THE EFFECTS OF DIFFERENT FAT SOURCES ON THE BIOPRODUCTIVE PERFORMANCES AND THE ESSENTIAL FATTY ACIDS COMPOSITION OF TIGHTS AND ABDOMINAL FAT IN BROILERS

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Abstract

Taking into consideration that the energy source added to the combined fodder can significantly modify the fatty acids profile in broiler food, through its redirection even the fatty acids profile of carcasses can be modified through enrichment in a certain fatty acid and obtaining functional foods. An experiment was coduced on broilers, made up of three experimental groups, fed with a combined base fodder in which 2% of different fat sources have been incorporated (sunflower oil, soybean oil, linseed oil). The experimental period was of 42 days, during which the bioproductive indicators have been established (food ingestion, weight gain, conversion indicator), % of fatty acids in 100 g product (linoleic acid, linolenic acid and oleic acid), ∑ SFA, ∑ MUFA, ∑ PUFA and the ratio between linoleic acid and linolenic acid, in thighs (Th),thigh skin (ThS) and abdominal fat (AF) in the broilers from the experimental groups. Fatty acids were determined using gaz cromatography.

The data obtained after statistc processing and interpretation have highlighted the fact that, concerning the bioproductive indicators, the three experimental groups do not differ. Regarding the fatty acids profile in thighs and abdominal fat there are some variations in the determined fatty acids content, which denotes that they can be influenced by food factors.

Key words: essential fatty acids, ω-6 : ω-3 rapport, energetic sources, fatty acids profile, ω-3 enriched foods

INTRODUCTION

In using different energy sources to satisfy energy demands for different poultry catagories and especially broilers, the influence, aport and ratio of some very important nutrients for human consumption is not taken into consideration, as in the case of poliunsaturated ω -3 and ω -6 fatty acids, whose ratio be considerably modified by energy addition in the structure of combined fodder for broiler [1], [2], [3], [4].

Food habits of the modern man have deterimned a growth of the ω -6: ω -3 ratio in food up to 20-25:1, comparing to the recomended 1-2:1, which indicates a reduced apport of omega-3 fatty acids through alimentation [5], [6], [7], [8].

Enriching foods with ω -3 fatty acids is preferable to the nutritional supliments with this ingredient. In the paper another set of results is presented [9], regarding the possibilities of influencing the ω -6, ω -3 fatty acids profile and their ratio in broiler fodder through using three energy sources (sunflower oil, soybean oil, linseed oil), as well as their influence on the bioproductive indicators in broilers and the content of fatty acids in thighs and abdominal fat**.**

MATERIALS AND METHODS

To assess the effects exerted by various fat sources on the polyunsaturated fatty acids profile in broiler feed, we organized an experiment according to the work protocol presented in table 1, as follows:

- the chickens in the three experimental groups were fed two types of forage, combined with the same basic components

that supplied, during the period 1-21 days, 22.9% CP (crude protein) and 3235 kcal ME/kg, respectively 20% CP and 3244 kcal ME/kg during the second period, 22-42 days.

- the feed differentiation factor between the experimental groups was the 2%-incorporation of sunflower oil in L1, soybean oil in L2 and linseed oil in L3.
- the bioproductive effect of the three energetic sources was determined in concordance with the following indices: combined forage intake, body weight gain, and feed conversion index.
- the profile of some fatty acids (linoleic omega-6, linolenic omega-3, oleic-9) in broiler meat was determined with the help of the Gas Chromatoraphy. Lipids were extracted following the of FOLCH method [10]. Fatty acid profiles of experimental fats, diets and meat were separated and identified by using a GCMS-QP 2010+SHIMAGZU gas chromatograph, equipped with a AT-5MS (30m x 0.32 mm inside diameter) capillary column of silica. The oven program was the following: 70^0C for 2 min., than it was heated to 150^0C with a gradient of 10^0C/min. and than, a floor of 3 min., after that it was raised again to 235^0C with a gradient of 4^0C/min. The temperature of the injector was 260^0 C, injection mode split, split ratio 20. Helium was used as carrier gas. The preliminary experimental data were statistically processed with the international software SPSS 16. (ANOVA) student's test (MINITAB 15) for difference significance testing; for calculations, we used the Microsoft Office Excel software.

