The Effects of Different Fat Sources on Bioproductive Performances and Essential Fatty Acids Composition in Broiler Breast

Dragos Sorin Fota, Dan Drinceanu, Lavinia Ştef, Iosif Gergen, Ersilia Alexa, Eliza Simiz, Izabella Baliga, Ioan Luca

Banat's University of Agricultural Sciences and Veterinary Medicine Timisoara – 300645,Calea Aradului, 119, Romania

Abstract
Since fats added in combined fodder may change the fatty acids profile in broilers feed, it is possible to influence their share in a desired structure, which can balance the n-6:n-3 ratio in food, according to the consumers needs. Thus, an experiment was conducted over a period of 42 days, on four groups of broilers fed with a basal diet, which incorporated various fats (sunflower oil-2%, soybean oil-2%, linseed oil-2%, lard-2%). The bioproductive indicators (food intake, body weight gain, and the conversion index CI) were established during the experiment, and in the end, the content of essential fatty acids (linoleic and linolenic acids) in broiler breast were determined. The obtained data, analyzed and statistically interpreted, have revealed that the established (evaluated) bioproductive indicators in the four experimental groups did not differ significantly. However there are some variations in the fatty acids content in broiler chicken breast.There are, though, some variations of the determied fatty acids content in broiler breast, in pectoral muscles as well as in breast skin.

Keywords: essential, fatty acids, fatty acids profile, ω-3 enriched foods, ω -6: ω -3 ratio, vegetal oils.

1. Introduction

In the conduct of different fat sources usage to satisfy the energy requests for different types of birds, and especially for broiler chickens, its influence on the contribution and report of some nutrients with implications in human food consumption is not taken into consideration. This is also the case of omega-3 and omega-6 polyunsaturated fatty acids the report of which cand be considerably modified by energetic supllements in the structure of combined fodder designed for broiler chicken [1, 2, 3, 4].
At present, the human alimentation regime has determined a growth in omega-3:omega-6 ratio in food up to 20-25:1, comparing to the recommended values of 1-2:1, that indicate a reduced intake of omega-3 fatty acids through alimentation [5, 6, 7, 8].
Diet enrichment with omega-3 fatty acids is preferable compared with the nutritional supplements with this ingredient. This work presents the first results regarding the influence exerted by four fat sources (sunflower oil, soybean oil, linseed oil and lard) on the omega-6 and omega-3 profile and on their proportion in broiler chickens, and also their influence on broiler bioproductive indices and on the fatty acids content within breast.

2. Materials and methods

To assess the effects exerted by various fat sources on the polyunsaturated fatty acids profile

* Corresponding author: D.S. Fota, email: dragosfota@animalsci-tm.ro

in broiler feed, we organized an experiment according to the work protocol presented in table 1, as follows:

- the chickens in the four experimental variants 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 3224 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 and lard in L4.

➢ the bioproductive effect of the four 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 breast was determined with the help of the Gas Chromatoraphy. Lipids were extracted following the of FOLCH method [9]. 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) and the student's test (MINITAB 15) for difference significance testing; for calculations, we used the Microsoft Office Excel software.

Table 1. General experimental organization scheme

Specification	L1	L2	L3	L4
period **1 -21 days**	CF1 22,9 CP% ME 3235kcal/kg	CF 1 22,9 CP% ME 3235kcal/kg	CF 1 22,9 CP% ME 3235kcal/kg	CF1 22,9 CP% ME 3235kcal/kg
22-42 days	CF 2 20 CP% ME 3244kcal/kg	CF 2 20 CP% ME 3244kcal/kg	CF 2 20 CP% ME 3244kcal/kg	CF 2 20 CP% ME 3244kcal/kg
Feed differentiation factor	Sunflower oil 2% linoleic acid n-6 0.150 linolenic acid n-3 0.004 oleic acid n-9 0.350	Soybean oil 2% linoleic acid n-6 0.160 linolenic acid n-3 0.176 oleic acid n-9 0.400	Linseed oil 2% linoleic acid n-6 0.350 linolenic acid n-3 0.950 oleic acid n-9 0.500	lard 2% linoleic acid n-6 0,130 linolenic acid n-3 0,015 oleic acid n-9 0,810
Fatty acids profiles within the feed	CF 1: linoleic acid n-6 1.93 linolenic acid n-3 0.26 oleic acid n-9 1.14 CF 2: linoleic acid n-6 1.92 linolenic acid n-3 0.27 oleic acid n-9 1.26 ω-6: ω-3 7,04:1	CF 1: linoleic acid n-6 1.55 linolenic acid n-3 0.43 oleic acid n-9 1.28 CF 2: linoleic acid n-6 1.54 linolenic acid n-3 0.44 oleic acid n-9 1.31 ω-6: ω-3 3,47:1	CF 1: linoleic acid n-6 0.74 linolenic acid n-3 1.20 oleic acid n-9 1.38 CF 2: linoleic acid n-6 0.74 linolenic acid n-3 1.22 oleic acid n-9 1.41 ω-6: ω-3 0,60:1	CF 1: linoleic acid n-6 0,53 linolenic acid n-3 0,27 oleic acid n-9 1,69 NC2: linoleic acid n-6 0,52 linolenic acid n-3 0,28 oleic acid n-9 1,72 ω-6: ω-3 1,82:1
Determined incicators	- CF consumption - Body weight gain	- Fatty acids profile within feed - Fatty acids profile within breast		- Conversion index

