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THE EFFECT OF DIETARY FAT ON BROILER MEAT QUALITY

UTJECAJ MASTI IZ HRANE NA KAKVOĆU MESA BROJLERA

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ABSTRACT

The objective of these investigations was to examine the effect of polyunsaturated fatty acids (PUFA) originating from different sources (full-fat rape-seed and rape-seed oil) on performance and body composition in broilers and on their body fatty acid content. In the experiments 480 broilers (160 per treatment) were used. The diets were formulated taking into account the nutrient recommendations of the NRC (1994). In the first half of the rearing period (days 1 to 21) all livestock were given a diet of the same composition, while in the second half (days 22 to 42) three treatments were applied. The treatments differed in the source of the fat or fatty acid they contained (animal fat, full-fat rape seed or rape-seed oil) in such a way that the AME_n, crude protein, amino acid, calcium and phosphorus content of the diets remained the same. The data obtained indicate that the treatments had no effect ($P \geq 0.05$) on performance (feed intake, daily weight gain and feed conversion). While the treatments did not affect ($P \geq 0.05$) body content of dry matter, protein, fat or ash, significant changes ($P \leq 0.05$) were observed in the fatty acid composition of the body. It was established from the accumulation of data obtained that significant changes in body fatty acid composition can be caused by the unsaturated fatty acid content of diets, which can increase body PUFA content. With respect to nutrition physiology, it can be recommended that dietary fats with a high proportion of unsaturated fatty acids be used in order to enrich the energy content of broiler diets. However, it is considered necessary to note that the use of fatty acids in animal nutrition for such purposes should always be preceded by economic analyses.

Key words: Broiler, Dietary polyunsaturated fatty acids, meat quality.

INTRODUCTION

Meat quality is influenced by a very large number of factors: for example, the genotype of the livestock, the sex, age and health status of each animal, and also various environmental factors, such as stress, livestock transport, temperature of surroundings, humidity, housing of livestock, and nutrition. Experience indicates that, by means of nutrition, in a similar way to that observed with

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other environmental factors, meat quality can be influenced - not only in a positive way, but also in a way which undermines it.

Of the nutritional factors exerting an influence on meat quality, emphasis should be laid upon the technology and intensity of feeding and the quantity, quality and relative proportions of nutrients ingested, along with dietary energy source (carbohydrate, fat) and type of dietary fat. However, it is considered necessary to point out that additives of various chemical origins used in the nutrition of livestock and drugs used in an unprofessional way can also have an effect - in most cases, a harmful one - on meat quality.

In recent years, experiments carried out with omega-3 polyunsaturated fatty acids (PUFA) have become the focus of interest both in the field of animal nutrition and in that of research into human nutrition.

This is due to the results of clinical investigations, which demonstrate that consumption of these fatty acids eases, or alleviates completely, the symptoms of certain diseases (coronary heart complaints, psoriasis and certain types of inflammation) and improves the development of sight in both healthy and premature babies, the maintenance of healthy skin in adults, brain functions and the production of certain hormones (Barlow and Pike, 1991).

The omega-3 polyunsaturated fatty acids occur in significant quantities in fish oils. The results of a number of investigations demonstrate that, if the diet of fattening pigs or broiler chickens is supplemented with fish meal or fish oil, the quantity of long carbon chain omega-3 polyunsaturated fatty acids (e.g. eicosapentaenoic acid and docosahexaenoic acid) in the meat can be increased (Castell and Falk, 1980, Hulan et al., 1988, and 1989, Chanmugam et al., 1992, Cherian and Sim, 1992, Arbuckle et al., 1994).

However, a problematic issue is presented by the fact that feeding on a diet of more than 1% fish oil content can result in an undesirable taste effect when the meat is eaten (Gualtieri et al., 1993). In a number of European countries, consumer demand traditionally favours pig or broiler meat in preference to fish, and for this reason consumers react with more sensitivity to a 'fishy taste' in meat.

Linoleic acid in an omega-3 polyunsaturated fatty acid with a shorter carbon chain which occurs in significant quantities in vegetable oils such as rape-seed oil (Chanmugam et al., 1992). The 'double zero' types (low erucic acid and glucosinolate content) and low fibre content types of rape-seed can be put to effective use in the nutrition of poultry. Results obtained from research also indicate that, in some cases, the omega-3 fatty acid content of poultry meat may increase when rape-seed oil is included in the diet of livestock.

The objective of this paper is to demonstrate the effect of dietary polyunsaturated fatty acids on the performance of broilers and on the fatty acid composition of broiler meat.