Table 1 Experimental Scheme

Specification		L1		L2		L3	
period	0-21 days	CF1		CF1		CF1	
		22,9 CP% ME 3235kcal/kg		22,9 CP% ME 3235kcal/kg		22,9 CP% ME 3235kcal/kg	
	22-42 days	CF2		CF2		CF2	
		20 CP% ME 3244kcal/kg		20 CP% ME 3244kcal/kg		20 CP% ME 3244kcal/kg	
Differential factor		Sunflower oil 2%		Soybean oil 2%		Linseed oil 2%	
Fatty acids profile in feed	0-21 days	ω-6: ω-3	7,39:1	ω-6: ω-3	3,58:1	ω-6: ω-3	0,61:1
	22-42 days	ω-6: ω-3	7,04:1	ω-6: ω-3	3,47:1	ω-6: ω-3	0,60:1

RESULTS AND DISCUSSIONS

Introducing 2% of sunflower oil, soybean oil and linseed oil in the structure of combined fodder for broilers of the three experimental groups modifies the ratio of polyunsaturated omega-6:omega-3 fatty acids in fodder. Thus, the most unbalanced ratio of 7.04:1 hase been registered in the case of L1 experimental group in which the fat source was sunflower oil.

The most balanced ratio 0.61:1 was obtained for the experimental groups L3 whose lipid source was linseed oil.

The effect of modifing the omega-6:omega-3 ratio in broiler fodder has been established on the following indicators:

- Bioproductive indicators:

The evolution of body mass, food ingestion and conversion indicator was established through the experiment:

- The statistic indicators of body mass established at the age of 7, 21 and 42 days are presented in table 2. The values of the table show that the energetic and nutritional level of combined fodder administered being the same in all experimental groups, the differences in weight and body weight gain are not significant from the statistic point of

view. It can alsso be seen that the combined fodder administered have satisfied the energy and nutritional demands of broilers so the weight values are in the race standard.

Table 2 Statistic indicators of the body mass

Specification		Body mass			dwg (cumulated)	
		$\bar{x} \pm S\bar{x}$	S	VC%	g	%
7 days	L_1	138,69±3,02[a]	12,08	8,71	14,10	100
	L_2	126,11±2,97[b]	12,58	9,98	12,30	87,2
	L_3	133,88±3,93[a,b]	15,74	11,76	13,41	95,1
21 days	L_1	715,6±10,0[a]	40,1	5,60	32,17	100
	L_2	703,9±23,1[a]	97,9	13,91	31,61	98,3
	L_3	737,1±22,7[a]	90,8	12,32	33,19	103,2
42 days	L_1	2367,2±47,0[a]	182,2	7,70	55,40	100
	L_2	2386,4±78,5[a]	314,2	13,17	55,86	100,8
	L_3	2378,5±74,6[a]	298,3	12,54	55,67	100,5

** Between the mean values with the same ratio there are no significant differences
[a,b] p<0.05

- The fodder consumtion and the conversion index between the two growth periods (0-21 days and 22-42 days) and on the whole experimental period respectively (0-42 days) are presented in table 3. It is also shown through theese indicators that the three energy sources in the combined fodder for broilers as well as the change of the main essential fatty acids in food (omega-6:omega-3) do not significantly influence the ingestion and the conversion indicator, for both the percentual differences between groups being between 1.5 and 2.4 %p.

Table 3 Forage consumption, conversion indicator's values in broilers from the experimental groups

Specification		CF Consumption			CI	
		total (g/chicken/period)	dwg		kg CF/kg body mass	%
			g/chicken/zi	%		
21 days	L_1	1100	52,38	100	1,69	100
	L_2	1000	47,62	90,9	1,56	92,2
	L_3	1080	51,42	98,2	1,60	94,8
22-42 days	L_1	2960	140,95	100	1,96	100
	L_2	3060	145,71	103,4	1,99	101,1
	L_3	2850	135,71	96,3	1,90	96,6
Total	L_1	4000	95,24	100	1,96	100
	L_2	3940	93,80	98,5	1,99	101,1
	L_3	3930	93,57	98,3	1,90	96,6

The data come to sustain the results obtained by Mierlita [4], who, testing the efects of different fat sources utilisated in broiler feed concluded that the origin of the fats does not influence the production performances.