3. Results and discussion

A number of studies have examined the effects of diatry long-chain polyunsaturated fatty acids, such as those contained in vegetable oils and lard on the fatty acids composition of the broiler carcass [3, 10] and their influence on the bioproductive indices [11].

The sunflower, soybean and liseed oils and the lard incorporation, in a proportion of 2 %, in the structure of combined forage for the broiler chickens within the 4 experimental groups drammatically changes the polyunsaturated fatty acids ratio in feed. In these terms, the most imbalanced ratios, 7.04:1 and 3.47:1, were recorded in the experimental groups L1 and L2, where the lipid source was represented by sunflower oil.

The most balanced and preferable ratios, namely 0.60:1 and 1.82:1, were achieved in the experimental groups L3 and L4, whose lipid source were the linseed oil and the lard.

The effect exerted by the modification of the polyunsaturated fatty acids ratio in chicken feed was determined according to the following indices:

- Bioproductive indices:

In our experiment, we determined the body weight gain, the feed ingestion and the conversion index:

- The statistical body weight indices determined at 7, 21 and 42 days are presented in table 2. In this table, we may observe that the energetic and nutritional effect of the combined forage is similar in all experimental groups; however, the weight and growth differences between groups are not statistically significant. We may also notice that the forage met the energetic and nutritional requirements of broilers, so that the weight values are concordant with the standard values of this breed.

Table 2. Statistical body weight indices

Specification		Body weight			Mean daily gain (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
	L_4	130.44±3.58[a,b]	14.31	10.97	12.92	91.6
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
	L_4	738.1±20.0[a]	80.1	10.85	33.25	103.4
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
	L_4	2346.6±62.0[a]	248.2	10.57	55.87	100.9

*There are no significant differences ($p>0.05$) between the means having the same coefficients; [a,b] $p<0.05$;
VC -Variability coefficient; S-Variance

- The forage intake and the conversion index for the two growth periods (0-21 days and 22-42 days), respectively for the entire experimental period (0-42 days) are presented in table 3. Regarding these indices, to, we may observe that the three energetic sources incorporated in the combined forage for broilers and also the modification of the essential fatty acids within feed (omega-6:omega-3) ratio do not significantly influence the ingestion and the conversion index; for both indicators, the percentage differences between groups ranged between 1.5 and 2.4 p%.

The bioproductive indices recorded at the end of the experimental period are graphically represented in figure 1.

Table 3. Forage intake and CI

Specification		CF consumption			CI	
		total	mdc*			
		(g/chicken/period)	g/chicken/day	%	kg CF/kg body weight	%
21 days	L_1	1100	52.38	100	1.54	100
	L_2	1000	47.62	90.9	1.42	92.2
	L_3	1080	51.42	98.2	1.46	94.8
	L_4	1050	50.00	95.4	1.42	92.2
22-42 days	L_1	2960	140.95	100	1.79	100
	L_2	3060	145.71	103.4	1.81	101.1
	L_3	2850	135.71	96.3	1.73	96.6
	L_4	2860	136.19	96.6	1.78	99.5
Total	L_1	4000	95.24	100	1.69	100
	L_2	3940	93.80	98.5	1.65	97.6
	L_3	3930	93.57	98.3	1.65	97.6
	L_4	3910	93.09	97.7	1.66	98.2

