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Comparative studies on the fatty acid composition of White brined cheese, marketed in the town of Stara Zagora

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Abstract. *The study was carried out in March-April 2009. Ten cheese samples representing different cheese batches were sampled to compositional and fatty acid profile analysis. The palm oil and four white-brined cheeses (2 representing palm oil cheese batches and 2 - free of palm oil cheese batches) were purchased from a commercial manufacturer. Other six cheeses were purchased from the market where they were offered as "free of vegetable oil". An extremely high level of saturated (73.55÷75.78%) fatty acids is established for 3 cheese batches due mainly to the higher amount of lauric (34.86÷36.97%), or palmitic acid (30.24÷34.00%). The high levels of the hypercholesterolemic fatty acids of the dairy factory palm oil cheeses and four market batches in combination with the very low or very high n-6/n-3 fatty ratios in these products pose a risk to consumer health. Only one of the all six market cheeses offered as "free of vegetable oil" dairy products does not cause suspicion of added vegetable fat or unfair sale to the customers.*

Keywords: cheese, fatty acids, vegetable oil, market

Abbreviations: SFA – saturated fatty acids, MUFA - monounsaturated fatty acids, PUFA - polyunsaturated fatty acids, SCFA – short-chain fatty acids, MCFA - medium-chain fatty acids, LCFA - long-chain fatty acids, FAP - fatty acids profile, FVO - free of vegetable oils, HyperChlFA - hypercholesterolemic acids.

Introduction

The biological value of fat is determined by its effect on the organism, which depends on its composition (mostly the content of essential fatty acids) and the balanced content of saturated and unsaturated fatty acids. Decomposition products of milk significantly affect the taste and aroma of cheese. Minimum amount of butyric, caproic, caprylic and capric acid is sufficient to give salient flavor of the cheese (Baltadjieva, 1993; Pinho et al., 2003).

Saturated fatty acids (SFA) are major dietary constituents that raise plasma concentrations of total cholesterol and LDL cholesterol in humans, but not all saturated fatty acids are equivalent regarding their effects on serum lipoproteins and apolipoproteins (Grundy and Denke,1990; Denke and Grundy,1992; Berner,1993). In comparison with lauric, myristic and palmitic acids, which are generally considered to raise the serum total and LDL cholesterol, approximately 59% of the major fatty acids in milk are not hypercholesterolemic: 1) short-chain saturated fatty acids (butyric, caproic, caprylic and capric); 2) stearic acid; 3) monounsaturated fatty acids (MUFA palmitoleic, oleic); 4) polyunsaturated fatty acids (PUFA linoleic, linolenic); and 5) traces of others (Berner, 1993). In earlier investigations it is suggested that lauric, myristic and palmitic fatty acids differently affect the raising of blood cholesterol (Ng et al., 1991; Tholstrup et al., 1994; Zock et al., 1994; Temme et al., 1996), but according to Baer et al. (2004) all these three fatty acids increase equally "bad" blood LDL cholesterol.

Brown et al. (2005) determine palm oil as "cruel oil" - more dangerous to health than other fats used in food products for the U.S. market. Palm oil increases significantly the level of total blood cholesterol (Temme et al., 1996) and threaten the health of people with cardiovascular problems. Palmitic acid increases the ratio total/LDL cholesterol level significantly, more than the other saturated fatty acids, including lauric and myristic, which are abundant in the palm and other "tropical oils" (Mensink et al., 2003). For the growing threat to the health of people consuming food products with palm oil speaks the stand of the World Health Organization since 2003: "There is convincing evidence that palmitic acid increases the risk of cardiovascular disease" (Brown et al., 2005).

MUFA and PUFA have protective effect against the risk of cardiovascular disease. The consumption of foods, containing balanced ratio n-6/n-3 fatty acids is extremely important and can reduce the risk of developing cancer (breast, colon and prostate), cardiovascular diseases, immune system disorders, allergies, diabetes, chronic diseases and other diseases (Judd et al., 1998; Simopoulos et al., 1999; Connor, 2000; Xia et al., 2005; Song et al., 2008). The composition of the original milk (milk fat, respectively) can vary according to nutritional, genetic and physiological factors (Berner, 1993) and during the cheesemaking process is modified differently depending on the technological process used (Lucas et al., 2006).