2. MATERIAL AND METHOD

2.1. Animals and housing

The investigations were performed using 480 Arbor Acres broilers (50% cocks, 50% pullets), 160 being subjected to each treatment, with 5 replicates. The broilers were housed in groups in deep litter compartments (32 broilers per compartment).

2.2. Experimental arrangements and diets

In the first phase of the experiments (days 1 to 21 of life) all the broilers were given a diet of the same composition, the nutrient content of which corresponded to the recommendations of the NRC (1994). In the second phase (days 22 to 42) three treatments were applied. The experimental diets used in this phase, which had identical energy, crude protein and amino acid content, were also formulated on the basis of the recommendations of the NRC (1994). Fat of animal origin was used as an energy supplement in the diet for the first treatment, which was based on maize and soya bean. The diet used in the second treatment was enriched with 'double zero' full-fat rape-seed in a quantity equivalent to that of the fat supplement used in the first treatment, while 'double zero' rape-seed oil in an equivalent quantity was used in the third treatment. This oil was refined from the same batch of rape-seed as that used in the second treatment.

The composition and nutrient content of the experimental diets are shown in table 1.

Table 1. Composition and nutrient content of diets (g/kg) fed to broilers between 22 and 42 days of age (g/kg)
Tablica 1. Sastav i sadržaj hranjivih tvari (g/kg)) davanih brojlerima između 22. i 42. dana starosti (g/kg)

	Treatments[a] - Postupci		
Ingredients - Sastojci	I	II	III
Maize - Kukuruz	581.5	534.5	553.2
Soybean extr. sol – Sojina sačma	312.8	295.0	346.0
Animal fat - Životinjska mast	65.5	0.0	0.0
Full-fat rape-seed - Punomasno sjeme repice	0.0	134.0	0.0
Rape-seed oil - Ulje repice	0.0	0.0	61.5
Others[b] - Ostalo[b]	40.2	36.5	39.3
Total - Ukupno:	1000.0	1000.0	1000.0
Nutrient content - Sadržaj hranjivih tvari			
AMEn (MJ/kg)	13.4	13.4	13.4
Crude protein - Sirove bjelančevine	197.0	196.0	198.0
Crude fat - Sirova mast	100.0	101.0	104.0
Lysine - Lizin	11.4	11.4	11.4
Methionine+Cystine[c] - Metionin + cistin	9.3	9.3	9.3
Calcium - Kalcij	8.9	8.7	8.8
Phosphorus - Fosfor	6.1	6.2	6.2
Fatty acids (methyl ester %) - Masne kiseline			
Palmitic acid (16:) - Palmitinska kiselina	21.2	8.7	8.2
Palmitoleicacid (16:1) - Palmitoleinska kiselina	2.6	0.4	0.2
Margaric acid (17:0) - Margarinska kiselina	0.3	0. 1	0. 1
Stearic acid (18:0) - Stearinska kiselina	7.7	2.4	2.0
Oleic acid (18:1) - Oleinska kiselina	44.8	53.0	50.4
Linoleic acid (18:2ω6) - Linolenska kiselina	20.4	28.5	30.3
Arachidic acid (20:0) - Arahidonska kiselina	0.3	0.5	0.6
Eicosanoic acid (20:1) - Eikosonoična kiselina	1.0	0.8	1.1
Linolenic acid (18:3 cω3) - Linolenska kiselina	0.8	5.1	5.1
Behenic acid (22:0) - Behenska kiselina	0.10	0.3	0.3

a: I: control - I. kontrola II: full fat rape-seed - II. punomasno sjeme repice III: rape-seed oil - III. ulje repice

b: mineral and vitamin premix, lysine-HCl, DL-methionine, limestone, monocalcium phosphate
mineralni i vitaminski premiks, lizin-HCL, DL-metionin, monokalcijfosfat

c: calculated value

2.3. Data recording

The following data were recorded or established in the course of the investigations: daily feed intake, daily weight gain, feed conversion, body composition (dry matter, crude protein, crude fat and crude ash), and also body fatty acid composition. These were determined at the end of the individual phases of the rearing period; i.e., on days 21 and 42.

2.4. Laboratory analysis

The nutrient, calcium and phosphorus content of the diets and the chemical body composition of the broilers were determined in accordance with the

stipulations of the Hungarian Standards Code (MSz. 6830, 77-81).

Fatty acid analysis of the diet samples and of the bodies of the broilers was performed on the basis of the specifications of MSz. 19928/86.

2.5. Statistical analysis

The experimental data were analysed by means of variance analysis (GLM, SAS 1990). The Tukey test was used to examine differences between the treatments.

