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FATTY ACID COMPOSITION OF EDAM, EMMENTAL AND GOUDA CHEESES PRODUCED IN SLOVENIA IN AUTUMN 1997

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ABSTRACT

The aim of our work was to determine fatty acid composition of three different types of cheeses - Edam, Gouda and Emmental, produced in Slovenia in autumn 1997. The analysed Edam and Gouda cheese was produced by three and Emmental cheese by two different producers. All samples were purchased in the local supermarkets twice in the period of three months in autumn 1997. The methyl esters of the fatty acids were prepared by *in situ* transesterification (ISTE) and determined by gas chromatography. The average total SAT (saturated fatty acids) content was 56.80 wt % (relative percentage for each fatty acid of the total fatty acids) for Emmental cheese, 56.62 wt % for Edam cheese and 57.49 wt % for Gouda cheese. The average total MUFA (monounsaturated fatty acids) content was 34.26 wt % for Emmental cheese, 34.28 wt % for Edam cheese and 33.45 wt % for Gouda cheese. The average total PUFA (polyunsaturated fatty acids) content was 5.30 wt % for Emmental cheese, 5.74% for Edam cheese and 5.64% for Gouda cheese. No great difference was found between three types of cheese concerning the fatty acid profile (wt %).

Key words: milk products / cheese / Edam / Emmental / Gouda / composition / fatty acids / Slovenia

MAŠČOBNO-KISLINSKA SESTAVA SIROV EDAMEC, EMENTALEC IN GAVDA, PROIZVEDENIH V SLOVENIJI JESENI 1997

IZVLEČEK

V našem delu smo določili maščobno-kislinsko sestavo treh različnih tipov sira - edamca, ementalca in gavde, proizvedenih v Sloveniji jeseni 1997. Analizirali smo edamca in gavdo treh ter ementalca dveh različnih proizvajalcev. Vse vzorce smo kupili jeseni 1997 na slovenskem tržišču, in sicer dvakrat v času treh mesecev. Metilne estre maščobnih kislin (FAME-s) smo pripravili z metodo *in situ* transesterifikacije (ISTE) in sestavo določili s plinsko kromatografijo. Povprečna vsebnost skupnih nasičenih kislin (SAT) v ementalcu je bila 56,80 ut % (utežni odstotek posamezne kisline glede na skupne maščobne kisline), v edamcu 56,62% in v gavdi 57,49%. Povprečna vsebnost skupnih enkrat nenasičenih kislin (MUFA) v ementalcu je bila 34,26%, v edamcu 34,28% in v gavdi 33,45%. Povprečna vsebnost skupnih večkrat nenasičenih kislin (PUFA) v ementalcu je bila 5,30%, v edamcu 5,74% in v gavdi 5,64%. Med analiziranimi različnimi vrstami sira nismo našli bistvenih razlik glede na maščobno-kislinsko sestavo (ut. %).

Ključne besede: mlečni izdelki / siri / emadec / ementalec / gavda / sestava / maščobne kisline / Slovenija

INTRODUCTION

Fatty acids constitute over 90% of total edible fats and oils. There are many naturally occurring fatty acids with very different chemical and physical characteristics. Unsaturated fatty acids, particularly those with more than one double bond, are susceptible to changes and alterations caused by chemical and physical factors. In addition to being a concentrated source of energy, fatty acids and substances derived from them such as prostaglandins and leukotrienes carry out many important physiological functions. However, dietary fatty acids, when in excess, can have undesirable consequences. Dietary lipids have been found to play a significant role in the pathogenesis of cardiovascular diseases, cancer and other disorders (Chow, 1992; Chow, 2000).

The milk fat of ruminants is characterised by its high proportion of short - chain fatty acids. The lipids are readily available, but exceptionally complex. Cow milk fat contains about 200 different fatty acids, many of them at trace levels; 12 - 18 fatty acids are found in all samples. The fatty acid composition of cow milk fat changes with the seasons following the changes in the cow feed (Koletzko *et al.*, 1989). Sollberger (1997) wrote in his article that the quality of Emmental cheese depended on the cow's feed. The quality is better during summer than in winter because with the summer type of feed the oleic fatty acid (18:1) content in milk - and then in cheese - is higher and the cheese has softer consistence.