*mdc – mean daily consumption

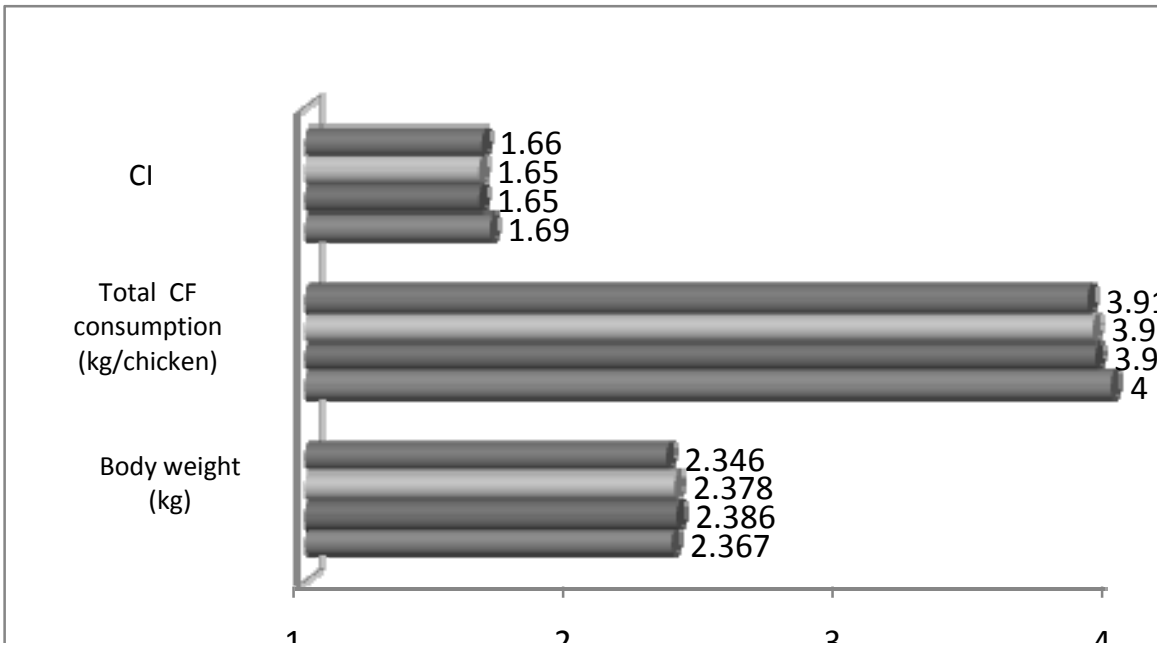

Figure 1. Bioproductive indices in broilers, during the entire experimental period

➢ Fatty acids profile

Regarding the fatty acids values determined in pectoral muscles, skin and breast (breast with skin), they were determined at the end of the experimental period (42 days).

- Regarding the values of linoleic acid (L n-6), it was the highest in breast skin for experimental group L3 (214 mg/g fat) and L2 (201 mg/g fat) in which the fat sources was linseed and soybean oil, but for the pectoral muscles and the breast, the highest values were those of experimental lot L1 (151 mg/g fat) (155 mg/g fat) and L2 (144 mg/g fat) (150 mg/g fat) in which the fat source was sunflower oil and soybean oil. The lowest values were registered for breast in experimental groups L3 (92 mg/g fat) and L4 (82 mg/g fat) in which the fat source was linseed oil and lard.
- Linolenic acid (L n-3) was detected in pectoral muscles and in the breast skin only for experimental group L3 (43 mg/g fat, 145 mg/g fat respectively) and in L4 (39 mg/g fat) only in breast. For experimental groups L1, L2 the quantity of linolenic acid could not be identified, being under the detectable value (20 ppm).
- Oleic acid registered the highest values for breast skin, thus: for L3, 262 mg/g fat, for L4, 232 mg/g fat, for L2, 108 mg/g fat, and 165 mg/g fat for experimental group L1. For pectoral muscles,

the values were as such: 151 mg/g fat for experimental groups L2 and L1, 120 mg/g fat for L4 and 112 mg/g fat for L3.

For the breast, the highest quantity of oleic acid was registered by the experimental group L1 (155 mg/g fat), as opposed to L2 (150 mg/g fat), L3 (104 mg/g fat) and L4 (87 mg/g fat). In regards to the content of linolenic acid, the highest quantity was determined in experimental group L3 (53 mg/g fat) and in L4 (35 mg/g fat).

The highest quantity of oleic acid was determined in L2 (156 mg/g fat) as opposed to L1 (152 mg/g fat), L4 (132 mg/g fat) and L3 (127 mg/g fat).

In regards to the omega 6:omega 3 report, it was of 1.94:1 for experimental group L3 and of 2.64:1 for L4.

The differences of fatty acids distribution L n-3, L n-6 and O n-9 for pectoral muscles, breast skin and breast for experimental groups are given in Table 4.