Dairy fat is a major source of myristic acid. Myristic and palmitic acid should be reduced in diets for treatment of hypercholesterolemia. (Zock et al., 1994). A natural and successful way about that is the feeding of dairy cows with lower amount of roughage which results in reduced acetate production from rumen fermentation and leads to reduced endogenous synthesis of saturated fatty acids. The additional diet supplementation with protected fat, rich in unsaturated fatty acids results in a higher absorption of unsaturated fatty acids and higher milk expression of MUFA and PUFA. Such milk contains almost 50% lower amounts of lauric, myristic and palmitic acids. The including of dairy products from this milk in human diets shows significant decrease of the total plasma cholesterol (Noakes et al., 1996).

Bulgarian white-brined cheese is one of the most important dairy products manufactured and marketed in our country. However,

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in recent years some dairy products made with vegetable fats (e.g. palm oil) have become widespread on our market.

Mihailova et al. (1995) do not determine significant change in the fatty acids profile (FAP) of the cow`s white brined cheese during processing (one-day-old cheese), maturation (60 days) and storage (9 months). Similar data are received also for the one-day- and 60-day- old ewe's cheese (Addis et al., 2005), very likely because of the fact, that the intracellular lipases and esterases of the cheese starter lactobacilli are determined as "weak" (Khalid and Marth, 1990).

The aim of the present study is to establish the fatty acid composition of different market batches of Bulgarian white-brined cheese offered as "free of vegetable oils" (FVO).

Material and methods

The palm oil and four white-brined cheeses (2 representing palm oil cheese batches and 2 - free of palm oil cheese batches) were purchased from a commercial manufacturer. Other six cheeses were purchased from the market. They were delivered from different cheese manufacturers and offered as "free of vegetable oil". The cheeses were sampled to compositional (dry matter, fat, protein, fat in dry mater, water in non-fat substance, salt in the moisture – data are not presented and discussed in this paper) and fatty acid profile analysis.

The extraction of milk fat was done using the method of Rose-Gottlieb - with a diethyl ether and petroleum ether (Methodenbuch, Bd. VI VDLUFA-Verlag, Darmstadt, 1985). After that the solvents were evaporated on a vacuum-rotary evaporator. Sodium methylate (CHONa) was used for producing of methyl esters of the fatty acids (Jahreis et al., 1997). The fatty acid composition of cheese was determined by gas chromatography "Pay-Unicam 304" with flame ionization detector and column EC™- WAX, 30 m, ID 0.25 mm, Film:0,25 μm. For statistical analysis, ANOVA was performed on all batches using a statistical software (Statistica 6.0).

Results and discussion

The palm oil used in dairy factory cheese batches is characterised by a high level of palmitic ($C_{16:0}$) and oleic acid ($C_{18:1}$), which constitute 85.38% of the total fatty acids (Table 1). Our results for these fatty acids are much the same as the composition of palm oil, established by Mukherjee and Mitra (2009). As regards the negligible amount of lauric acid ($C_{12:0}$) established for the palm oil in our study, its presence seems much more typical for the palm kernel and coconut oils, but Knothe (2002) also indicates similar small amount of this fatty acid in the palm oil. Compared to the results of Mukherjee and Mitra (2009), and Knothe (2002) we detect much less linoleic acid ($C_{18:2}$) and more stearic ($C_{18:0}$) acid in the analyzed palm oil. The rest: pentadecanoic ($C_{15:0}$), palmitoleic ($C_{16:1}$) and arachidonic ($C_{20:0}$) fatty acids have not been detected or reported by the above-mentioned authors. The short-chain fatty acids (SCFA - $C_4 \div C_{10}$) are easily digestible which is their main advantage and in this respect milk fatty acids are a potential of human nutrition (Jenness, 1980). SCFA in the milk fat behave as carbohydrates and have no effect on plasma cholesterol (Simopoulos, 2008).