In order to properly evaluate the fatty acid composition of cheese the fatty acid profile of original milk should be known but this is nearly impossible when samples of commercially available cheese are studied.

The aim of our work was to determine the fatty acid composition of semihard and hard cheese produced by various Slovenian producers from various geographical regions found on the market.

MATERIAL AND METHODS

Samples:

- purchased locally twice from October to December, 1997;
- Edam cheese, semihard, 45% fat in dry matter, ripened by eye forming bacteria, three different producers - three geographical regions;
- Gouda cheese, semihard, 45% fat in dry matter, ripened by eye forming bacteria, three different producers- three geographical regions;
- Emmental cheese, hard, 45% fat in dry matter, ripened by eye forming bacteria, two different producers- two geographical regions.

Analytical procedure

Each sample was analysed in duplicate before the expiry date of the product.
The dry matter content was determined using the IDF method (IDF 4A: 1982).

The representative analytical samples homogenised using high - speed blender.

↓

in situ transesterification (ISTE) without prior extraction (Park and Goins, 1994)

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fatty acid (FA) composition of resulting fatty acid methyl esters (FAME-s) determined by GC

↓

FAME-s identified by comparison of retention times with standards
(Nu Check Prep., Inc., Sigma)



concentrations (wt% of the total FAs) calculated by use of adequate response factors (Rf) based on standard mixture (NuCheck 87, NuCheck Prep. Inc.) and the conversion factors for conversion of FAME-s to their corresponding fatty acids (AOAC, 1998).

The fatty acid composition of resulting FAME-s was determined by GC using Hewlett Packard 5890 series I gas chromatograph equipped with a flame ionisation detector (FID) and integrator 3392A under following conditions (Stibilj and Koman Rajšp, 1997):

- Capillary column: HP-20M (Carbowax 20M, 50 m x 0.32 mm x 0.3 µm)
- Oven program: 140° C (0 min); 7° C min⁻¹ to 215° C (81.29 min)
- Injection: Split, 30:1, volume injected 1 µl
- Carrier gas: Ar, 2 ml min⁻¹
- Makeup gas: N₂, 30 ml min⁻¹
- Inlet: 250° C
- Detector: 270° C

In addition to fatty acids, the total fat in most food includes the glycerol of the triglycerides, phosphate from phospholipids, and unsaponifiable components such as sterols. To allow the calculation of the total fatty acids in a given weight of food, we used the formula (Fatty acids, 1998, Kunachowicz, 1998)

$$\text{g FA/100g cheese} = (\% \text{ total fat} \times 0.945 \times \% \text{ FA}) / 100$$

Total fat calculation was based on fat in dry matter content as stated by producers and recalculated to original sample. The determined average dry matter content was 663.5 g kg⁻¹ for Emmental cheese, 605.5 g kg⁻¹ for Edam cheese and 623.5 g kg⁻¹ for Gouda cheese.

The precision and the accuracy of the used analytical method was checked by analysis of BCR Certified Reference Material No. 164 Anhydrous Milk Fat (Pocklington *et al.*, 1993).

RESULTS AND DISCUSSION

The precision and the accuracy of the used analytical method by analysing the BCR Certified Reference Material No. 164 Anhydrous Milk Fat (Pocklington *et al.*, 1993) is shown in Table 1.

