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ASSESSMENT OF THE EFFECT OF THE TECHNOLOGICAL PROCESSING AND THE STORAGE TERM ON THE FATTY ACID COMPOSITION OF BUFFALO YOGHURT

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Abstract

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The fatty acid composition of the milk fat of buffalo yoghurt after lyophilization and gamma ray treatment with dozes of 2 and 4 kGy has been investigated. It has been established that the fatty acid spectrums of these fat contain a considerable number of short, medium and long chain fatty acids. The content of the saturated fatty acids in the treated samples does not change substantially as a result of the technological processing and during six months storage.

The studied buffalo milk fat after lyophilization, gamma irradiation and storage has fatty acid composition for which the authors have established a typical specific quantitative balancing that is of considerable importance for their taste, aroma, consistency, high nutritious and biological value.

Key words: buffalo yoghurt, milk fat, fatty acid composition, lyophilization, gamma sterilization.

Introduction

Buffalo yoghurt is a source of biologically active substances and antioxidants and has a specific effect on human health. The health benefits from milk and dairy products have been known since the Middle Ages. Dairy products act preventively for some contagious diseases and tumors. (Gill et al., 2004; Santosa et al., 2006). The most important biogenic metabolites in the lactic acid products are vitamins, proteins, peptides, oligosaccharides and organic acids, including fatty acids as well. Among the twelve important milk fatty acids only three are saturated: the lauric, the miristine and the palmitic (German et al., 2004, 2006). The milk fat contains a lot of components which have specific functions: sphingomyelin and other sphingolipids, oil acid, vitamin A, D and E, including β-carotin and the essential fatty acids, including CLA (conjugated linoleic acid). Dairy products and meat from ruminants are the richest source of CLA in human nutrition. The milk fat is not only a source of biologically active components; it is also an important means for supply of nutritive substances, including fat-soluble vitamins (Parodi, 1997). Butyric acid (C4:0) is found only in ruminants fats and it is considered an important anticarcinogene, which together with the vitamins A, D, E and the conjugated linoleic acid form a protective barrier against various, mainly non-contagious diseases (Parodi, 1997, 1999, 2004; German, 1999). The caprylic and caprynic acids (C8:0 and C10:0) can have an antivirus effect (Thormar et al., 2007). The lauric acid (C12:0) has antivirus and antibacterial functions (Sun et al., 2002; Thormar et al., 2007), and it also prevents the forming of caries and tooth plaque (Schuster et al., 1980). From the 12 main fatty acids in milk, only three saturated fatty acids – lauric (C12:0), miristine (C14:0) and palmitic (C16:0) are connected with the increasing of the total cholesterol levels in the plasma, but their individual effects are very different – both on the increasing of the LDL and the increasing of the HDL level. The increase of the HDL-cholesterol is caused by the favourable effect of saturated fatty acids. A diet rich in saturated fats can contribute to the development of obesity, cardiac diseases and metabolite syndrome (Mensink et al., 1992). The stearic fatty acid (C18:0) does not lead to an increase of the concentration of the serum cholesterol (Grundy, 1994) and clinical studies have shown that it does not accelerate the aterogenesis (Mensink et al., 2003). The oleic acid (C18:1) is one of the unsaturated acids with highest concentration in the milk (≈ 8 g/ l). The monounsaturated oleic acid is considered to be beneficial for health as it reduces the plasma cholesterol, the LDL-cholesterol and the triacylglycerols (Mensink et al., 2003). A diet rich in monounsaturated and polyunsaturated fatty acids provides for a better protection against cardio-vascular diseases, than a diet rich only in polyunsaturated FA (De Lorgeril et al., 1994).

OBJECTIVE: Investigation of the changes in the fatty acid profile as a result of treatment of buffalo yoghurts with different technological methods – lyophilization and gamma irradiation, for prolongation of the product shelf-life. Following up the changes during six months storage.

Materials and Methods

1. Object of the investigation – The investigations were carried out on buffalo yoghurt supplied from the market and lyophilized in ICFT.

