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THE EFFECT OF FRESH AND CONSERVED FEED ON THE QUALITY OF ANIMAL PRODUCTS

DJELOVANJE SVJEŽEG I KONZERVIRANOG KRMIVA NA KAKVOĆU ŽIVOTINJSKIH PROIZVODA

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Scientific review - Pregledno znanstveni članak
UDC: 636.085.7
Received - Primljeno: 20.may-svibanj 2000.

SUMMARY

This paper concerns the effects of fresh and preserved feed on the quality of animal products. The importance and the influences on the content of saturated, unsaturated and trans fatty acids and content of conjugated linoleic acid in milk, egg and meat fat are reviewed.

INTRODUCTION

The animal breeding food production is rather expensive and the products are distinguished by its special quality. The quality of foodstuffs is very complex and encompasses at least five objective points strongly linked together. However, there are even more subjective factors. The five objective points are:

1. nutritional value
2. hygienic quality
3. sensoric quality
4. quality of production
5. market quality

All the five quality factors are influenced by the quality of animal nutrition. In our case only one of these factors, the nutritional value, shall be given considerable attention. We shall limit ourselves only to on the discussion of the influence of fresh and conserved feed on the nutritional value of some animal products. This concerns the nutritional and/or physiological suitability of foodstuffs for meeting the nutritional requirements for essential nutrients for the consumer. It also includes their influence on the consumer's health.

In the recent years, the quality of foodstuffs of animal products has been judged very critically and even rejected on the part of consumers from the point of view of health. The reason for this lies in the health awareness on the part of the consumers and their interest in food production, as well as inadequate or incorrect information concerning food products and its influence on health. Accusations against the quality of foodstuffs of animal origin are made mainly because of the fraction of fats in them, fatty acid composition and the cholesterol content.

Namely, it is known that many fats, some saturated fatty acids and cholesterol found in greater or smaller amount or fractions in the feedstuffs of animal product, increase the level of cholesterol in the blood. The prevalence of heart diseases and coronary artery diseases is closely linked to the concentration of cholesterol in the blood.

For health reasons animal production in all the developed countries strives for the preparation of meat, milk and eggs, which would contain the least cholesterol and fats whit, a more favourable fatty acid composition.

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With regard to the above two tasks it is easier to influence the amount of fat in the animal products. It is possible to reduce the fat percentage in animals by carefully selecting the animal and applying the suitable nutrition. In Slovenia, the preparation of low-fat meat has been a very long tradition. The proportion of fat originating from meat in the diet of a Slovenian is much lower than in the USA, where meat, especially beef, has traditionally been more greasy.

The level of cholesterol in blood is influenced by the cholesterol found in the consumed food. However, this influence is comparatively small. Keys et. al. (1965) have established that, for example, reducing the consumption of cholesterol from 1050 mg/d to 450 mg/d (daily intake of 3000 kcal) reduces the level of cholesterol in the serum by 9 mg/100 ml. Even more important is the influence of individual fatty acids on the concentration of cholesterol in the blood. It is generally believed that saturated fatty acids increase the amount of cholesterol and unsaturated fatty acids reduce it. In addition, it is important to point out the influence on HDL cholesterol. Its concentration in the blood should be the highest possible. Katan et al. (1993) (cit. according to FAO, 1994) have studied and summarised the results of numerous researches on the influence of individual fatty acids on cholesterol in the blood. This summary illustrates that saturated fatty acids (lauric, myristic, palmitic) increase the level of cholesterol in the blood, as well as the amount of the favourable HDL cholesterol. Trans unsaturated fatty acids increase total and LDL cholesterol but reduce HDL cholesterol. Nevertheless, mono- and polyunsaturated fatty acids reduce the total and LDL cholesterol in the blood and increase HDL. The amount of cholesterol in the blood is also reduced by the stearic acid. Therefore, the atherogenic fatty acids (those which increase the level of cholesterol in the blood) include lauric and myristic acid which increase most the level of cholesterol), palmitic acid and trans fatty acids. The quality of animal fats variables greatly with regard to fatty acid composition. The amount of saturated fatty acids is considerable in all animal fats, especially in milk fats. The fatty acid composition of animal fats is one of the fundamental criteria in determining the quality of feedstuffs of animal origin.