RESULTS AND DISCUSSION

The results obtained from this series of experiments are summarised in tables 1 to 4. These data indicate that neither live weight nor average daily gain was influenced by the different fatty acid composition of the dietary fats and experimental diets used. At the end of the 42-day rearing period the live weight of the broilers ranged from 1936 to 1970 grammes. Average daily gain in the second phase of the rearing period was determined to be 61.0, 60.1 and 62.0 grammes respectively for the three treatments. Neither was any difference observed in mean daily feed intake or feed conversion. Both of these production parameters were found to be characteristic of the hybrid (table 2). Livestock mortality was not affected by the treatments applied. (The data for this are not given in this paper.)

Body composition determined at the age of 21 days and at the end of the rearing period (at 42 days, when the broilers were slaughtered) is illustrated in table 3. The effect of the various fat sources on body fatty acid composition is summarised in table 4.

Table 2. Effect of different fat sources on the performance of broilers

Tablica 2. Djelovanje različitih izvora masnoća na proizvodna svojstva brojlera

	Treatments* - Postupci					
	I		II		III	
	x	sd	x	sd	x	sd
Live weight, g - Živa vaga, g						
at 1 d of age - 1 dan starosti	48.2	3.9	47.9	4. 4	47.6	4. 4
21 d of age - 21. dan starosti	670	91	673	86	667	89
42 d of age - 42. dan starosti	1951	244	1936	279	1970	237
Daily gain, g - Dnevni prirast, g						
1 - 21 d	29.6	4.0	29.8	3.8	29.5	3.9
22 - 42 d	61.0	7.6	60.1	8.7	62.0	7.5
Daily feed intake, g - Dnevno uzimanje hrane, g						
1 - 21 d	47.4	2.0	47.2	0.8	47.7	1.7
22 - 42 d	138.8	6.3	138.0	4.0	137.6	3.6
Feed conversion kg/kg - Utrošak hrane, kg/kg						
1 - 21 d	1.62	0.06	1.59	0.06	1.62	0.02
22 - 42 d	2.28	0.10	2.30	0.12	2.22	0.08

* I. control II. full fat rape-seed III: rape-seed oil – I. kontrola II. punomasno sjeme repice III. ulje repice

Table 3. Chemical composition of broilers at 21 and 42 days of age

Tablica 3. Kemijski sastav brojlera 21. i 42. dana starosti

(g/kg)

	At 21 d of age 21. dan starosti		At 42 d of age - 42. dan starosti					
			Treatments - Postupci					
			I		II		III	
	x	sd	x	sd	x	sd	x	sd
Dry matter - Suha tvar	28.5	1.3	32.0	2.9	30.9	2.7	31.5	3.1
Protein - Bjelančevine	15.4	0.7	15.6	1.1	16.2	1.5	16.4	1.6
Fat - Masti	10.1	1.5	13.7	2.7	12.4	2.1	11.9	2.2
Ash - Pepeo	2.7	0.3	2.3	0.5	2.3	0.4	2.8	0.5

Table 4. Effect of different fat sources on the fatty acid composition of broilers at 42 days of age (methyl ester %)

Tablica 4. Djelovanje različitih izvora masnoće na sastav masnih kiselina brojlera 42. dana starosti (metil ester%)

Fatty acids: - Masne kiseline:	Treatments* - Postupci					
	I		II		III	
	x	sd	x	sd	x	sd
Miristic acid (14:0) - Miristinska kiselina	0.86^{a}	0.02	0.58^{b}	0.03	0.55^{b}	0.04
Palmitic acid (16:) - Palmitinska kiselina	24.09^{a}	0.81	20.62^{b}	1.10	10.21^{c}	1.09
Palmitoleic acid (16:1) - Palmitoleinska kiselina	6.21^{a}	0.77	4.84^{b}	0.63	4.49^{b}	0.74
Margaric acid (17:0) - Margarinska kiselina	0.20^{a}	0.02	0.15^{b}	0.02	0.14^{b}	0.01
Stearic acid (18:0) - Stearinska kiselina	5.98^{a}	0.48	5.50^{ab}	0.42	5.07^{b}	0.44
Oleic acid (18:1) - Oleinska kiselina	47.30^{a}	0.64	47.90^{a}	0.80	49.10^{b}	0.76
Linoleic acid (18:2ω6) - Linolna kiselina	13.30^{a}	0.73	16.80^{b}	1.41	17.10^{b}	1.46
Arachidic acid (20:0) - Arahidonska kiselina	0.08^{a}	0.01	0.10^{b}	0.01	0.10^{b}	0.02
γ-Linolenic acid (18:3ω6) - γ-Linolenska kiselina	0.17	0.03	0.20	0.02	0.18	0.04
Eicosanoic acid (20:1) - Eikosanoična kiselina	0.59^{a}	0.04	0.54^{b}	0.03	0.63^{a}	0.05
Linolenic acid (18:3 ω3) - Linolenska kiselina	0.58^{a}	0.02	1.88^{b}	0.16	2.49^{c}	0.19
Eicosadienoic acid (20:2ω6) - Eikosadienoična kiselina	0.15^{a}	0.01	0.19^{b}	0.02	0.18^{b}	0.03
Arachidonic acid (20:4ω6) - Arahidonična kiselina	0.44^{a}	0.08	0.59^{b}	0.14	0.57^{b}	0.12
Docosatetraenoic acid (22:4ω6) - Dokosatetraenoična kiselina	0.10^{a}	0.02	0.13^{b}	0.03	0.12^{ab}	0.03