The samples were distributed in 3 groups as follows:

№1 – control group non-irradiated;
№2 - test group, irradiated with dose 2 kGy;
№3 – test group, irradiated with dose 4 kGy.

2. Technological approach - Two high technology methods – lyophilization and gamma rays irradiation with follow up during six months storage were applied in the process of the technological tests.

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

The irradiation by doses of 3 kGy and 4 kGy was realized by gamma irradiating installation – "Gama-1300", with radiation source Cs ^{137} and dose power 1.5 kGy/min.

3. Packing and storage conditions – The products treated by the two technological methods – lyophilized and gamma ray irradiated were packed in polymer packings – three-layer aluminum folio, under vacuum and were preserved at temperature 0° – 5°C

The extraction of total lipids was carried out by the method of Roese-Gottlieb (A.O.A.C, 2000), by means of diethyl and petroleum ether. The transesterification of the milk fat was realized with the aid of sodium methilate (CH_3ONa, Merck, Darmstadt) and a consequent drying with $NaHSO_4.H_2O$.

The methyl esters of the fatty acids /FAME/ were analyzed with the aid of a gas chromatograph Shimadzu-2010 (Kyoto, Japan), equipped with a flame-ionizing detector and an automatic injection system (AOC- 2010). The analysis was carried out on a capillary column CP7420 (100m x 0.25mm i.d., 0.2 µm film, Varian Inc., Palo Alto, CA). As a carrier gas was used hydrogen and as a make-up gas – nitrogen. A five-step operating regime of the furnace was programmed – initial temperature of the column – 51°C min, kept for 8 min after which it was increased by 10°C/min up to 170°C and was maintained for 20 minutes, followed by a new increase by 4°C/min up to 186°C for 19 min, then it was increased again by 4°C/min up to 220°C and by 2°C up to 240°C till the end of the process.

The obtained data were statistically processed with Statistica for Windows software.

Results and Discussion

The fatty acid composition of the buffalo yoghurt after lyophilization and gamma ray treatment, and after six months storage is presented in Tables 1, 2, 3, 4 and 5.

The total content of saturated fatty acids in the lyophilized buffalo yoghurt is 65.49 g/100g fat and it is preserved comparatively constant (65.27 g/100g fat) after a six months storage as analogous results are obtained also for the irradiated lyophilized buffalo milk with 2kGy and 4 kGy - from 66.27 g/100g fat to 65.85 g/100g fat and from 66.96 g/100g fat to 66.17 g/100g fat, respectively (Table 5).

The concentration of the short chain fatty acids (C4:0, C6:0, C8:0 и C10:0) increases after the process of irradiation respectively by 3.45 % for the samples irradiated with 2 kGy and with 2.39 % for 4kGy compared to the control samples. During storage a decrease in their values is observed in the lyophilized yoghurts while in the irradiated with 2 kGy their value increases by 2.5 % and in the irradiated with 4 kGy it remains unchanged (Table 1).

The level of the lauric (C12:0) acid increases from 2.92 g/100g fat in the control to 2.99 g/100g fat in the irradiated samples with 2 kGy and 3.15 g/100g fat for 4 kGy. After six month's storage of the buffalo yoghurts a decrease of the concentration of C12:0 in the lyophilized product to 2.84 g/100g fat and irradiated with 4 kGy to 3.10 g/100g fat is observed while for 2 kGy it increases to 3.06 g/100g fat. The content of the miristine (C14:0) acid remains relatively constant (from 10.63 to 10.66 g/100g fat) as a result of the technological processes but a decrease of its value is observed during storage. The palmitic (C16:0) acid changes its concentration from 25.75 g/100g fat in the control to 26.40 g/100g fat and 26.30 g/100g fat in the irradiated yoghurt respectively with 2 kGy and 4 kGy. During storage the concentration of C16:0 in the lyophilized product increases (27.00 g/100g fat) while in the irradiated ones a decrease is observed respectively to 25.49 g/100g fat for 2 kGy and 26.10 g/100g fat for 4 kGy. The content of the stearic acid is relatively constant for the different technological treatments and the six months storage conditions (Table 1).