Dairy factory palm oil cheeses (No 1-2) demonstrate significantly lower SCFA levels (0.67÷0.97%) in comparison with other batches (Figure 1). The amount of these fatty acids in dairy factory cheeses, produced without palm oil (No 3-4)) or commercially available as FVO ranges from 7.25% (batch No 7) to 10.34% (batch No 3). In respect to dairy factory cheeses without palm oil (48.99÷55.46%) and FVO cheese samples (52.10÷65.85%), the factory palm oil cheese contains less amount of medium-chain fatty acids (MCFA - $C_{12} \div C_{17}$). But the LCFA - above

Table 1. Fatty acids composition of the palm oil, applied to the white-brined cheese

		Mukherjee and Mitra, 2009		Knothe, 2002	
Fatty Acids, %	Palm Oil Our results	Palm Oil	Palm Kernel Oil	Palm Oil	Coconut Oil
C6:0					
C8:0			3,30		
C10:0			10,40		
C12:0	0,19		48,20	0÷0.4	45.1÷50.3
C14:0	1,23	1,00	16,20	0.5÷2.0	16.8÷20.6
C15:0	0,04				
C16:0	45,67	44,30	8,40	40.1÷47.5	7.7÷10.2
C16:1	1,61				
C18:0	10,40	4,60	2,50	3.5÷6.0	2.3÷3.5
C18:1	39,71	38,70	15,30	36÷44	5.4÷8.1
C18:2	0,08	10,50	2,30	6.5÷12	1.0÷2.1
C18:3	0,21			0÷0.5	0÷0.2
C20:0	0,78				
Other/Unknown	0.08	0.90	0,40		

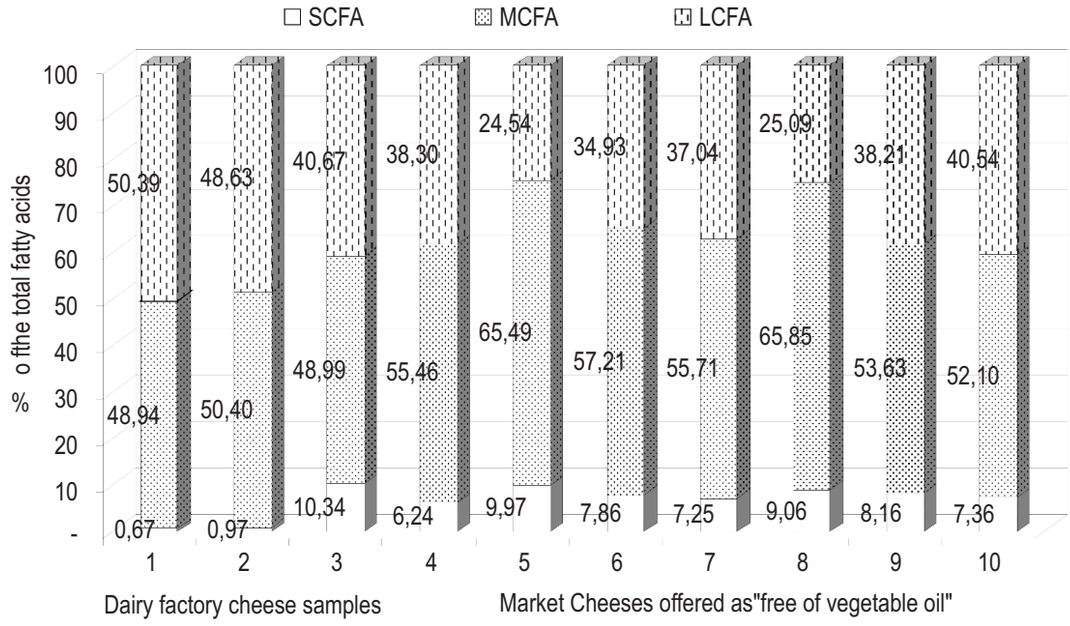

Figure 1. Amounts of short-chain (SCFA), medium-chain (MCFA) and long-chain (MCFA) fatty acids in the studied sheese samples