Animal nutrition, especially the fatty acid composition of the feed, plays a major role in the composition of fatty acids in animal fats. .Regarding non-ruminants, the quality of fats in animal products (fats in the fat and muscle tissues, eggs) can be greatly influenced by changing the fatty acid composition of fats in the feed. In ruminants, however, the influence of nutritive fats is less distinct because of the microbiological hydration of the double bonds of fatty acids in the rumen. However, it is even more important from different aspects.

Omega-3 fatty acids are believed to have very important properties: antiatherogenic, antiflamatory, antitrombogenic, antihypertensive, antilipidaemic. In good human diet the omega-3 fatty acids should represent 20% of the total essential fatty acids. The proportion of omega-3 fatty acids is especially high in fish fats (oils). In small quantities they are also found in eggs, meat and milk.

It is often neglected that forage also contains certain amount of fats, which can greatly influence the quality of animal products. The quality of forage is influenced by the preservation. The effect of forage preservation on the fat quality has so far not been analysed in depth.

Table 1 shows some data on the fatty acid composition of hay, grass, and some types of vegetables. As shown in the table the particularity of pasture lies in the fact that it is very rich in polyunsaturated fatty acids, especially α-linolenic acid (in grass more than 50% of all fatty acids). According to the presented data, the proportion of α-linolenic acid in hay is half lower (Mathes et al., 1996). The data should be interpreted with some reservation since the phase of conservation is not stated. It is known that polyunsaturated fatty acids are very sensitive to oxygen and light and therefore their fraction in hay diminishes with time. Thus the fatty acid composition of animal product is less influenced by hay feeding compared to fresh grass feeding.

Table 1. Fatty acid composition (as percentage of total fatty acids) in hay, fresh grass and vegetables
Tablica 1. Sastav masne kiseline (kao postotak ukupnih masnih kiselina) u sijenu, svježoj travi i povrću

Fatty acid Masna kiselina	Hay[1] Sijeno	Grass[1] Trava	Grass[2] Trava	Spinach[3] Špinat	Cabbage[3] Zelje	Broccoli[3] Prokulica	Lettuce[3] Zelena salata
Palmitic (16:0) Palmitinska	29.01	13.62	18.52	16.22	16.42	18.90	12.75
Palmitoleic (16:1n-7) Palmitoleinska	1.67	1.34	0.42	3.82	3.66	2.72	3.76
Stearic (18:0) Stearinska	3.16	1.66	2.40	0.99	2.87	2.70	1.27
Oleic (18:1-n9) Oleinska	5.81	1.89	11.13	3.41	5.81	5.14	1.01
Linoleic (18:2-n6) Linolna	29.08	18.72	14.06	13.97	25.24	18.13	13.51
Linolenic (18:3-n3) Linoleinska	27.89	55.78	53.46	61.57	45.99	52.37	63.70
ω-3/ω-6	1.04	2.98	3.80	4.41	1.81	2.89	5.01
ω-3 from (ω-3 + ω-6), %	48.90	74.90	79.17	81.50	64.6	74.30	83.40

[1]Mathes et al., 1996., [2] Lopez-Botez et al. 1998, [3] Hwang, 1992.

INFLUENCE OF FRESH AND PRESERVED FEED ON THE QUALITY OF ANIMAL PRODUCTS IN NON-RUMINANTS

It has been demonstrated in many researches (Otten et al., 1993, Specht-Overholt et al., 1997) that in pigs the influence of nutrition on the fatty acid composition and proportion of desired fatty acids in meat is very strong. The use of fresh green feed, rich in polyunsaturated fatty acids, could favourably influence the fatty acid composition. However under intensive pig production conditions, this is not feasible. Only in conditions of outdoor pig breeding with the access to fresh green feed the positive effect of the feed fatt acid composition on the quality of the meat and bacon could be expected. However, there are still no research data available. In the feed of non-ruminants hay is practically not used with the exception of dehydrated alfalfa, clover and grass. Yet Wenk and Prabucki (1990) found a great influence of these feeds on the quality of fat tissue (fatty acid composition), although in literature these data have not been traced yet. The addition of alfalfa, clover and grass meal to such feeds for layers as a source of carotenoids for a better yolk colour, undoubtedly favourably influences as well the fatty acid composition of egg fat. This belief needs to be proven.