Table 1. Results for fatty acid profile in the BCR Certified Reference Material No. 164 Anhydrous Milk Fat

Fatty acid (g/100g of the total fatty acids)	Certified value (n=36) ± uncertainty	Analytical results (n=6) ± standard deviation
C 14:0	10.79 ± 0.35	10.28 ± 0.57
C 16:0	26.58 ± 0.84	26.14 ± 1.17
C 18:0	10.51 ± 0.40	10.10 ± 0.79
C 18:1	24.82 ± 0.61	25.99 ± 1.74
C 18:2	2.68 ± 0.40	2.43 ± 0.15
C 18:3 (n-3)	0.51 ± 0.04	0.67 ± 0.05

Table 2. Fatty acid composition (relative percentage of the total FAs - wt % and g FA/100g edible portion) obtained in Edam, Gouda and Emmental cheese samples (45% fat in dry matter) of different producers

Fatty acid	TYPE OF CHEESE								
	Emmental (4) ^s (29.9% fat)			Edam (6) ^s (27.3% fat)			Gouda (6) ^s (28.1% fat)		
	(wt %)		g/100 g	(wt %)		g/100 g	(wt %)		g/100 g
Abbreviations	Mean	SD		Mean	SD		Mean	SD	
12:0	1.84	0.31	0.52	2.03	0.46	0.52	2.24	0.42	0.59
13:0	0.06	0.01	0.02	0.07	0.01	0.02	0.07	0.01	0.02
14:0	8.55	0.53	2.41	8.87	0.73	2.28	9.41	0.57	2.49
14:1,n-5	0.83	0.01	0.23	0.82	0.07	0.21	0.86	0.04	0.23
15:0	1.13	0.19	0.32	1.27	0.08	0.33	1.26	0.10	0.33
15:1,n-5	<0.01*		<0.01*	<0.01*		<0.01*	<0.01*		<0.01*
16:0	28.64	0.27	8.08	27.87	0.98	7.18	28.42	0.46	7.54
16:1,n-7 cis + 16:1,n-7 trans	1.88	0.15	0.53	1.78	0.12	0.46	1.80	0.08	0.48
17:0	1.06	0.04	0.30	1.06	0.05	0.27	1.02	0.04	0.27
17:1,n-7	0.49	0.01	0.14	0.49	0.02	0.13	0.47	0.04	0.12
18:0	14.98	0.51	4.23	14.86	0.87	3.83	14.54	1.17	3.86
18:1,n-9 cis + 18:1,n-9 trans	31.06	0.89	8.76	31.19	1.13	8.03	30.32	1.00	8.04
18:2,n-6 cis-+ 18:2,n-6 trans/trans	2.31	0.06	0.65	2.40	0.13	0.62	2.34	0.11	0.62
18:3,n-6	0.06	0.01	0.02	0.09	0.04	0.02	0.08	0.04	0.02
18:3,n-3	1.01	0.17	0.28	1.09	0.20	0.28	1.07	0.08	0.28
18:4,n-3	1.40	0.24	0.39	1.65	0.41	0.43	1.61	0.11	0.43
20:0	0.42	0.05	0.12	0.45	0.06	0.12	0.41	0.03	0.11
20:1,n-9	<0.01*		<0.01*	<0.01*		<0.01*	<0.01*		<0.01*
20:2,n-6	0.05	0.03	0.01	0.04	0.03	0.01	0.06	0.04	0.02
20:3,n-6	0.10	0.01	0.03	0.10	0.01	0.03	0.09	0.01	0.02
20:4,n-6	0.19	0.01	0.05	0.20	0.01	0.05	0.19	0.01	0.05
20:3,n-3	0.04	0.01	0.01	0.05	0.01	0.01	0.04	0.01	0.01
20:5,n-3	<0.01*		<0.01*	<0.01*		<0.01*	<0.01*		<0.01*
22:0	0.12	0.01	0.03	0.14	0.02	0.04	0.12	0.02	0.03
22:1,n-9	<0.01*		<0.01*	<0.01*		<0.01*	<0.01*		<0.01*
22:2,n-6	0.07	0.04	0.02	0.04	0.04	0.01	0.06	0.03	0.02
22:6,n-3	0.07	0.01	0.02	0.08	0.02	0.02	0.10	0.06	0.03
24:1,n-9	<0.01*		<0.01*	<0.01*		<0.01*	<0.01*		<0.01*
Total SATFA	56.80		16.03	56.62		14.59	57.49		15.24
Total MUFA	34.26		9.66	34.28		8.83	33.45		8.87
Total PUFA	5.30		1.48	5.74		1.48	5.64		1.50
Total n-3 PUFA	2.52		0.70	2.87		0.74	2.82		0.75
Total n-6 PUFA	2.78		0.78	2.87		0.74	2.82		0.75