C_{18} in cheese samples with palm oil is significantly higher (over 10÷12%) compared to the other batches, where the highest amount of LCFA is determined for cheese batch 3 (40.67%) and the lowest for batch 5 (24.54%). Although milk fat is not high in cholesterol, it is hypercholesterolemic, primarily because of its high content of saturated fatty acids (Simopoulos, 2008).

Higher amount of saturated fatty acids (SFA) is observed in the cheeses produced in the dairy factory without palm oil (batches 3 and 4) or commercially available as FVO (Figure 2). An extremely high level of these fatty acids is observed in batches 5, 6, 7 and 8, which varies within the range 73.55÷75.78%, while in the others

FVO batches it is within 66.89÷67.04%. Both dairy factory cheese batches without palm oil contain less amount of (57.04÷58.14%) SFA. However, one should not take unfair advantage of the lower amount of SFA in cheese with palm oil. The greater amounts of SFA in some of the other cheese batches (3, 4 and 9) should not be worrying, because stearic acid and SCFA do not belong to the group of hypercholesterolemic acids (HyperChlFA) - lauric, myristic and palmitic (Berner, 1993; Zock et al., 1994). Discussing data about the individual HyperChlFA, it should be noted

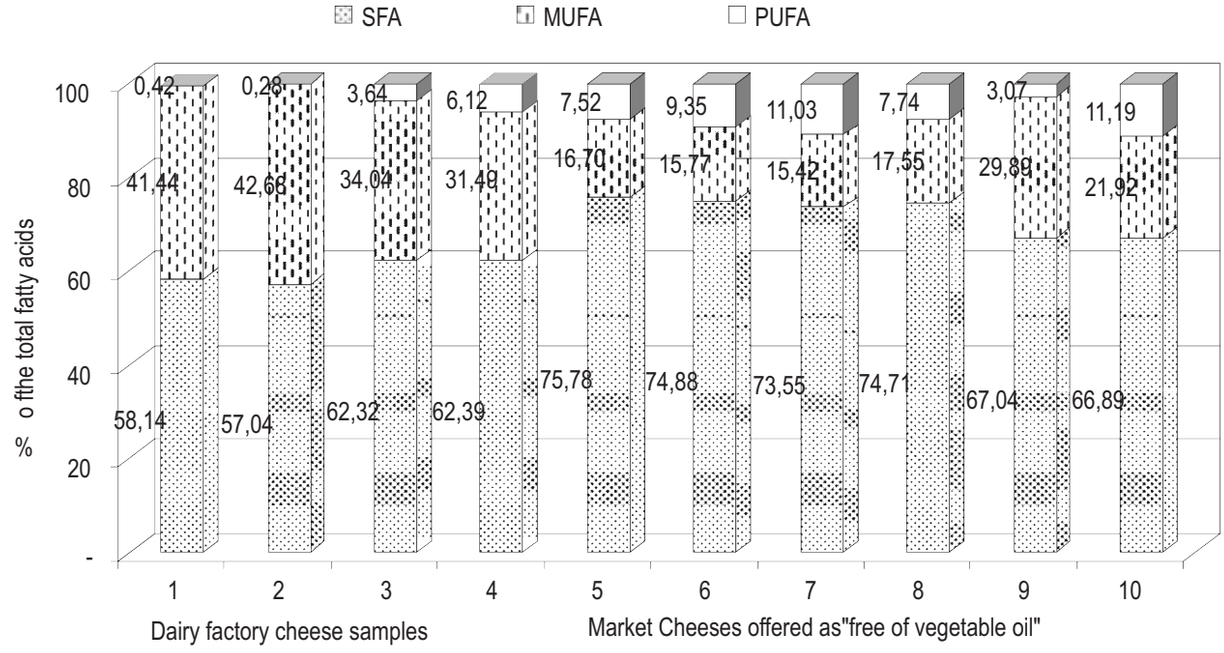

Figure 2. Amounts of the saturated (SFA), monounsaturated (MUFA) and polyunsaturated fatty acids (PUFA) in the studied sheese samples