- Fatty acids profile

Regarding the fatty acids values determined from tight, tight skin and abdominal fat, theese have been established at the end of the experimental period (42 days).

After statistic interpretation it can be observed that there exist segnificant differences between the experimental groups, regarding the fatty acids content of L ω-6, L ω-3 and O ω-9 in Th, ThS and AF, as it is shown in table 4.

Table 4 Statistic indicators of the fatty acids in the three experimental groups

Specification	Thigh		Thigh skin		AF	
	$\bar{x} \pm S\bar{x}$	VC%	$\bar{x} \pm S\bar{x}$	VC%	$\bar{x} \pm S\bar{x}$	VC%
L1 (Sunflower oil)						
Oleic ω-9	6,51 ± 0,34	1,22	24,80 ± 0,26	1,84	32,69 ± 0,20	1,10
Linoleic ω-6	5,75 ± 0,24	7,51	17,30 ± 0,21	5,18	28,66 ± 0,24	6,45
ALA ω -3	0,20 ± 0,05	1,12	0,60 ± 1,11	2,33	0,99 ± 0,11	1,12
L2 (Soybean oil)						
Oleic ω-9	5,30 ± 0,32	1,70	21,76 ± 0,21	1,72	31,38 ±0,25	1,43
Linoleic ω-6	4,26 ± 0,27	11,18	16,71 ± 0,20	12,13	23,77 ± 0,42	13,09
ALA ω-3	0,30 ± 0,05	1,82	0,95 ± 0,08	1,46	1,33 ± 0,14	1,52
L3 (Linseed oil)						
Oleic ω-9	4,34 ± 0,12	3,13	18,85 ± 0,67	6,22	29,85 ± 0,35	2,05
Linoleic ω-6	3,42 ± 0,27	1,75	13,40 ± 0,24	1,14	23,22 ± 0,14	1,06
ALA ω-3	1,02 ± 0,05	5,95	4,53 ± 0,20	4,86	7,54 ± 0,13	3,13

Regarding the O ω -6 content, significant differences appear between the experimental groups L1 and L3, in Th, ThS and AF ($p<0,001$); between L1 an L2 allso apear segnificant differences in Th ($p<0,01$), ThS and AF ($p<0,001$). But compairing L2 and L3, segnificant differences appear at the AF ($p<0,001$), than at the level of the ThS ($p<0,01$), and the lowest statistical difference was registered at the Th level ($p<0,05$)

Segnificant differences apear allso in case of the L ω -6 content, between L1 and L3 at all three studied pieces ($p<0,001$); segnificant differences ($p<0,001$) apear allso between L1 and L2 in Th and AF while the differences at ThS is not so significant ($p>0,05$) regarding the L ω -6 content. Between L2 and L3 appear segnificant differences ($p<0,01$) at the Th. ($p<0,001$) at the ThS, but at the AF the difference is unsegnificant ($p>0,05$), regarding the L ω -6 content.

Analysing the values after statistical processing, there were allso observed segnificant differences regarding the L ω -3 thus: between L1 and L3 the statistical difference being high ($p<0,001$), while between L1 and L2 there are no segnificant differences ($p>0,05$) at the Th, existing only at the ThS ($p<0,01$) and at the AF ($p<0,05$).

The data presented, come to confirm the results obtained by Palfy T. [11], who says that different fat sources segnificantly modify the fat quality, respectivly the fatty acids structure.

Table 5 Content of the studied fatty acids in 100g product

Structure and name	L1			L2			L3		
	Th	ThS	AF	Th	ThS	AF	Th	ThS	AF
	g/100g prod.	g/100g prod.	g/100g prod.	g/100g prod.	g/100g prod.	g/100g prod.	g/100g prod.	g/100g prod.	g/100g prod.
C18:1n9c (oleic ac.)	6,51	24,81	32,69	5,31	21,76	31,38	4,34	18,85	29,86
C18:2n6c (linoleic ac.)	5,74	17,30	28,66	4,27	16,71	23,78	3,42	13,41	23,22
C18:3n3c (linolenic ac.)	0,20	0,60	0,95	0,31	0,95	1,33	1,02	4,53	7,54

Oleic acid. Regarding this acid, the highest quantity was determined in L1, in the abdominal fat (AF 32.69 g/100 g product), followed by L2 (AF 31.38 g/100 g product) and by L3 (AF 29.86 g/100 g product).