* I. control II. full fat rape-seed III: rape-seed oil – I. kontrola II. punomasno sjeme repice III. ulje repice

a, b, c: $P \leq 0.05$

The data presented in the tables indicate that the different fatty acid composition of the diets had no effect on body content of dry matter, protein, fat or ash. However, significant differences in body fatty acid composition were measured. In the bodies of broilers fed the diets containing the highest proportion of unsaturated fatty acids the ratios of the polyunsaturated fatty acids most important with respect to nutrition physiology increased. Thus, for treatments II and III the ratio of linoleic acid was 26.3% and 28.6% higher (13.3, 16.8 and 17.1% methyl ester) respectively than that

of the control. In the case of linoleic acid values 224.1% and 329.3% higher, respectively, than those for the control were measured for the two treatments (0.58, 1.88 and 2.49% methyl ester). Arachidonic acid showed an increase of 34.1% for treatment II and 29.5% for treatment III (0.44, 0.59 and 0.57% methyl ester). The ratio of docosatetraenoic acid in the bodies of the experimental livestock also increased by 30% and 20% respectively by means of the two treatments (0.1, 0.13 and 0.12% methyl ester).

Therefore, on the basis of the accumulated data obtained it can be stated that the unsaturated fatty acid content of diets can yield significant increases in body PUFA composition in broilers. Arbuckle et al., 1994. reached a similar conclusion on the basis of their studies on pigs.

In the interest of producing broiler meat of higher value with respect to nutrition physiology it can be recommended that dietary fats containing a high proportion of unsaturated fatty acids be used for the enrichment of broiler diets. However, it is considered necessary to note that the application of unsaturated fatty acids for such purposes in animal nutrition should always be preceded by economic analyses.

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SAŽETAK

Cilj ovih istraživanja bio je ispitati djelovanje višestruko nezasićenih masnih kiselina (PUFA) podrijetlom iz raznih izvora (punomasno sjeme repice i ulje repice) na proizvodna svojstva i sastav tijela brojlera, te na sadržaj masne kiseline u njihovu tijelu. U pokusima je upotrijebljeno 480 brojlera (160 po postupku). Obroci su sastavljeni uzevši u obzir preporuke NRC-a o hrani (1994). U prvoj polovici uzgojnog razdoblja (1. do 21. dana) sve su životinje dobile obrok istog sastava, dok su u drugoj polovici (22. do 42. dana) pripremljena tri postupka. Postupci su se razlikovali po izvoru sadržaja masnoće ili masnih kiselina (životinjska masnoća, punomasno

sjeme repice ili ulje repice) tako da je sadržaj AMEn, sirovih bjelančevina, kalcija i fosfora u obrocima ostao isti. Dobiveni podaci pokazuju da postupci nisu djelovali ($P \geq 0.05$) na proizvodna svojstva (uzimanje hrane, dnevni prirast i konverzija hrane). Dok postupci nisu djelovali ($P \geq 0.05$) na sadržaj suhe tvari, bjelančevina, masnoće ili pepela u tijelu, primijećene su značajne promjene ($P \leq 0.05$) u sastavu masnih kiselina u tijelu. Iz mnoštva dobivenih podataka ustanovljeno je da značajne promjene u sastavu masnih kiselina u tijelu može prouzročiti sadržaj nezasićenih masnih kiselina u obrocima, što može povećati sadržaj PUFA u tijelu. Što se tiče fiziologije hranidbe može se preporučiti upotreba masnoće s visokim postotkom nezasićenih masnih kiselina da se obogati sadržaj energije u obrocima brojlera. Međutim, smatra se potrebnim primijetiti da upotrebi masnih kiselina u životinjskoj hranidbi u takve svrhe uvijek moraju prethoditi gospodarske analize.

Ključne riječi: brojler, višestruko nezasićene masne kiseline u hrani, kakvoća mesa