The total content of the monounsaturated fatty acid is 29.42 g/100g fat in the control and 29.73 g/100g fat and 29.19 g/100g fat in the irradiated yoghurts (Table 5). In the course of storage a decrease of their total quantity is observed – in the lyophilized product to 28.34 g/100g fat, in the samples irradiated with 2 kGy to 27.48 g/100g fat and with 4 kGy to 28.99 g/100g fat. The monounsaturated fatty acids (MUFA) are presented in Table 2.

From MUFA the spectrum of the cis- and trans-isomers of C18:1 is the richest, with a predominant share of the oleic acid C18:1cis9 (about 20g/100g fat) and the vaccenic acid C18:1trans11. The content of the vaccenic acid varies in low ranges from 3.63 g/100g fat for the control group to 3.70 g/100 g fat and 3.55 g/100g fat. After storage the quantity of C18:1trans11 decreases in the lyophilized yoghurts to 2.80 g/100g fat and 2.49 g/100g fat in the irradiated with 2 kGy while in the irradiated with

Table 1
Saturated fatty acids, g/100g fat

Fatty acid	Control		2 kGy		4 kGy	
	1	6	1	6	1	6
C-4:0	4.47 ± 0.05	4.38±0.00	4.66 ± 0.03	4.60±0.02	4.71 ± 0.03	4.58±0.00
C-6:0	2.49 ± 0.03	2.42±0.00	2.60 ± 0.02	2.64±0.01	2.60 ± 0.01	2.73±0.00
C-8:0	1.62 ± 0.02	1.41±0.00	1.65 ± 0.01	1.71±0.01	1.66 ± 0.01	1.70±0.00
C-10:0	4.13 ± 0.05	3.42±0.00	4.24 ± 0.03	4.34±0.02	4.50 ± 0.02	4.34±0.00
C-11:0	0.08 ± 0.00	0.05±0.00	0.06 ± 0.00	0.06±0.00	0.07 ± 0.00	0.07±0.00
C-12:0	2.92 ± 0.03	2.84±0.00	2.99 ± 0.02	3.06±0.02	3.15 ± 0.02	3.10±0.00
C-13:0	0.09 ± 0.00	0.09±0.00	0.09 ± 0.00	0.11±0.03	0.09 ± 0.00	0.10±0.00
C-14:0	10.63 ± 0.09	10.53±0.01	10.10 ± 0.07	10.08±0.05	10.66 ± 0.05	10.38±0.00
C-15:0	1.01 ± 0.01	1.03±0.00	1.00 ± 0.01	1.00±0.01	1.04 ± 0.01	1.04±0.00
C-16:0	25.75 ± 0.30	27.00±0.02	26.40 ± 0.19	25.49±0.14	26.30 ± 0.14	26.10±0.00
C-17:0	0.65 ± 0.01	0.62±0.00	0.66 ± 0.01	0.63±0.00	0.68 ± 0.00	0.61±0.00
C-18.0	11.18 ± 0.13	11.00±0.01	11.33 ± 0.08	11.54±0.06	11.06 ± 0.06	10.98±0.00
C-20:0	0.20 ± 0.00	0.16±0.10	0.20 ± 0.00	0.19±0.00	0.19 ± 0.00	0.20±0.00
C-22:0	0.12 ± 0.00	0.11±0.00	0.13 ± 0.00	0.10±0.00	0.13 ± 0.00	0.11±0.00
C-24:0	0.08 ± 0.00	0.06±0.00	0.08 ± 0.00	0.06±0.00	0.07 ± 0.00	0.06±0.00

4 kGy it increases inconsiderably to 3.67 g/100g fat. All trans-isomers except for C18:1trans11 are considered “unwanted” because of their varied carcinogenic level.

The polyunsaturated fatty acids decrease by 5.15% in case of irradiation with 2 kGy and by 17.40% in case of irradiation with 4 kGy compared to the control group (Table 5). The storage of the buffalo yoghurts shows a decrease of the total quantity polyunsaturated fatty acids in the lyophilized and irradiated with 2 kGy samples while in the irradiated with 4 kGy a constant level is preserved. For the isomers of the linoleic acid C18:3n-3 is observed a decrease of the concentration from 0.85g/100g fat in the control to 0.73 g/100g fat (2 kGy) and 0.64 g/100g fat (4 kGy, and a constant level of C18:3n-6 (Table 3).