In literature, there are several data on fatty acid composition of eggs of hens with the access to green feed. Data gathered in Table 2 show that it is possible to influence the fatty acid composition through nutrition. Feed rich in omega-3 fatty acids greatly increases the proportion of these acids in eggs (Stibilj and Koman-Rajšp, 1997). The proportion of omega-3 fatty acids in eggs is increased most remarkably when adding fish oil (Stibilj and Koman-Rajšp, 1997), less so with supplementing the standard feed mixture with green feed (Lopez-Bote et al., 1998) but not at all in free range breeding with no access to green feed (Scharf and Elmadfa, 1998). The omega-3 fatty acid content a very useful indicator of whether the hens are fed on pasture.

Table 2. The effect of breeding method and nutrition of layers on content of nutritionally important fatty acids in eggs

Tablica 2. Djelovanje načina uzgoja i hranidbe nesilica na sadržaj hranidbeno važnih masnih kiselina u jajima.

	Battery breeding[1] (Jata Reja) Uzgoj u kavezima		Experimental comparison[2] Pokusna usporedba		Comparison of market eggs[3] Usporedba jaja na tržištu		
Faty acid - Masna kiselina	Usual feed Uobičajena krma	ω-3 rich feed Krma obogaćena s ω-3	Battery breeding, usual feed Baterijski uzgoj, uobičajena krma	Free range, grass+feed mixtu. Slobodno držanje, travnata smjesa	Battery breeding Baterijski uzgoj	Free-range, summer Slobodno držanje, ljeti	Free-range, winter Slobodno držanje, zimi
Palmitic acid	21.7	21.4	24.0	27.0	22.8	21.6	21.0
Palmitoleic acid (16:1n-7)	3.6	3.3	2.3	2.7	2.3	1.8	2.1
Stearic acid (18:09	9.8	8.8	13.1	14.1	8.6	8.5	7.5
Oleic acid (18:1-n9)	43.9	41.3	36.0	36.9	39.7	39.6	37.2
Linoleic acid (18:2-n6)	14.9	16.1	18.7	12.0	13.4	14.4	14.6
Linolenic acid (18:3-n3)	0.52	1.73	0.39	0.99	0.12	0.11	0.10
Arahidonic (20:4n-6)	2.6	1.3	2.1	2.0	0.13	0.11	0.13
Eikosapentaenic (20:5n-3)	<0.01	0.29	0.02	0.15	1.70	1.90	1.50
Dokosahexsaenic (22:6n-3)	1.34	4.13	0.62	1.57	0.69	0.89	0.76

[1] Stibilj and Koman-Rajšp, 1997, [2] Lopez-Bote et al, 1998, [3] Scharf and Elmadfa, 1998

THE INFLUENCE OF FRESH AND PRESERVED FEED ON THE QUALITY OF ANIMAL PRODUCTS IN RUMINANTS

Fresh and preserved forage feeds are standard feeds for ruminants, where the influence of forage feeds on the quality of animal products is most interesting and has been thoroughly investigated.

It is well known that fresh and green preserved feeds influence the quality of milk fats. Recently, the influence on the quality of meat has been given more attention. First observed influence of fresh vs. preserved feeds is the influence on the consistency of milk fats, or rather, the spreading of butter. It is known that butter in winter is not as soft and spreadable as in summer and can sometimes even be too soft. The spreadability of butter depends on the fatty acid composition. The more unsaturated fatty acids it contains, the better it spreads. Whereas the increase in saturated fatty acids reduces the spreadability (Schöne et al., 1998).

The measure for the amount of unsaturated fatty acids is the iodine number of milk fat which throughout the year alters due to the variations in nutrition as shown in Figure 1 (Kirchgessner et al., 1965). Figure 1 indirectly shows that the amount of unsaturated fatty acids in hay and silage used in winter is smaller than in pasture.

Of all animal fats milk fats are the tastiest from the atherogenic aspect, however, they have the most unfavourable fatty acid composition. Figure 2 shows the comparison of the typical and ideal fatty acid profile of milk fat (Grummer, 1990).