A lower quantity was determined for thigh skin (ThS), following the same

decreasing tendency L1 – L3, thus: L1 (24.81 g/100 g product), L2 (21.76 g/100 g product), L3 (18.56 g/100 g product)

The lowest quantity for this fatty acid was determined in thigh (Th), the values keeping their decreasing tendency L1 – L3 : L1 (6.51 g/100 g product), L2 (5.31 g/100 g product), L3 (4.34 g/100 g product).

Linoleic acid. The decreasing tendency is still present for this acid, from L1 – L3 and from abdominal fat > thigh skin > thigh: AF L1 (28.66 g/100 g product), L2 (23.78 g/100 g product), L3 (23.22 g/100 g product); ThS L1 (17.30 g/100 g product), L2 (16.71 g/100 g product), L3 (13.41 g/100 g product); Th L1 (5.74 g/100 g product), L2 (4.27 g/100 g product), L3 (3.42 g/100 g product).

A-linolenic acid (ALA). Does not follow the same pattern as the previous two acids, by registering the highest values for L3 (AF 7.54 g/100 g product; ThS 4.53 g/100 g product; Th 1.02 g/100 g product). The lowest values are registered for L1 (AF 0.95 g/100 g product; ThS 0.60 g/100 g product; Th 0.20 g/100 g product) followed by L2 (AF 1.33 g/100 g product; ThS 0.95 g/100 g product; Th 0.31 g/100 g product). The results presented are shown in table 5.

Analising the values obtained after summing the sturated fatty acuds (∑SFA), monunsaturated fatty acids (∑MUFA), and the polyunsaturated fatty acids (∑PUFA) from the Th, ThS and AF of the chicken from the experimental groups, we can conclude the results presented in table 6 thus:

Table 6 Values of the different ratios between SFA, MUFA and PUFA

Specification	g/100g fat								
	L1			L2			L3		
	Th	ThS	AF	Th	ThS	AF	Th	ThS	AF
(1)∑SFA	28,48	29,20	28,16	39,10	30,59	31,49	43,19	29,61	27,06
(2)∑MUFA	33,21	36,02	33,54	27,75	32,24	31,91	23,74	30,67	30,55
(3)∑PUFA	30,79	26,43	30,80	24,14	26,35	25,56	24,58	29,51	31,94
(2:1)	1,17	1,23	1,19	0,71	1,05	1,01	0,55	1,04	1,13
(3:1)	1,08	0,91	1,09	0,62	0,86	0,81	0,57	1,00	1,18
(2+3:1)	2,25	2,14	2,28	1,33	1,92	1,83	1,12	2,03	2,31
(2+3)	64	62,4	64,33	51,89	58,59	57,48	48,32	60,18	62,49
(L ω-6: L ω-3)	28,89	28,59	30,12	13,56	17,51	17,88	3,36	2,96	3,12

By analyzing the MUFA/SFA ratio, we can say that its highest values have been registered by L1 for ThS (1.23:1), with the lowest value being registered by L3 for Th (0.55:1).

The PUFA/SFA ratio shows that the highest registered value was that of L3 (FA 1.18:1) and the lowest one was registered by the same group, for Th (0.57:1).

Regarding the MUFA+PUFA/SFA ratio, the lowest as well as the highest registerd value was that of L3 (AF 2.31:1) (Th 1.12:1).

Regarding the linoleic (ω-6) and linolenic (ω-3) acids ratio, it can be observed that the most unbalanced ratio is that of L1, followed by L2 for all the studied pieces.