The six months storage has a negative effect on the concentration of C18:3n-3 while the changes in the content of C18:3n-6 are inconsiderable.

The buffalo yoghurt contains a very low quantity CLA compared to the sheep’s milk and dairy products (Table 5). The total content of the conjugated fatty acids decreases by 1.8% in the buffalo yoghurt irradiated with 2 kGy and by 18.6% in the irradiated with 4 kGy, compared to the control. During storage of the buffalo yoghurts the total quantity CLA decreases to 1.36 g/100g fat in the lyophilized and to 1.33 g/100g fat at irradiation with 2 kGy while in the irradiated with 4 kGy no change in the CLA value is observed. The CLA content is highest in the control samples-1.49 g/100g fat and lowest in the irradiated with 4 kGy – 1.23 g/100g fat. In the course of storage the concentration of CLA decreases by 21% in the lyophilized yoghurt and by 7.5% in the irradiated with 2 kGy, compared to the source while in the irradiated with 4kGy buffalo yoghurt it marks an increase by 7%. CLA is a functional nutritious component in milk and dairy products and is a protector for a number of diseases. The unsaturated long chain fatty acids occupy an important place in human nutrition and are necessary for the normal functioning of the central nervous system, the cardio-vascular system

Table 2

Monounsaturated fatty acids, g/100g fat

Fatty acid	Control		2 kGy		4 kGy	
	1	6	1	6	1	6
C-10:1	0.16±0.00	0.15±0.00	0.16±0.00	0.18±0.00	0.16±0.00	0.18±0.00
C-12:1n1	0.07±0.00	0.02±0.03	0.09±0.00	0.06±0.01	0.11±0.00	0.05±0.00
C-14:1n5	0.57±0.01	0.63±0.00	0.54±0.00	0.56±0.00	0.58±0.00	0.58±0.00
C-16:19tr	0.26±0.01	0.20±0.00	0.25±0.01	0.29±0.00	0.28±0.00	0.32±0.00
C-16:1n7	1.20±0.01	1.22±0.00	1.19±0.00	1.26±0.01	1.24±0.01	1.19±0.00
C-17:1n7	0.22±0.00	0.21±0.00	0.22±0.00	0.21±0.00	0.21±0.00	0.21±0.00
C-18:1t4	0.02±0.00	0.02±0.00	0.02±0.00	0.03±0.00	0.02±0.00	0.08±0.00
C-18:1t5/6/7	0.32±0.00	0.33±0.08	0.33±0.00	0.42±0.13	0.32±0.00	0.52±0.17
C-18:1t9	0.21±0.00	0.13±0.08	0.22±0.00	0.11±0.13	0.23±0.00	0.19±0.17
C-18:1t10	0.45±0.01	0.38±0.00	0.43±0.00	0.42±0.00	0.46±0.00	0.46±0.00
C-18:1t11	3.63±0.04	2.80±0.00	3.70±0.03	2.49±1.66	3.55±0.02	3.67±0.00
C-18:1c9/C-18 :1t12/13/	20.28±0.24	20.11±0.01	20.51±0.15	19.14±0.10	20.08±0.13	20.08±0.00
C-18:1t15/C-18:1c11	0.67±0.01	0.58±0.12	0.71±0.00	0.48±0.12	0.68±0.00	0.37±0.00
C-18:1c12	0.13±0.00	0.23±0.00	0.14±0.00	0.13±0.00	0.14±0.00	0.11±0.00
C-18:1c13	0.02±0.00	0.23±0.00	0.07±0.00	0.06±0.00	0.06±0.00	0.05±0.00
C-18:1t16	0.49±0.03	0.40±0.28	0.56±0.00	0.32±0.21	0.54±0.01	0.39±0.00
C-18:1c15	0.44±0.05	0.40±0.22	0.50±0.00	0.18±0.21	0.48±0.01	0.37±0.00
C-20:1n9	0.04±0.00	0.03±0.00	0.05±0.01	0.06±0.00	0.04±0.00	0.06±0.00