Figure 1. The changes in iodine number of milk fat throughout the year (Kirschgessner et al., 1965)
Slika 1. Promjene jodnog broja u masnoći mlijeka tijekom godine (Kirchgessner i sur., 1965.)

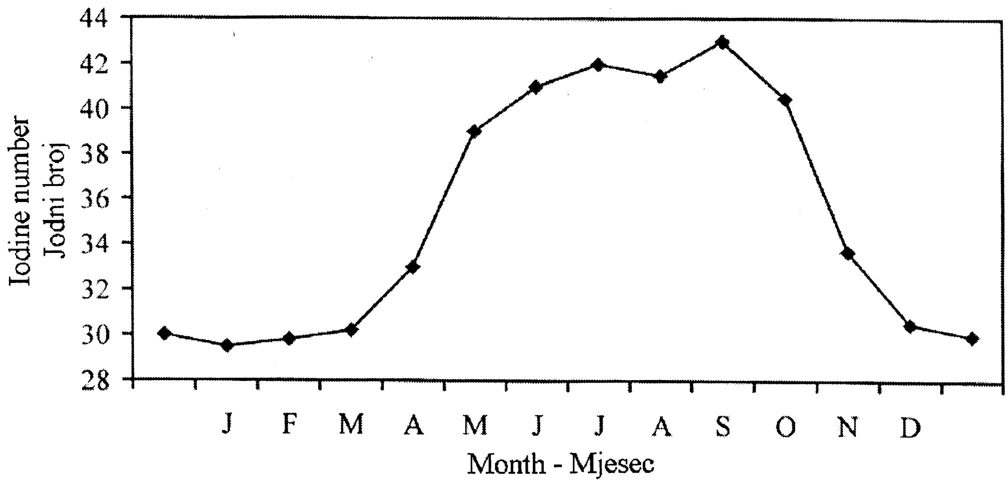
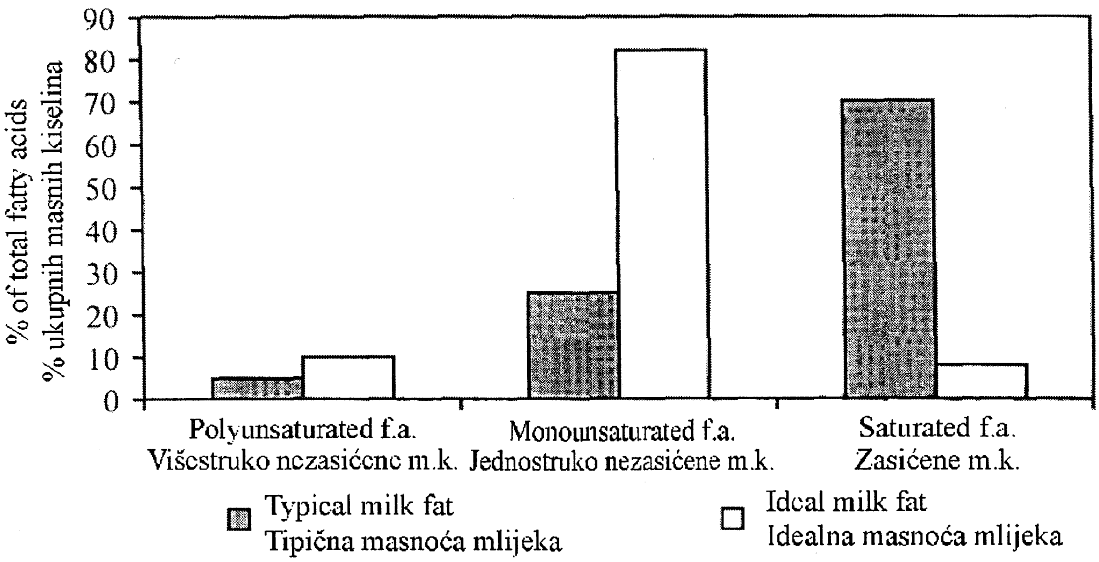


Figure 2. A comparison of the typical and ideal fatty acid profile of milk fat (Grummer, 1990)
Slika 2. Usporedba tipičnog i idealnog profila masne kiseline u masnoći mlijeka (Grummer, 1990).



