Abstract

The physicochemical composition and the content of fatty acids in the mild fat of buffalo yoghurt after lyophilization and treatment with gamma rays with doses 2 and 4 kGy has been studied. A comparatively constant physical-chemical composition of the buffalo yoghurt after treatment by the two technological methods and preservation for six months has been established. The indices atherogenic index (AI) and lipid preventive score (LPS) have been used for determining of the quality of the buffalo yoghurt. The studied buffalo milk fat after lyophilization and gamma irradiation has a relatively low atherogenic index which is a nutritionally valuable factor in relation to the risk of cardiovascular diseases. The buffalo yoghurt has a high lipid preventive score which is an index of a relatively high content of saturated fatty acids (SFA) and low concentration of unsaturated fatty acids (MUFA, PUFA).

Key words: buffalo yoghurt, fatty acids composition, lyophilization, gamma sterilization, atherogenic index (AI), lipid preventive score (LPS)

Introduction

Yoghurt is a main source of the useful for the human organism lactic acid bacteria but it also contains a number of essential substances such as amino acids, fatty acids, enzymes, micro- and macro elements. Some fatty acids in milk products play the role of a cardio protector. The higher content of stearic (C18:0) and oleic (C18:1) acids, as well as MUFA in the buffalo yoghurt have a favorable effect on human nutrition compared to the cow and goat milk. It has been established that the trans fatty acids and the saturated fatty acids, such as the myristic and palmitic, lead to hypercholesterolemia (Aro et al., 1997; Jensen, 2002). American Heart Association (AHA) recommends a decrease of the intake of C16:0, C14:0 and C12:0 with food (American Heart Association, 2002). Due to the small quantities unsaturated fatty acids in the dairy products, the intake of trans fatty acids through milk and diary products is insignificant and does not have an unfavourable effect on human health status (Jensen, 2002; Palmquist et al., 1993; Mihailova, 2006).

MUFA have a neutral effect on the cholesterol lev-
els while PUFA incline to decrease the quantity of the total cholesterol and the HDL cholesterol (Sacks and Katan, 2002). The milk fat with high content of unsaturated fatty acids is characterized by a lower atherogenic index. The high risk of cardio-vascular diseases of humans has necessitated the study of the dairy products because of the fact that compared to other lipid sources they contain a bigger quantity lauric (C12:0), myristic (C14:0) and palmitic (C16:0) acids and unsaturated fatty acids in low concentrations (Sacks and Katan, 2002; Ulbricht and Southgate, 1991). Ulbricht and Southgate (1991) have proposed the term atherogenic index (AI) for the lipids as a nutritional indices for the risk of cardio-vascular diseases. The atherogenic index is calculated on the basis of the content of the middle chain fatty acids C12:0, C14:0 and C16:0, and the groups MUFA and PUFA:

\[
AI = \frac{C12:0 + 4 \times C14:0 + C16:0}{MUFA + PUFA} \quad (1)
\]

It is assumed that the feeding of the animals is a basic factor influencing the fatty acid composition of milk (Lokuruka, 2007; Richard and Charbonnier, 1994; Sacks and Katan, 2002).

The consumption of dairy products with lower atherogenic index values leads to a decrease of the total cholesterol and the LDL-cholesterol in human blood plasma (Poppitt et al., 2002). Edmondson et al. (1974) have established in their studies that milk fats with lower atherogenic index values cultivate a rancid-type taste which is a potential disadvantage of dairy products with low atherogenic index.

Bobe et al. (2003) as a result of their investigations with cows have established that milk with low AI can be a result of the specific individual features of the cows.

Another factor verifying the healthy quality of milk is the Lipid Preventive Score (LPS). It was firstly suggested by Richard and Charbonnier (1994). An optimally balanced fatty acid content is obtained when the quantities of SFA, MUFA and PUFA correspond to a calculated LPS value equal to the total lipids (TL) content. Mihailova (2007) has established in her studies LPS 12.35 for buffalo yoghurt with butter content 6%. LPS was calculated by the formula:

\[
LPS = TL + 2 \times SFA - MUFA - 0.5 \times PUFA \quad (2)
\]

the changes in the physical-chemical and fatty acid composition of buffalo yoghurt after lyophilization and after gamma ray treatment; Prolongation of the preservation term by combining of the two technological approaches; Determining of AI and LPS of the analyzed buffalo yoghurts.

Material and Methods

Object of the investigation

The investigations were carried out on buffalo yoghurt delivered from the shops network and lyophilized at ICFT.

The samples were distributed in groups as follows: No1 control group, not irradiated; No2 - test group, irradiated by dose 2 kGy; No3 test group, irradiated by dose 4 kGy.

Technological approach

Two high technology tests were applied in the test process lyophilization and gamma rays irradiation with a follow-up of the preservation term for six months.

The sublimation 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 2 kGy and 4 kGy was realized by gamma irradiating installation “Gamma-1300”, with radiation source Cs ^{137} and dose power 1.5 kGr/min.

Packaging and preservation conditions

The products treated by the two technological methods lyophilized and gamma ray irradiated were
packed in polymer packings three-layer aluminium folio, under vacuum and were preserved at temperatures 0°-5°C.