Table 3

Polyunsaturated fatty acids, g/100g fat

Fatty acid	Control		2 kGy		4 kGy	
	1	6	1	6	1	6
C-18:2c9,12/19:0	1.70±0.04	1.76±0.00	1.67±0.01	1.66±0.01	1.58±0.00	1.64±0.00
gC-18:3n6	0.06±0.01	0.07±0.06	0.06±0.00	0.07±0.02	0.05±0.00	0.14±0.05
aC-18:3n3	0.85±0.01	0.74±0.00	0.73±0.01	0.65±0.00	0.64±0.00	0.74±0.00
CLA9c,11t	1.49±0.02	1.28±0.00	1.43±0.01	1.19±0.01	1.23±0.01	1.32±0.00
CLA9c,11c	0.10±0.00	0.06±0.03	0.12±0.00	0.05±0.02	0.11±0.00	0.02±0.00
CLA9t,11t	0.04±0.01	0.01±0.00	0.06±0.02	0.08±0.00	0.04±0.02	0.05±0.00
C-20:2n6	0.08±0.00	0.05±0.04	0.08±0.00	0.05±0.03	0.07±0.00	0.07±0.00
C-20:3n6	0.05±0.00	0.05±0.03	0.05±0.00	0.06±0.00	0.04±0.00	0.06±0.00
C-20:4n6	0.09±0.00	0.12±0.08	0.08±0.00	0.03±0.02	0.06±0.00	0.05±0.05
C-20:5n3	0.06±0.00	0.05±0.00	0.04±0.00	0.06±0.00	0.04±0.00	0.04±0.00
C-22:2n6	0.05±0.00	0.02±0.02	0.07±0.00	0.07±0.00	0.06±0.00	0.05±0.01
C-22:5n3	0.09±0.00	0.08±0.00	0.07±0.00	0.05±0.00	0.05±0.00	0.06±0.00

and others (omega-3 and omega-6 fatty acids). The buffalo yoghurt is characterized by a very good correlation ω-6: ω-3 and varies from 2.4 to 2.73 / raw materials and natural foods, whose factor is <5 are with low risk factor/. During the storage of the buffalo yoghurts an increase of this coefficient is observed for the lyophilized milk (from 2.14 to 2.45) and for the irradiated with 2 kGy while for the irradiated samples with 4 kGy it decreases to 2.52. The content of ω-3 decreases by 18% (2 kGy) and 36% (4 kGy) compared to the control irradiated group. Their quantity in the analyzed groups is unstable and in the course of time they decrease for the lyophilized yoghurt by 8%, in case of irradiation by 3% but in case of irradiation with 4 kGy it increases by 28%. The content of the group of ω-6 fatty acids decreases by 0.9% as a result of applying of different irradiation doses but during storage it increases for all the three variants of the treated buffalo yoghurts, as follows: lyophilized by 6%, irradiated with 2 kGy – 2%, irradiated with 4 kGy – 5%.

Table 4

Branched fatty acids, g/100g fat

Fatty acid	Control		2 kGy		4 kGy	
	1	6	1	6	1	6
C-13iso	0.30±0.00	0.07±0.00	0.04±0.00	0.05±0.00	0.04±0.00	0.05±0.00
C-13aiso	0.01±0.00	0.01±0.00	0.01±0.00	0.02±0.01	0.01±0.00	0.01±0.00
C-14iso	0.16±0.03	0.15±0.00	0.13±0.00	0.14±0.00	0.15±0.00	0.14±0.00
C-15iso	0.30±0.00	0.22±0.14	0.26±0.00	0.27±0.00	0.26±0.00	0.27±0.00
C-15aiso	0.59±0.01	0.57±0.00	0.57±0.00	0.57±0.00	0.59±0.00	0.59±0.00
C:16iso	0.31±0.01	0.32±0.00	0.27±0.00	0.27±0.01	0.28±0.00	0.28±0.01
C-17iso	0.33±0.00	0.32±0.00	0.34±0.00	0.42±0.00	0.35±0.00	0.36±0.00
C-17aiso	0.41±0.00	0.40±0.00	0.41±0.00	0.41±0.00	0.41±0.00	0.41±0.00
C-18iso	0.06±0.00	0.05±0.00	0.07±0.00	0.06±0.00	0.06±0.00	0.06±0.00