Fats with a greater iodine number have a more favourable fatty acid profile, since the amount of oleic and polyunsaturated fatty acids is greater. The fatty acid profile is improved by feeding the animals with fresh pasture. It is possible to attain an even greater effect by adding oilseeds to polyunsaturated fatty acids. As shown in the research carried out by Jahreis et al. (1996) the addition of rapeseed or oil rich rapeseed cakes decreased the amount of atherogenic fatty acids (lauric, myristic and palmitic) by 18%, increased the amount of oleic acid by 47% and yet concurrently increased the amount of trans fatty acids by 47%.

Experiences and researches in Switzerland show that fatty acids of green feeds are also, important for the quality of cheese. Sollberger and

Jan (1997) established that the quality of cheese was best in summer because of the greater amount of unsaturated fatty acids, and could be improved in winter by adding oilseeds (especially sunflower seeds).

Concerning the fatty acids the publications on the amount and effects of conjugated linoleic acid has lately drawn ample attention. The fat (milk and body) of ruminants is rich on conjugated linoleic acid. Pariza et al. (Cit. In Pariza and Ha, 1990) discovered a substance in the extracts of roasted beef inhibiting the activity of mutagenic substances. Later on, it was demonstrated that this substance was a conjugated dien derivate of linoleic acid, in other words, conjugated linoleic acid. It carries a very strong anticancerogenous activity (Pariza and Ha, 1990; Belury, 1995; Parodi, 1997). Conjugated linoleic acid shows its anticancerogenous activity already in relatively small concentrations, that is in less than one percent of food. The activity does not depend on the presence, or rather, the combination of other fatty acids in the food.

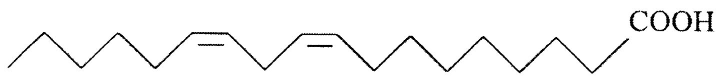
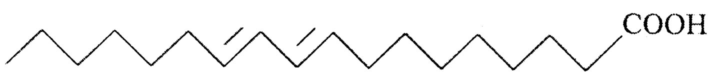
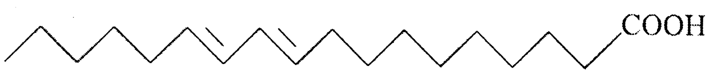
According to the researches carried out on rabbits (Li et al., 1994) conjugated linoleic acid has antiatherogenous properties. Interestingly, it also influences the metabolism of fats. Park et al. (1997) show that in testing animals it reduces the amount of body fats.

The intake of conjugated linoleic acid is practically totally dependent on the intake of fats of ruminants, especially milk. It is illustrated in the research by Fritsche and Steinhart (1988) that Germans consume a good amount of conjugated linoleic acid with milk and milk product: women 0.24 g out of 0.35 g/day, men 0.28 g out of 0.43 g/day.

As previously mentioned, conjugated linoleic acid includes dien derivates of linoleic acids (positional and geometrical isomers). Structures are shown im Figure 3.

The awareness of the importance of the conjugated linoleic acid is increasing with the research. A question is being asked, whether its proportion in the fats of ruminants can be increased by appropriate feeding.

Figure 3. A comparison of the chemical structure of linoleic acid and conjugated linoleic acid (Jahreis, 1997)
Slika 3. Usporedba kemijske strukture linolne kiseline i konjugirane linolne kiseline (Jahreis, 1997.)

Fatty acid - Masna kiselina	Positional isomer - Pozicijski izomer	Geometrical isomer in vivo Geometrijski izomer in vivo
Linoleic acid - Linolna kiselina		
	 10,12-octadecadienoic acid	c9, c12
Conjugated linoleic acid - Konjugirana linolna kiserlina		
	 9,11-octadecadienoic acid	c9, t11 t9, c11
	 10,12-octadecadienoic acid	insignificant part beznačajan dio