^s number of samples; * under detection limit which is 0.01 wt % of the total FAME-s

Table 3. Literature data on fatty acid composition of Edam, Emmental and Gouda cheese

Literature source	Kunachowicz <i>et al.</i> (1998)			Souci <i>et al.</i> (1994)		
	g/100g edible portion			g/100g edible portion (45% fat in dry matter)		
	Edam (23% fat)	Emmental (29.7% fat)	Gouda (22.9% fat)	Edam	Emmental	Gouda
Butyric acid (4:0)	0.71	0.90	0.70	1.040	1.150	1.060
Caproic acid (6:0)	0.45	0.56	0.44	0.480	0.510	0.680
Caprylic acid (8:0)	0.26	0.33	0.26	0.310	0.300	0.460
Capric acid (10:0)	0.62	0.78	0.60	0.610	0.650	0.980
Lauric acid (12:0)	0.78	0.98	0.76	0.520	0.540	1.290
Myristic acid (14:0)	2.48	3.15	2.42	3.050	3.190	3.230
Palmitic acid (16:0)	5.75	7.30	5.63	8.370	8.140	7.290
Palmitoleic acid (16:1,n-7)	0.59	0.75	0.58	0.840	0.920	0.950
Stearic acid (18:0)	2.48	3.15	2.42	3.090	3.390	3.110
Oleic acid (18:1,n-9)	6.15	7.80	6.02	7.160	6.290	6.800
Linoleic acid (18:2,n-6)	0.31	0.40	0.30	0.440	0.650	0.280
Gamma Linolenic acid (GLA) (18:3,n-6)				0.260	0.370	0.420
Alpha linolenic acid (ALA) (18:3,n-3)	0.33	0.42	0.32			
Arachidonic acid (AA) (20:4,n-6)	0.00	0.00	0.00		0.028	
Total SAT	13.99	17.74	13.69			
Total MUFA	7.45	9.45	7.30			
Total PUFA	0.64	0.82	0.62			

Table 4. Literature data on fatty acid composition of Edam, Emmental and Gouda cheese.

Literature source	Chow (1992)					
	Edam 28.8% fat		Swiss Emmental 24.8% fat		Gouda 24.8% fat	
	Wt %	g/100 g	wt %	g/100 g	wt %	g/100 g
Butyric acid (4:0)	3.96	1.00	5.85	1.45	5.54	1.52
Caproic acid (6:0)	1.82	0.46	2.03	0.50	2.14	0.59
Caprylic acid (8:0)	1.19	0.30	1.30	0.32	1.38	0.38
Capric acid (10:0)	2.34	0.59	2.88	0.71	3.13	0.86
Lauric acid (12:0)	1.98	0.50	3.24	0.80	3.74	1.02
Myristic acid (14:0)	11.65	2.94	10.62	2.63	10.94	3.99
Palmitic acid (16:0)	31.99	8.07	26.91	6.67	26.28	9.59
Palmitoleic acid (16:1,n-7)	3.21	0.81	2.65	0.66	2.65	1.02
Stearic acid (18:0)	11.81	2.98	9.56	2.37	9.78	3.57
Oleic acid (18:1,n-9)	24.34 3.05(18:1t)	6.14 0.77(18:1t)	19.61 3.00(18:1t)	4.86 0.74 (18:1t)	22.41 3.01 (18:1t)	5.43 0.73 (18:1t)
Linoleic acid (18:2,n-6)	1.66	0.42	2.13	0.53	2.18	0.60
Gamma Linolenic acid (GLA) (18:3,n-6)						
Alpha linolenic acid (ALA) (18:3,n-3)	0.99	0.25	1.14	0.28	1.25	0.34
Arachidonic acid (AA) (20:4,n-6)						
Total SAT	66.75*	16.84*	63.39*	15.72*	62.93*	17.24*
Total MUFA	30.60**	7.72**	25.26**	6.26**	25.39**	6.26**
Total PUFA	2.66***	0.67***	3.27***	0.81***	3.43***	0.93***