Table 5

Groups fatty acids, g/100g fat

Fatty acid	Control		2 kGy		4 kGy	
	1	6	1	6	1	6
Σ CLA	1.64±0.01	1.36±0.02	1.61±0.01	1.33±0.01	1.38±0.02	1.40±0.00
ΣC-18:1Trans	5.79±0.05	4.63±0.17	5.97±0.04	4.27±1.63	5.81±0.01	5.69±0.00
Σ C-18:1Cis	20.87±0.21	21.21±0.09	21.22±0.15	19.69±0.17	20.76±0.10	20.70±0.00
SFA	65.49±0.73	65.27±0.10	66.27±0.47	65.85±0.29	66.96±0.43	66.17±0.00
MUFA	29.42±0.27	28.34±0.08	29.73±0.18	27.48±0.25	29.19±0.13	28.99±0.01
PUFA	4.70±0.03	4.47±0.18	4.47±0.02	4.24±0.22	4.00±0.02	4.39±0.09
Σ n-3	1.01±0.01	0.93±0.03	0.85±0.01	0.80±0.03	0.74±0.01	0.90±0.00
Σ n-6	2.17±0.04	2.41±0.17	2.15±0.01	2.24±0.21	2.02±0.00	2.21±0.09
Σn-6/Σn-3	2.14±0.07	2.59±0.14	2.53±0.04	2.79±0.20	2.72±0.03	2.47±0.09
Branched FA	2.47±0.01	2.11±0.14	2.08±0.01	2.21±0.01	2.15±0.01	2.17±0.01
CLA	1.49±0.02	1.28±0.00	1.43±0.01	1.33±0.01	1.23±0.01	1.32±0.00

The data for the branched fatty acids (Table 4) show that depending on the irradiation level their quantity varies in very narrow ranges (from 2.47 to 2.15 g/100g fat).

The data obtained after six months storage of the buffalo yoghurts are analogous.

Conclusions

The fatty acid profile of lyophilized buffalo milks treated with gamma irradiation does not undergo substantial changes during storage.

The content of the saturated fatty acids in the analyzed samples does not change substantially as a result of the irradiation process but in the course of time it causes their decrease which is most strongly expressed in the group irradiated with 4 kGy.

The quantity of the short chain fatty acids increases in the process of irradiation which might have an unfavorable effect on human organism.

The healthy nutrition level of the oleic fatty acid is comparatively constant as a result of the gamma ray treatment of the lyophilized buffalo yoghurts and during storage. Changes occur for the vaccenic acid during storage as its content is preserved in the buffalo yoghurts irradiated with 4 kGy.

The buffalo yoghurt analyzed in three groups-non-irradiated, irradiate-2 kGy and 4 kGy is with comparatively low content of anticarcinogenic substances (CLA). With the increase of the irradiation value the CLA concentration decreases from 1.49 g/100g fat in the non-irradiated group to 1.43 g/100g fat in the case of irradiation with 2 kGy and 1.23 g/100g fat- with 4 kGy. Identical effect is observed during six months storage as well.

The buffalo yoghurt is characterized by a very good correlation ω-6: ω-3 and varies from 2.14 to 2.73, i.e. the obtained irradiated yoghurts are with a low risk factor for human health. After six months storage of the treated milks the risk factor increases for the lyophilized and irradiated with 2 kGy yoghurt and decreases for the milk irradiated with 4 kGy.

Therefore the fatty acid profile is preserved to the greatest extent in the milks irradiated with 4 kGy, followed by the milks irradiated with 2 kGy and the lyophilized non-irradiated milks.

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