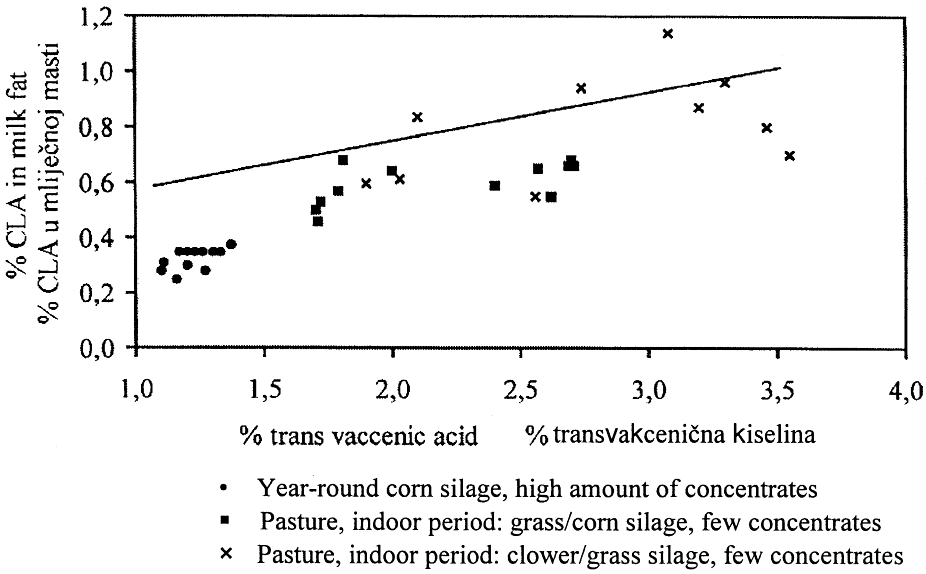
The conjugated linoleic acid results from biological hydration of fatty acids by the ruminal bacteria hematically shown in Figure 4. As clearly shown the biohydrogenation products of biological vs. industrial greatly differ. In the process of hydrogenation in the rumen more conjugated linoleic acid is produced than in the process of industrial hydrogenation, where an insignificant amount is produced.

Besides the desired conjugated linoleic acid, undesired trans fatty acids are produced by the hydrogenation in the rumen; most of them are trans vaccenic acid (fats of ruminants) and by industrial hydration ellagic acid (margarine) is produced. However, between these two trans fatty acids an essential biological difference exists. In epidemiological research, the intake of ellagic acid demonstrated a positive correlation with the frequency of heart and coronary diseases, whereas the trans vaccenic acid did not demonstrate this correlation (Aro et al., 1995). From Figure 5, it is clear that the regression between the production of trans vaccenic and conjugated linoleic acid is positive and linear.

Figure 4. Synthesis of conjugateg linoleic acid by rumen bacteria (Jahreis, 1997)
Slika 4. Sinteza konjugirane linolne kiseline bakterijama u buragu (Jahreis, 1997.)

Figure 5. **Regression between the percentage of conjugated linoleic acid (CLA) and trans vaccenic acid in milk fat of dairy cows fed on three different diets (Jahreis, 1997)**

Slika 5. **Regresija između postotka konjugirane linolne kiseline (CLA) i transvakcenične kiseline u masnoći mlijeka mliječnih krava hranjenih različitim obrocima (Jahreis, 1997.)**



The proportion of the conjugated linoleic acid in the milk fat is dependent on the cow nutrition. There is a huge difference when feeding fresh compared to conserved feed. As Figure 6 demonstrates the amount of conjugated linoleic acid in milk fats is greatest when cows weren pasture. Whereas in winter, the proportion is greater if the use of concentrates are low.

Figure 6. **Fluctuations of the content of conjugated linoleic acid (CLA) during the year expressed in percentage of total fatty acids in milk cows fed on two different diets (Jahreis, 1997)**

Slika 6. **Fluktuacija/kolebanje sadržaja konjugirane linolne kiseline (CLA) tijekom godine izražena postotkom ukupnih masnih kiselina u mliječnih krava hranjenih s dva različita obroka (Jahreis, 1997.)**