CONCLUSIONS

- Using different energy sources: sunflower oil, soybean oil and linseed oil in a 2% proportion in combined fodder for broilers do not significantly influence the bioproductive indicators: body mass, food ingestion and the conversion indicator.
- Although there exist segnificant differences between the experimental groups regarding the fatty acids content (L ω -6, L ω -3 şi O ω -9) in Th, ThS and AF, the data prove that most of the differences are registered between L1, in which the fat source was sunflower oil and L3, in which the fat source was linseed oil, being followed by the differences between L2 which had as fat source the soybean oil and L3.
- Regarding the studied fatty acids content for 100 g of product we can conclude the following:
  - ✓ Oleic acid. The highest quantity was determined in L1 for AF (32.69 g/100 g

product) and the lowest value in L3 for Th (4.34 g/100 g product);

- ✓ Linoleic acid. The highest quantity was determined in L1 for AF (28.66 g/100 g product) and the lowest value in L3 for Th (4.34g/100 g product);
- ✓ α-Linolenic acid. The highest quantity was determined in L3 for AF (7.54g/100 g product) and the lowest value in L1 for Th (0.20 g/100 g product);

- ➢ The MUFA/SFA ratio shows that its highest values have been registered by L1 for ThS (1.23:1), with the lowest value being registered by L3 for Th (0.55:1).
- ➢ The PUFA/SFA ratio shows that both the highest and lowest value were registered by L3 for AF (1.18:1) and for Th (0.57:1).
- ➢ The MUFA+PUFA/SFA ratio: the lowest as well as the highest registerd value was that of L3 AF (2.31:1) Th (1.12:1).
- ➢ The results of the present experiment show that linoleic, linolenic and oleic acids profile can be influenced by incorporated fat sources in the basic ratio in order to modify the fatty acids profile in the studied cut pieces.

ACKNOWLEDGEMENTS

I would like to thank my wife and miss Miruna Dobândă for the support in translating this paper This work was supported by the grant POSDRU /21/1.5/G/38347".

BIBLIOGRAPHY

[1] Meluzzi Adele., F. Siri,: Functional eggs: Fortification with n-3 PUFA, CLA and antioxidants. J. Food Sci. 2004, 14: 159-166.

[2] Bourre J. M., „Where to find omega-3 fatty acids and how feeding animals with diet enriched in omega-3 fatty acids to increase nutritional value of derived products for human: what is actually useful?", J. Nutr. Health Aging 2005 Jul-Aug; 9(4):232-42

[3] Haug Anna, Susanne Eich-Greatorex, Aksel Bernhoft, Jens P Wold, Harald Hetland, Olav A Christophersen, and Trine Sogn; Effect of dietary selenium and omega-3 fatty acids on muscle composition and quality in broilers, Lipids Health Dis norvegia 2007

[4] Mierliță D., I. Chereji, Cristina Maerescu The effects of different fat sources on the performance of broiler chickens and on the fatty acid composition of selected tissues Bulletin Vol 64, No 1-2: Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Animal Science and Biotechnologies USAMV-CN, 63 - 64/2007 BUASV

[5] Simopoulos, A. P., The future direction of nutrition research: A nutrition and food sciences agency is the key to progress. J. Nutr. 1989 119:137–139.

[6] Simopoulos, A. P., Redefining dietary recommendations and food safety. World Rev. Nutr. Diet. 1998 83:219–222.

[7] Simopoulos A. P., „Human Requirement for n-3 Polyunsaturated Fatty Acids", Poultry Science, 2000 79:961-970.

[8] Simopoulos, A. P., and F. Visioli, ed., Mediterranean Diets Karger 2000 (S Karger, AG), Basel, Switzerland.

[9] Fota D. S., Drinceanu D, Ştef Lavinia, Gergen I, Alexa Ersilia, Simiz Eliza Baliga Izabella, Luca I., „The Effects of Different Fat Sources on Bioproductive Performances and Essential Fatty Acids Composition in Broiler Breast", Animal Sciences and Biotechnologies, 2010, 43 (1).

[10] Folch, J., Lees, M., Slaon-Stanley, G. N., 1957, A simple method for the isolation and purification of the lipids from animal tissues. J. Biol. Chem. 226, 497-509.

[11] Palfy T., I. Erdelyi 2005 – The Effects of Different Fat Sources on Broiler Performance and Fatty Acid Composition. Sustainable Agriculture Across Borders in Europe, p:234-238.