that the higher amount of SFA in some commercially available cheeses is due mainly to the higher amount (about 20÷30%) of lauric (batches 5 - 34.88 and 8 - 36.95%), or (approximately over 15%) palmitic acid (batches 6 - 30.38, 7-33.97 and 10 - 34.02%) (Figure 3). This suggests that either these cheese batches contained palm-kernel oil/or coconut oil or their presence was not indicated properly.

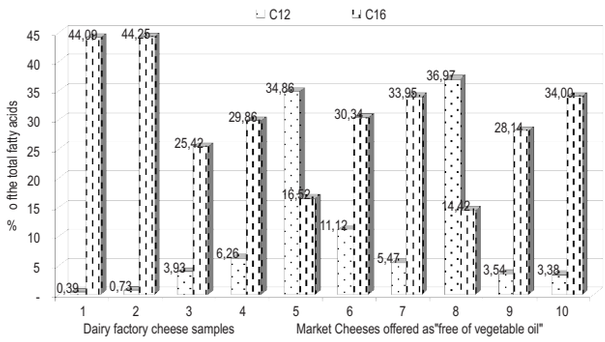

Figure 3. Amounts of lauric ($C_{12:0}$) and palmitic ($C_{16:0}$) fatty acids in the studied sheese samples

More possible is the incorporation of a mixture of palm/palm-kernel oil in cheese batch No 6, mainly because of higher levels of lauric and palmitic fatty acids, according to fatty acid composition data of the above-mentioned oils in Table 1. The levels of the HyperChlFA (lauric, palmitic and myristic) in four batches (5÷8) are above 50%, which poses a risk to consumer health (Grundy and Denke, 1990; Denke and Grundy, 1992; Zock et al., 1994; Baer et al., 2004; Brown and Jacobson, 2005). Obviously some Bulgarian cheese producers have chosen another way of FAP modifying in analogy of their colleagues in Australia (Noakes et al., 1996), through direct replacement of milk fat by vegetable oils. Probably that is the reason for establishing such higher levels of the HyperChlFA.

The established amounts of lauric, palmitic and myristic in batches 3, 4 and 9 are typical for the white-brined cheese (Mihailova et al., 1995) or very similar to the FAP of those sorts of cheeses (Kinik et al., 2005), as well as 15 other types of cheese (Iverson and Sheppard, 1988). At the same time, in the remaining FVO cheeses (batches 5÷8) a significant increase of some HyperChlFA is observed. Similarly to our results for the FAP of cheese without palm oil (batch 4), Kinik et al. (2005) also establish some higher values for lauric and palmitic fatty acids in the white-brined cheeses. This study clearly indicates that only one (batch 9) of all six FVO cheeses does not cause suspicion of added vegetable fat or unfair sale to the customers.

The consumption of HyperChlFA $C_{12:0}$, $C_{14:0}$ and $C_{16:0}$ in amounts greater than 10% of total calories can increase plasma cholesterol levels, but this effect may be lessened by $C_{18:0}$, $C_{18:1}$ and $C_{18:2}$ in dairy products and other foods (Jensen et al., 1991). In the cheese group without palm oil (3 and 4) or cheeses sold as FVO, the highest amount of oleic acid ($C_{18:1}$) is determined in batches 3 (30.58%), 4 (26.41%) and 9 (25.76%) (Figure 4).

These data of ours are very close to the results in an earlier study of Mihailova et al. (1995) about the fresh and matured white brined cheese and Kinik et al. (2005) who investigate some similar cheeses in Turkey. The balance of omega-6/omega-3 fatty acids is an important determinant in decreasing the risk of coronary heart disease, both in the primary and secondary prevention of coronary heart disease (Simopoulos, 2008).