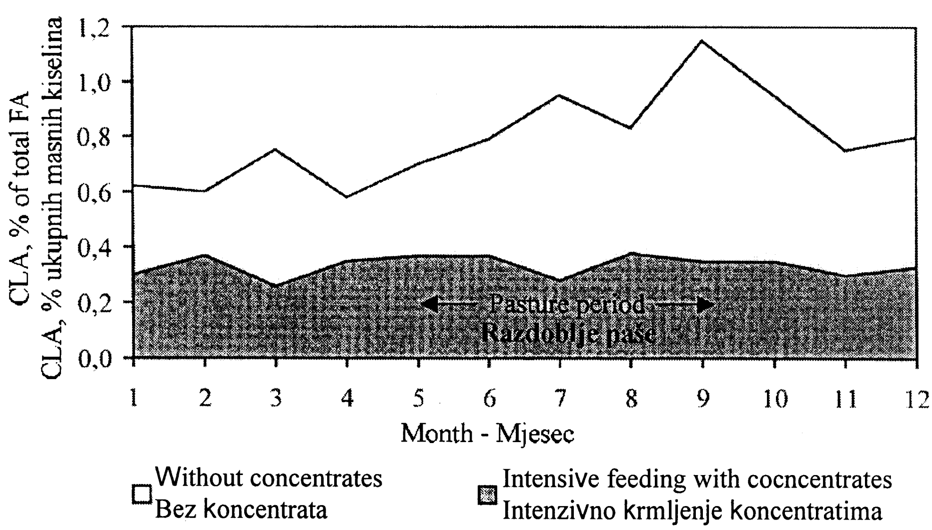


Table 3. Year mean percentage of trans fatty acids in milk fat of cows fed on different feeding regimes (weight percentage of total methyl esters) (Jahreis 1997)

Tablica 3. Godišnji srednji postotak trans masnih kiselina u masnoći mlijeka krava hranjenih prema dva različita režima hranjenja (težinski postotak ukupnih metil estera) (Jahreis, 1997.)

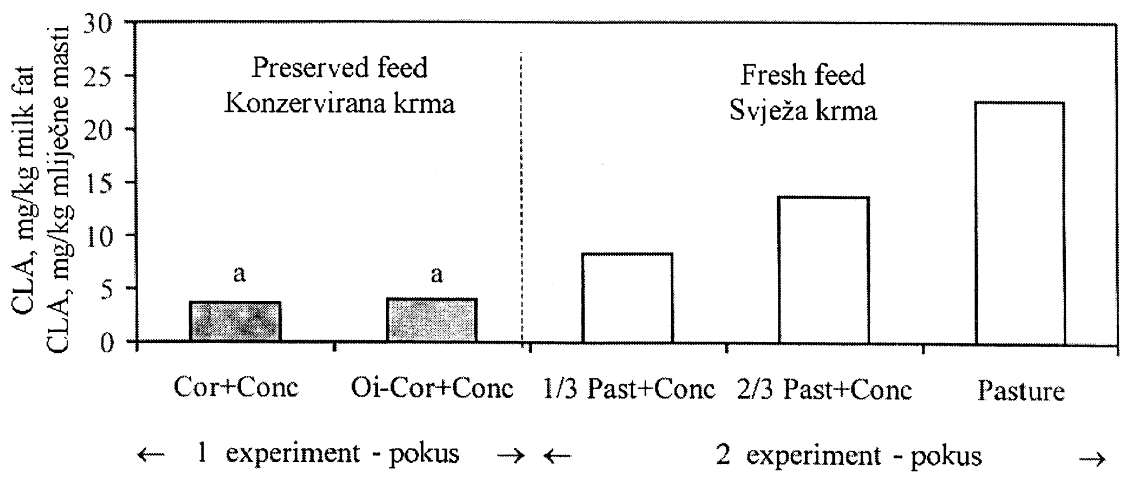
Trans fatty acids Trans masne kiseline	Whole year corn silage, a lot of concentrates Cijela godina silaža, dio koncentrati	Pasture, indoor period: gras/corn silage, few concentrated Paša, unutarnje razdoblje: trava/kukuruzna silaža, malo koncentrata	Pasture, indoor period: clover/grass silage, concentrates few concentrates Paša, unutarnje razdoblje: djetelinasko travna silaža, malo koncentrata
C14:1 t9	$0.24^{b}\pm0.02$	$0.29^{a}\pm0.03$	$0.32^{c}\pm0.04$
C16:1 t7	$0.05^{a}\pm0.00$	$0.06^{a}\pm0.01$	$0.06^{a}\pm0.01$
C16:1 t9	$0.36^{b}\pm0.02$	$0.46^{a}\pm0.03$	$0.43^{a}\pm0.04$
C18:1 t9	$0.32^{a}\pm0.03$	$0.33^{a}\pm0.03$	$0.37^{b}\pm0.04$
C18:1 t11	$1.21^{b}\pm0.08$	$2.21^{a}\pm0.43$	$2.67^{c}\pm0.64$
C18:1c14+t16	$0.28^{a}\pm0.03$	$0.32^{a}\pm0.03$	$0.39^{b}\pm0.11$
C18:2 t9, 12+18:1c16	$0.28^{a}\pm0.03$	$0.24^{a}\pm0.04$	$0.31^{b}\pm0.07$
C18:2 c9, t12	$0.18^{b}\pm0.02$	$0.11^{a}\pm0.03$	$0.13^{a}\pm0.04$
C18:2 t9, c12	$0.06^{a}\pm0.02$	$0.10^{a}\pm0.02$	$0.30^{b}\pm0.07$
C18:2 c9, t11+C18:2 t9, c11	$0.34^{b}\pm0.04$	$0.61^{a}\pm0.08$	$0.80^{c}\pm0.17$

