 at 2 kGy and 66.83 at 4 kGy is observed. The concentration of the butyric aced decreases by 14.80 % at 2 kGy and by 23.82 % at 4 kGy compared to the control sample. A similar effect of decreasing of the concentration is observed for the caproic (C6:0) and the caprilic (C8:0) acids, but for the capric (C10:0) acid, regardless of the quantity of the applied irradiation, the concentration does not change substantially. The concentration of lauric (C12:0) decreases from 2.69 % in the control sample up to 2.33% at 2 kGy and 2.34% at 4 kGy. The results for myristic (C14:0) are identical – it decreases from 11.68 to 10.29 at 2 kGy and to 10.30 at 4 kGy. For palmitic (C16:0) the concentration in the control sample is 30.56 % and for the irradiated by 2 kGy it is 30.09 and by 4 kGy it is 29.88%. The concentration of the last three fatty acids is related to the increase in the cholesterol level in human organism. From the obtained data it is seen that in case of

Table 1
Saturated fatty acids, g/100g fat

Fatty acid	Control	2 kGr	4 kGr
C-4:0	5.38±0.04	4.68±0.02	4.34±0.04
C-6:0	2.75±0.02	2.27±0.01	2.13±0.02
C-8:0	1.30±0.01	1.15±0.01	1.12±0.01
C-10:0	2.50±0.02	2.44±0.01	2.44±0.02
C-11:0	0.03±0.00	0.03±0.00	0.03±0.00
C-12:0	2.69±0.02	2.33±0.01	2.34±0.02
C-13:0	0.08±0.00	0.08±0.00	0.08±0.00
C-14:0	11.68±0.08	10.29±0.05	10.30±0.10
C-15:0	1.10±0.01	1.07±0.00	1.06±0.01
C-16:0	30.56±0.21	30.09±0.13	29.88±0.30
C-17:0	0.66±0.00	0.63±0.00	0.62±0.01
C-18.0	11.25±0.08	12.06±0.05	11.99±0.11
C-20:0	0.22±0.00	0.26±0.01	0.23±0.00
C-21:0	0.01±0.00	0.01±0.00	0.01±0.00
C-22:0	0.11±0.00	0.13±0.00	0.13±0.00
C-24:0	0.06±0.00	0.07±0.00	0.07±0.00
C-26:0	0.05±0.00	0.03±0.00	0.03±0.00

irradiation their level decreases and the differences after irradiation at 2 kGy and 4 kGy are insignificant. The content of stearic (C18:0) fatty acid increases by 1.57% at irradiation with 2 kGy and by 2.31 % at irradiation of the samples with 4 kGy, compared to the control sample (Table 1).

The total content of monounsaturated fatty acids is presented in Table 5. Its quantity increases by 9.27% and 11.18% at irradiation at 2 kGy and 4 kGy respectively, compared to the control sample. The concentration of the trans-vaccenic acid decreases by 32.69% and 31.96% respectively at irradiation of the samples at 2 kGy and 4 kGy and a mathematical validity $P<0.001$ of the irradiated and the control samples. The oleic acid (18:1 cis 9) increases by 13.05% at irradiation with 2 kGy and by 12.64% at irradiation with 4 kGy, compared to the control sample (Table 2). For the oleic acid a mathematical validity ($P<0.01$) has been established of the irradiated and control cheese samples.

The total quantity of *trans*-fatty acids decreases two times in samples of lyophilized buffalo cheese irradiated at 2 kGy and 1.6 times in cheese samples irradiated at 4 kGy. Therefore, during the process of irradiation the undesirable fatty acids are disintegrated. The opposite effect has been observed for the cis isomers – their concentration increases by 1.2 (2 kGy) and 1.3 (4 kGy) in the irradiated samples and most of all there is an increase of the oleic acid content, which has a favorable effect on human organism (Table 5).

The level of the polyunsaturated fatty acids (PUFA) in the buffalo lyophilized irradiated cheese decreases by 18.98% (2 kGy) and 35.38% (4 kGy) compared to the non irradiated samples. The content of PUFA in foods is of vital importance because this fatty acids

Table 2
Monounsaturated fatty acids, g/100g fat

Fatty acid	Control	2 kGr	4 kGr
C-10:1	0.12±0.00	0.12±0.00	0.12±0.00
C-12:1n1	0.05±0.00	0.05±0.00	0.05±0.00
C-14:1n5	0.75±0.01	0.68±0.00	0.69±0.01
C-16:19tr	0.20±0.01	0.22±0.01	0.23±0.01
C-16:1n7	1.50±0.01	1.60±0.01	1.60±0.01
C-17:1n7	0.20±0.01	0.24±0.01	0.25±0.00
C-18:1t4	0.02±0.00	0.02±0.00	0.05±0.01
C-18:1t5/6/7	0.25±0.00	0.30±0.00	0.36±0.01
C-18:1t9	0.15±0.00	0.22±0.00	0.24±0.00
C-18:1t10	0.23±0.00	0.27±0.00	0.30±0.00
C-18:1t11	1.75±0.01	1.32±0.00	1.33±0.00
C-18:1c9/C-18:1t12/13/	20.85±0.13	23.57±0.10	23.49±0.20
C-18:1t15/C-18:1c11	0.54±0.01	0.58±0.01	0.70±0.03
C-18:1c12	0.12±0.01	0.15±0.01	0.23±0.02
C-18:1c13	0.05±0.01	0.05±0.01	0.13±0.04
C-18:1t16	0.30±0.01	0.25±0.01	0.33±0.05
C-18:1c15	0.22±0.01	0.20±0.00	0.27±0.06
C-20:1n9	0.04±0.00	0.05±0.00	0.05±0.00
C-22:1n11	0.02±0.00	0.01±0.00	0.01±0.00
C-22:1n9	0.01±0.00	0.01±0.00	0.01±0.00
C-24:1n9	0.02±0.00	0.01±0.00	0.01±0.00