We establish higher level of the PUFA ($C_{18:2}$ and $C_{18:3}$) in the market cheese samples (5÷8 and 10) and extremely low in the palm oil cheese batches (1 and 2) (Figure 5). The consumption of foods, containing balanced ratio ($C_{18:2}$)/($C_{18:3}$) fatty acids is extremely important and healthy (Simopoulos et al., 1999; Connor, 2000; Cordain et al., 2005; Xia et al., 2005). The optimal ratio n-6/n-3 fatty acids for a healthy diet is in the range of 1:1 to 2÷5:1 but we establish similar ratio only for the cheeses of batches 2, 3, 4, 8 9 and 10 (Figure 6). In the remaining cheese batches this ratio is either very low (batch 1) or much higher than desired. It is believed that the n-6/n-3 fatty acids above 5 represent health risk. Of course, in the examined cheeses there is not such a dramatic shortage of omega-3 fatty acids (10÷20:1 ratio) as Cordain et al. (2005) point out for other dietary fats.

Simopoulos (2008a) notes that a ratio of 5/1 has shown a beneficial effect on patients with asthma, whereas a ratio of 10/1 had adverse consequences. So the optimum ratio may vary with the disease under consideration. This is consistent with the fact that chronic diseases are multigenic and multifactorial. A lower ratio of omega-6/omega-3fatty acids is more desirable in reducing the risk of many of the chronic diseases of high prevalence in Western societies, as well as in the developing countries. On the other hand, Deckelbaum and Calder (2010) conclude that extremely low intakes of omega-6/omega-3 fatty acids can be harmful, too. Noakes et al. (1996) have achieved decreasing of the total plasma cholesterol by reducing the HyperChlFA - $C_{12:0}$, $C_{14:0}$ and $C_{16:0}$ and, respectively, increasing the $C_{18:0}$, $C_{18:1}$ and $C_{18:2}$ through slight increase of the omega-6/omega-3 ratio. Therefore, we should not discuss omega-6/omega-3 ratio without its relation to the actual cheese fatty acid

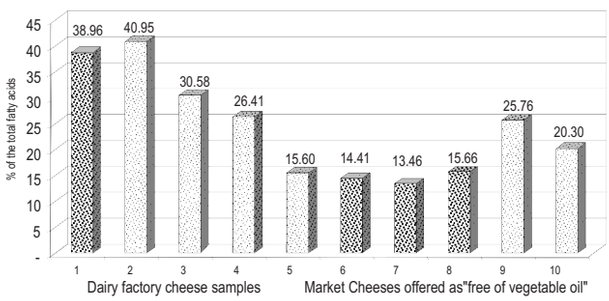

Figure 4. Amount of the oleic fatty acid ($C_{18:1}$) and in the studied sheeses

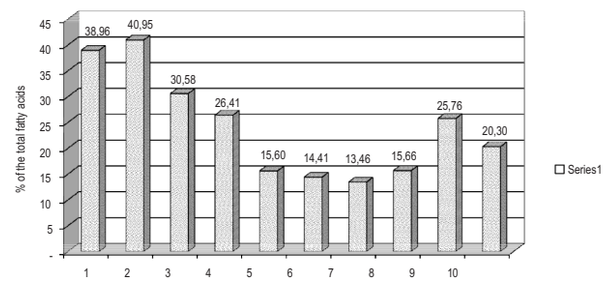

Figure 5. Amounts of the linoleic ($C_{18:2}$) and linolenic ($C_{18:3}$) fatty acids in the sheese