Table 4 Statistical indices of fatty acids in the four experimental groups

Specification	Pectoral muscles			Breast skin			Breast		
	$\bar{x} \pm S\bar{x}$	S	VC%	$\bar{x} \pm S\bar{x}$	S	VC%	$\bar{x} \pm S\bar{x}$	S	VC%
Sunflower oil (L1)									
L n-6mg/g F	151.45±4.51	10.09	6.66	189.18±9.44	21.11	11.6	155.22±3.59	8.02	5.17
L n-3mg/g F	-	-	-	-	-	-	-	-	-
O n-9mg/g F	151.39±2.66	5.95	3.93	165.61±3.13	7.00	4.22	152.81±1.79	4.00	2.62
Soybean oil (L2)									
L n-6mg/g F	144.76±4.86	10.87	7.51	201.69±2.14	4.79	2.38	150.45±2.90	6.49	4.31
L n-3mg/g F	-	-	-	-	-	-	-	-	-
O n-9mg/g F	151.56±2.35	5.26	3.47	198.70±2.60	5.81	2.92	156.27±2.63	5.88	3.77
Linseed oil (L3)									
L n-6mg/g F	92.17±1.39	3.12	3.38	214.87±2.02	4.52	2.10	104.44±2.83	6.33	6.06
L n-3mg/g F	43.62±1.49	3.34	7.66	145.55±2.75	6.14	4.22	53.81±2.53	5.65	10.50
O n-9mg/g F	112.61±2.45	5.47	4.86	262.49±2.74	6.12	2.33	127.60±2.94	6.58	5.15
Lard (L4)									
L n-6mg/g F	82.26±1.87	4.19	5.09	138.18±1.95	4.36	3.15	87.85±2.22	4.96	5.64
L n-3mg/g F	39.60±0.63	1.411	3.56	-	-	-	35.65±2.77	6.19	17.36
O n-9mg/g F	120.92±2.02	4.53	3.74	232.61±3.05	6.83	2.94	132.09±2.56	5.72	4.33

The statistical differences between the experimental groups in terms of L n-6 and L n-3 and O n-9 content in pectoral muscles, breast's skin and breast are presented in table 5.

Table 5. Significance of the differences between the essential fatty acids (L n-3; L n-6 and O n-9) content within pectoral muscles, breast and breast's skin under the influence exerted by four lipid sources

Specification			Pectoral muscles	Breast skin	Breast
Ln-6	**L1**	L2	ns	ns	ns
		L3	***	ns	***
		L4	***	**	***
	L2	L3	***	**	***
		L4	***	***	***
	L3	L4	**	***	**
Ln-3	**L3**	L4	ns	-	**
On-6	**L1**	L2	ns	***	ns
		L3	***	***	***
		L4	***	***	***
	L2	L3	***	***	***
		L4	***	***	***
	L3	L4	*	***	ns

Regarding the content of L n-6, there are significant differences ($p<0.001$) between experimental group L1 and experimental group L2, L4; between L2 and L3, L4 and between L3 and L4, in pectoral muscles, breast skin and breast. There are no significant differences ($p>0.05$) between L1 and L3 regarding breast skin, but there are significant differences

($p<0.001$) in regards to the content of L n-6 in pectoral muscles and breast.
There are no differences ($p>0.05$) between L3 and L4 regarding the content of linolenic acid in pectoral muscles but there are significant differences ($p<0.01$) in breast.
Also, there are significant differences ($p<0.001$) in the content of O n-9 between L1 and L3, L4, in pectoral muscles, breast skin as well as breast. There are no significant differences ($p>0.05$) between L1 and L2, in pectoral muscles and breast, but there are significant differences ($p<0.001$) in breast skin. Significant differences ($p<0.001$) also appear between L2 and L3, L4 in pectoral muscles, breast skin and breast. There are also differences between L3 and L4: ($p<0.05$) in the content of oleic acid in pectoral muscles, significant differences ($p<0.001$) in breast skin, but there are no differences ($p>0.05$) in breast.

4. Conclusions

Using different energy sources: sunflower oil, soybean oil, linseed oil and lard (2%) in the structure of combined fodder for broiler chicken does not signifincantly influence the bioproductive indixes: body weight, food ingestion and conversion index.
Using omega-3 fatty acids rich sources in broiler feed modifies the fatty acids profiles for the carcass, yet having different distribution in pectoral muscles and breast skin as follows: for experimental group L3 the fat source for which was linseed oil, the following values were obtained: 43.6 mg/g fat, 145.55 mg/g fat respectively and for L4 (pork fat) 36.9 mg/g fat in pectoral muscles.
Also, using sunflower oil and soy bean oil in broiler feed does not determine an enrichment of the carcasses with omega-3 fatty acids due to the small quantity of fatty acids that they contain, but they modify their profile regarding omega 6, 9 fatty acids as follows: for L1 (sunflower oil) and L2 (soybean oil) 151.45 mg/g and 144 mg/g fat respectively, in pectoral muscles and 151.39 mg/g fat and 151.56 mg/g fat respectively in breast skin.
The results of the present experiment show that the fatty acids profile, linoleic and linolenic, can be influenced by the fat sources incorporated in the baseal diet to modefie fatty acids profile in the breast.

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