**Physical-chemical indices:**
- Total fats- Sockslet, BSS EN ISO 1211:2002 ;
- Total protein- determined by the method of Keldal, BSS EN ISO 8968-1:2002 ;
- Lactose - BSS 1113-76;
- Moisture - BSS 1109:1989;
- Total solids - BSS 1109:1989;
- Titratable acidity - BSS 1111- 80;
- Active acidity- potentiometric;
- Determining of the residual moisture content after lyophilization- with balance Thermo Control, Sartorius (BSS EN ISO 5537:2005)

**Extraction of milk fat:** The extraction of total lipids was carried out by the method of Roese-Gottlieb (AOAC, 2000) by means of diethyl and petroleic ether. The transesterification of the milk fat was realized with the aid of sodium methilate Roese-Gottlieb, and a consequent drying with NaHSO₄. The methyl esters of the fatty acids (FAME) were analyzed with a gas chromatograph Shimadzu-2010 (Kyoto, Japan), equipped with a flame-ionizing detector and an automatic injection system (AOC-2010i). 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 carrying 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 minutes, 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 physicochemical content of buffalo yoghurt in fresh, lyophilized and gamma ray treated condition is presented in Table 1. The obtained results show a comparatively stable content, not depending on the mode of preservation. The titrated acidity of the analyzed samples has a satisfactory value of 124°T (at 100-150°T for buffalo yoghurt). The active acidity is with lowered values compared to the optimal for yoghurt 4.3 up to 4.6. This is most probably a result of the used lactic acid yeast.

The AL index was calculated based on the obtained values for the lauric (C12:0), myristic (C14:0) and palmitic (C16:0) acids and the unsaturated fatty acids. The obtained data have a relatively low AL 2.09 for the fresh and lyophilized yoghurt, 2.04 for the irradiated by 2 kGy and 2.17 for the irradiated by 4 kGy lyophilized buffalo yoghurt. The values are stable and are not affected by the oxidation processes during preservation (Table 2). Due to the low quantities

### Table 1

<table>
<thead>
<tr>
<th>Indices</th>
<th>Fresh milk</th>
<th>Control group</th>
<th>2 kGy</th>
<th>4 kGy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total fats, %</td>
<td>7.00</td>
<td>45.91</td>
<td>46.26</td>
<td>45.87</td>
</tr>
<tr>
<td>Total protein, %</td>
<td>4.30</td>
<td>28.76</td>
<td>28.70</td>
<td>28.72</td>
</tr>
<tr>
<td>Lactose, %</td>
<td>4.70</td>
<td>31.40</td>
<td>31.38</td>
<td>31.42</td>
</tr>
<tr>
<td>Moisture, %</td>
<td>85.49</td>
<td>2.94</td>
<td>2.94</td>
<td>2.94</td>
</tr>
<tr>
<td>Total solids, %</td>
<td>14.51</td>
<td>97.06</td>
<td>97.06</td>
<td>97.06</td>
</tr>
<tr>
<td>Titratable acidity, °T</td>
<td>124</td>
<td>124</td>
<td>124</td>
<td>124</td>
</tr>
<tr>
<td>pH</td>
<td>3.48</td>
<td>3.48</td>
<td>3.48</td>
<td>3.48</td>
</tr>
</tbody>
</table>
of unsaturated fatty acids in milk its regular consumption could not have a negative effect on human health, independent of the method of technological treatment.

LPS can serve as an estimate of the fatty acid content related to the risk of cardio-vascular disorders. The optimum balanced fatty acid content is when LPS=TL or LPS value is possibly closest to TL.

The intake of saturated fatty acids and trans-fatty acids gives information about the atherogenic risk. LPS serves as an estimate for the balancing of buffalo yoghurt. As a result of the analyses of the milks: fresh yoghurt (13.94) lyophilized (91.46) and irradiated (92.99) it has been established that LPS surpasses TL (Table 1). Preservation does not affect substantially the level of this index. For the samples irradiated by 4kGy the fatty acid composition and the LPS value remain relatively constant. The high SFA content and the low MUFA and PUFA levels lead to a higher LPS value and a lower preventive degree related to cardio-vascular disorders.

Conclusions

The buffalo yoghurt is characterized by a relatively constant physical-chemical composition after lyophilization and gamma irradiation.

The treated milks are with a sufficiently low atherogenic index from 2.04 up to 2.19, which could have a favorable effect on human health.

The LPS in the buffalo yoghurts surpasses considerably the quantity of TL in the natural product as well as in milks treated by various technologies.

The changes in the physical-chemical and fatty acid composition as a result of the preservation of the buffalo yoghurts treated by the two technological methods are minimal as the most stable indices show the milks irradiated by 4 kGy.

References


Dimitrov, T., S. Boicheva and N. Naidenova, 2008. Significance of milk and dairy products for the hu-


d | C 12:0, g/100g fat | C 14:0, g/100g fat | C 16:0, g/100g fat | ΣΗΜΚ, g/100g product | ΣΙΗМК, g/100g product | TL, g/100g product | LPS | AI
--- | --- | --- | --- | --- | --- | --- | --- | ---
Fresh milk | 2.92 | 10.63 | 25.72 | 65.49 | 29.42 | 4.7 | 13.94 | 2.09
Control group 1 | 2.92 | 10.63 | 25.72 | 65.49 | 29.42 | 4.7 | 91.46 | 2.09
6 | 2.84 | 10.53 | 27 | 65.27 | 28.34 | 4.47 | 91.46 | 2.19
2 kGy | 2.99 | 10.1 | 26.4 | 66.27 | 29.73 | 4.47 | 92.79 | 2.04
6 | 3.06 | 10.08 | 25.49 | 65.85 | 27.48 | 4.24 | 93.49 | 2.17
4 kGy | 3.15 | 10.66 | 26.3 | 66.96 | 29.19 | 4 | 92.99 | 2.12
man organism. *Scientific Works of the University of Ruse*, 47: 34-42 (Bg).


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