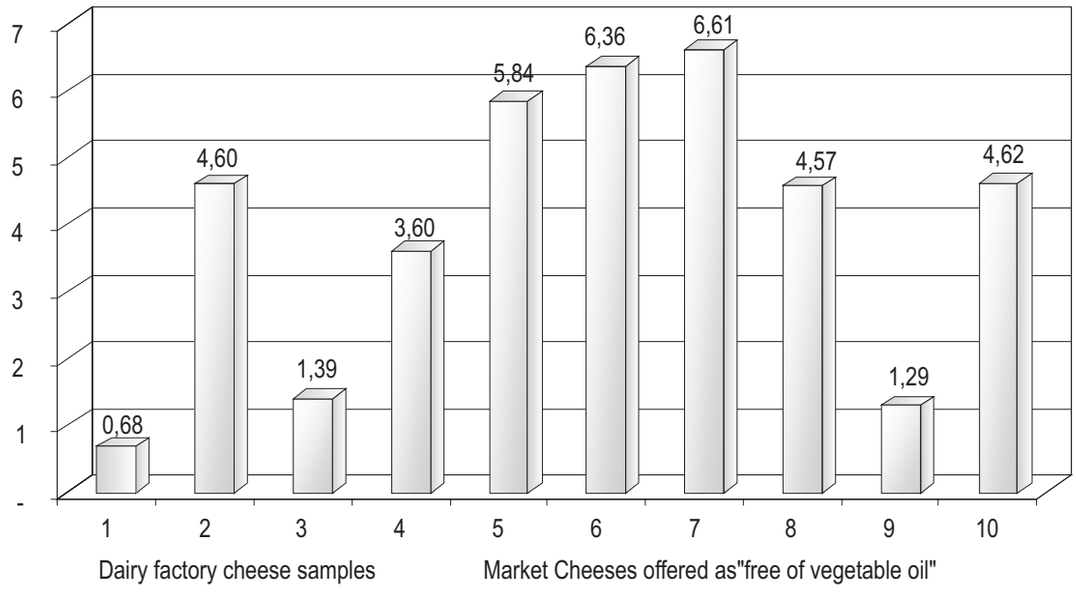

Figure 6. The $C_{18:2}/C_{18:3}$ ratio in the studied sheesees

amounts. Finally, we have to note that the wilful and incompetent modification of the cheese fatty acid profile of processed milk and achieving a combination of high level HyperChlFA with high n-6/n-3 fatty ratio might have a great negative effect on the health of consumers. Something like that must have been done to cheese batches 5, 6, 7, 8 and 10 or they are sold incorrectly as "free of vegetable oil".

Conclusion

In comparison with the result of Mukherjee and Mitra (2009) and Knothe (2002), we determine much less linoleic acid ($C_{18:2}$) and more stearic ($C_{18:0}$) acid in the analyzed palm oil. Dairy factory palm oil cheese (No 1-2) demonstrate significantly lower short-chain fatty acid levels, less amount of medium-chain fatty acids, but the amount of long-chain fatty acids is significantly higher (over 10÷12%) compared to the other cheese batches.

An extremely high level of saturated fatty acids is observed in batches 5, 6, 7 and 8, which varies in the range of 73.55÷75.78% due mainly to the higher amount (about 20÷30%) of lauric (batches 5 – 34.86 and 8 – 36.97%) or (approximately over 15%) palmitic acid (batches 6 – 30.24, 7 – 33.97 and 10 – 34.00%).

The high levels of the HyperChlFA of the dairy factory palm oil cheeses and four market batches (5÷8) in combination with the very low and higher n-6/n-3 fatty ratios in these products pose a risk to consumer health. Only one of all six market cheeses offered as “free of vegetable oil” dairy products does not cause suspicion of added vegetable fat or unfair sale to customers.

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The manuscript should be structured as follows: Title, Names of authors and affiliation address, Abstract, List of keywords, Introduction, Material and methods, Results, Discussion, Conclusion, Acknowledgements (if any), References, Tables, Figures.

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Penkov D, 2008. Estimation of metabolic energy and true digestibility of amino acids of some feeds in experiments with muscus duck (Carina moshata, L). Thesis for DSc. Agrarian University, Plovdiv, 314 pp.

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