Table 3
Polyunsaturated fatty acids, g/100g fat

Fatty acid	Control	2 kGr	4 kGr
C-18:2c9,12/19:0	1.53±0.07	1.66±0.01	1.49±0.06
gC-18:3n6	0.05±0.00	0.05±0.00	0.04±0.00
aC-18:3n3	0.50±0.00	0.21±0.00	0.19±0.00
CLA9c,11t	0.78±0.01	0.56±0.00	0.45±0.00
CLA9c,11c	0.12±0.00	0.13±0.00	0.13±0.00
CLA9t,11t	0.12±0.00	0.00±0.00	0.00±0.00
C-20:2n6	0.07±0.00	0.05±0.00	0.06±0.00
C-20:3n6	0.06±0.00	0.06±0.00	0.04±0.00
C-20:4n6	0.09±0.00	0.08±0.00	0.06±0.00
C-20:3n3	0.01±0.00	0.00±0.00	0.00±0.00
C-20:5n3	0.03±0.00	0.02±0.00	0.02±0.00
C-22:2n6	0.06±0.00	0.06±0.00	0.06±0.00
C-22:5n3	0.08±0.00	0.05±0.00	0.03±0.00

group contains anticancirogenic substances – Conjugated linoleic acids (CLA) and the essential fatty acids – n3 and n6. As a result of the irradiation the content of CLA decreases from 0.78 (control) to 0.56 (2 kGy) and 0.45 (4 kGy). Therefore, at 2 kGy the CLA level decreases 1.4 times and at 4 kGy – 1.7 times.

The content of omega-3 fatty acids decreases 2.2 times in cheeses irradiated at 2 kGy and 2.6 times in those irradiated at 4 kGy, compared to the control sample. The quantitative correlation between the two above mentioned fatty acid groups increases as a result of the gamma irradiation. The correlation for the non-irradiated control group is 3.17 and when irradiated at 2 kGy and 4 kGy this qualitative correlation increases respectively to 7.32 and 8.31, i.e. these foods have low omega-3 fatty acids content. The excessive use of omega-6 and the rather high correlation of omega-6/omega-3 fatty acids is relative to the pathogenesis of a number of diseases, including cardiovascular diseases, carcinoma, inflammatory and autoimmune diseases, while in cases of an increase of the omega-3 (low correlation omega-6/omega-3) levels, an inhibiting effect to said diseases has been

Table 4
Branched fatty acids, g/100g fat

Fatty acid	Control	2 kGr	4 kGr
C-13iso	0.04±0.00	0.03±0.00	0.04±0.00
C-13aiso	0.01±0.00	0.01±0.00	0.02±0.00
C-14iso	0.18±0.00	0.18±0.00	0.18±0.00
C-15iso	0.32±0.00	0.31±0.00	0.29±0.00
C-15aiso	0.60±0.00	0.59±0.00	0.59±0.01
C:16iso	0.39±0.00	0.40±0.00	0.40±0.00
C-17iso	0.32±0.00	0.34±0.00	0.34±0.00
C-17aiso	0.41±0.00	0.47±0.00	0.47±0.00
C-18iso	0.06±0.00	0.07±0.00	0.07±0.00

Table 5
Groups fatty acids, g/100g fat

Fatty acid	Control	2 kGr	4 kGr
Σ CLA	1.01±0.01	0.69±0.00	0.58±0.01
Σ C-18:1Trans-FA	3.23±0.01	2.96±0.02	3.31±0.12
Σ C-18:1Cis-FA	21.74±0.11	24.45±0.07	24.65±0.08
SFA	70.42±0.48	67.60±0.29	66.83±0.66
MUFA	3.50±0.06	2.94±0.01	2.58±0.05
PUFA	27.38±0.10	29.91±0.04	30.44±0.05
Σ n-3	0.63±0.01	0.29±0.00	0.24±0.00
Σ n-6	1.98±0.08	2.12±0.01	1.99±0.08
Σ n-6/Σn-3	3.17±0.15	7.32±0.05	8.28±0.48
Branched FA	2.33±0.01	2.39±0.01	2.39±0.02
CLA	0.78±0.01	0.56±0.00	0.45±0.00

observed. The balance between the omega-6/omega-3 fatty acids is an important factor for diminishing of the of coronary heart disease risk, as well as for the primary and secondary prevention of said disease (Wijendran and Hayes, 2004).

The omega 6/omega3 essential fatty acids are used for prevention and treatment of coronary artery diseases, hypertonia, diabetes, arthritis, osteoporosis, inflammatory and autoimmune disorders, carcinoms and others.

Conclusions

An analysis of the fatty acid content of buffalo cheese after lyophilization and gamma-ray treatment was made with the objective of prolongation of its shelf-life.

As a result of the irradiation a decrease of the saturated acids content has been established in the analyzed samples.

The quantity of the short chain fatty acids decreases by 13.16% at irradiation with 2 kGy and with 18.73% at irradiation with 4 kGy, compared to the control sample. This might have a favorable effect on human organism as the short chain fatty acids influence the values of LDL cholesterol in blood.

The content of oleic fatty acid increases while that of the vaccenic fatty acid decreases as a result of the applying of gamma irradiation as a conservation method.

The CLA concentration in buffalo cheeses is in insignificant quantities (0.78 g/100g fat) and after the applied irradiation at 2 kGy and 4 kGy it decreases 1.4 and 1.7 times respectively.

At gamma ray treatment the balanced correlation of omega-6/omega-3 fatty acids changes and increases up to 7.32 and 8.31 at 2 kGy and 4 kGy respectively.

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