*(4:0+6:0+8:0+10:0+12:0+14:0+16:0+18:0)

** (16:1+18:1+18:1t)

*** (18:2+18:3 - at least 90% ω-3)

Proper sampling of cheese, sample storage, and preparation are of crucial importance for successful analysis. We achieved it by the procedure described by AOAC (1997).

GC analysis gave a very reproducible separation of FAME-s from cheese samples.

The repeatability was tested by injecting the FAME-s of one sample four times in one day. The coefficient of variation was as stated below:

< 2% for fatty acids with wt % > 10%,

< 9% for fatty acids with wt % < 3%,

<10% for fatty acids with wt % < 0.5%.

Fatty acid composition (wt % of the acid and g FA /100g) of the same type of cheese depended neither on the producer nor on the geographical region. Therefore, the fatty acid composition of the same type of cheese is presented as an average composition of all collected and analysed samples (Table 2).

The results of analysis of fatty acid composition obtained in our laboratory are in good accordance with data in literature (Table 3, Table 4).

CONCLUSIONS

The above shown results of fatty acid composition of Edam, Gouda and Emmental cheese produced in Slovenia in autumn 1997 agree well with data in literature and are - to the best of our knowledge - the first published in Slovenia.

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POVZETEK

V našem delu smo določili maščobno-kislinsko sestavo treh različnih tipov sira -edamca, ementalca in gavde, proizvedenih v Sloveniji jeseni 1997. Analizirali smo edamca in gavdo treh ter ementalca dveh različnih proizvajalcev. Vse vzorce smo kupili jeseni 1997 na slovenskem tržišču in sicer dvakrat v času treh mesecev. Metilne estre maščobnih kislin (FAME-s) smo pripravili z metodo *in situ* transesterifikacija (ISTE). Maščobno-kislinsko sestavo smo določili s plinsko kromatografijo. Vsi rezultati so podani kot utežni odstotek posamezne kisline glede na skupne maščobne kisline (ut. %) in kot g posamezne kisline v 100 g jedilne količine sira. Povprečna vsebnost skupnih nasičenih kislin (SAT) v ementalcu je bila 56,80% (16,03 g/100g sira), v edamcu 56,62 (14,59 g/100g sira) in v gavdi 57,49% (15,24 g/100g sira). Povprečna vsebnost skupnih enkrat nenasičenih kislin (MUFA) v ementalcu je bila 34,26% (9,66 g/100g sira), v edamcu 34,28% (8,83 g/100g sira) in v gavdi 33,45% (8,87 g/100g sira). Povprečna vsebnost skupnih večkrat nenasičenih kislin (PUFA) v ementalcu je bila 5,30% (1,48 g/100g sira), v edamcu 5,74% (1,48 g/100g sira) in v gavdi 5,64% (1,50 g/100g sira). Povprečna vsebnost skupnih omega-3 in omega-6 kislin v ementalcu je bila 2,52% n-3 in 2,78% n-6 (0,70 g n-3 /100g sira in 0,78 g n-6 /100g sira), v edamcu 2,87% n-3 in 2,87% n-6 (0,74 g n-3 /100g sira in 0,74 g n-6 /100g sira) ter 2,82% n-3 in 2,82% n-6 (0,75 g n-3 /100g sira in 0,75 g n-6 /100g sira) v gavdi. Med analiziranimi različnimi vrstami sira nismo našli bistvene razlike glede na maščobno-kislinsko sestavo (ut. %). Maščobno-kislinska sestava analiziranih slovenskih sirov se dobro ujema s podatki iz drugih držav.

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