[a,b,c] Different letters indicate significant differences (P<0,05)

[a,b,c] Različita slova označavaju značajnost razlika (P<0,05)

Figure 7. The content of conjugated linoleic acid (CLA) expressed in percentages of milk fats in cows fed different diets. Experiment 1: corn silage and concentrate (Cor+Conc), high oil corn silage and concentrate (O-Cor+Conc). Experiment 2: 1/3 pasture and concentrate (1/3 Past+Conc), 2/3 pasture and concentrate (2/3 Past+Conc), only pasture (Pasture) (Dhiman et al., 1996)

Slika 7. Sadržaj konjugirane linolne kiseline (CLA) izražen u postocima mliječne masnoće u krava hranjenih različitim obrocima. Pokus 1: silaža kukuruza i koncentrat (Cor+Conc), silaža kukuruza visokog sadržaja ulja i koncenetrat (O-Cor+Conc). Pokus 2: 1/3 paše i koncentrat (Past+Conc.), 2/3 paše i koncentrat (2/3 Past+Conc.), samo paša (Pasture) (Dhiman i sur., 1996.).



The influence of feed on the fatty acid profile of milk fats, including the amount of conjugated linoleic acid, is illustrated in more details in Table 3. It is clear that a higher percentage of conjugated linoleic acid, and also other trans fatty acids, are found in pasture and in diets with greater amounts of forage feed.

Dhiman et al. (1996) studied in more detail the influence preeserved and fresh feed on the conjugated linoleic acid content in the milk fats. The results are summerized in Figure 7, demonstrating that the amount of conjugated linoleic acid in milk fats is positively correlated with the amount of pasture.

Nutrition has an influence on the composition of body fats, or rather, meat of ruminants. However, there is still a lack of data concerning these influences. Results of Matthes et al. (1996) show that the meat of pasture fed lambs contains more omega-3 fatty acids and a more favourable relation between omega-6 and omega-3 fatty acids. Also Payne (1988) concludes that the meat of game and pasture fed ruminants is an important source of essential omega-3 fatty acid.

CONCLUSION

The quality of feed, fresh or preserved, influences the quality of animal products, particularly the fatty acid profile of fats in meat, milk and eggs. Currently milk and milk products are considered as foods with unfavourable fatty acid profile. The effect of animal nutrition on the fatty acid composition of milk fats, especially on the conjugated linoleic acid content, is becoming increasingly important, since conjugated linoleic acid has shown strong anticancerogenous activity and omega-3 fatty acids are believed to have very important properties: antiatherogenic, antiflamatory, antitrombogenic, antihypertensive, antilipidaemic. This fact and the possibility that the amount of conjugated linoleic acid in milk fats could increased by nutrition can lead to the reevaluation of milk and milk products in human nutrition.

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IZVADAK

Ovaj se članak bavi djelovanjem svježe i konzervirane hrane na kakvoću životinjskih proizvoda. Dat je pregled važnosti i utjecaja svježe i konzervirane hrane na sadržaj zasićenih, nezasićenih i trans masnih kiselina i sadržaj spojene linolne kiseline u mlijeku, jajima i masnoći mesa.