Production Parameters, Carcass Development and Blood Parameters of the Broiler Chicks Fed Diets Which Include Rapeseed, Flax, Grape and Buckthorn Meals

Petru Alexandru Vlaicu[1*], Tatiana Dumitra Panaite[1], Margareta Olteanu[1], Mariana Ropota[1], Virgil Criste[2], Gabriela Vasile[2], Iulian Grosu[1]

[1]*National Research-Development Institute for Biology and Animal Nutrition (IBNA), Balotesti, Romania*
[2]*National Research Institute for Industrial Ecology (ECOIND), Bucharest, Romania*

Abstract

A feeding trial was performed on 75, day-old ROSS 308 chicks assigned to 3 groups (C, E1 and E2) to test new feeding solutions for broilers using oil industry by-products. In the starter phase (0-10 days), all chicks received a conventional compound feed. In the other two stages (growing, finishing), compared to the conventional diet given to the C group, the diet formulations of the experimental groups included different proportions, depending on the phase of development, rapeseeds meal and grape pomace (E1) and flaxseeds meal and buckthorn meal (E2). The compound feed for group E2 had significantly (P≤0.05) higher ω-3 PUFA concentrations than groups C and E1. Six blood samples/group were collected in the end of the feeding trial, used for biochemical and haematological determinations. Six chicks/group were slaughtered on day 42, to measure carcass and internal organs development. The feed intake and gains were monitored throughout the experimental period (10-42 days). At 42 days, E2 broiler chicks had significantly (P≤0.05) lower body weight than C broiler chicks. Serum glycaemia, cholesterol and trygliceride concentrations were significantly (P≤0.05) lower in E2 chicks than in C chicks, by 17.94 %, 25.70 % and 42.05%, respectively.

Keywords: blood parameters, broilers, by-products, carcass development, performance

1. Introduction

The impressive development of the poultry meat industry is the outcome of technological processes of growth, feeding and health, considerable investments being available in the private sector. The increasing purchases were stimulated by the increased in comes and led to lower prices for poultry in India [1]. Plants have been used for centuries as food and for medicinal purposes. The World Health Organisation estimated that 80% of Earth inhabitants rely on traditional medicines for their basic healthcare, and most of these therapies involve the use of plant extracts or of their active components, which are perceived by the consumers as “natural” and “safe”. The plants or products, including the plant extracts, essential oils or components of the essential oils, are alternative growth promoters already used in practice [2].

According to Biswas et al., 2010 [3], leaves, seeds and fruit residues of sea buckthorn have potential as a feed material for livestock and poultry. The fruit and leaves are rich in nutrients and bioactive components as vitamins [4, 5], amino acids [6, 7], lipids [8, 9] sugars and acids [10], and flavonoids [11]. Some studies have shown it has antioxidants [12, 13]. It is rich in carotenoids, xanthophylls, phenolics and flavonoids and has a high content of essential oils [14, 15]. Grape seed meals contain lipid, protein, carbohydrates, and 5-8% of polyphenols depending on the variety [16]. It has

* Corresponding author: Petru Alexandru Vlaicu
Tel: 0040755650467
Email: alexandru.vlaicu@outlook.com

also been reported that the grape polyphenols exhibit more antioxidant and thermos stability properties [17] but also have the potential to replace vitamin E as an antioxidant. It has been demonstrated that dietary fiber components may reduce protein and energy digestibilities in diets containing high levels of rapeseed meal [18-20]. Rapeseed meal derived from new and improved varieties is low in glucosinolate content, and therefore could effectively substitute soybean meal (SBM) in poultry diets. However, an excessive level of rapeseed meal, and thus high dietary glucosinolate content, could lead to hypothyroidism, abnormalities in thyroid function and liver enzyme activity, and leg, liver, and heart disorders [21].

The increasing demand for poultry meat prompted the nutritionists to enhance the rate of poultry exploitation, although several studies documented that a fast growth rate has adverse effects on meat quality [22], particularly in terms of higher abdominal adipose tissue, lower intramuscular fat (IMF) and lower polyunsaturated fatty acids (PUFA) [23, 24]. Meat quality is closely related to the distribution and composition of the fat within the body of the bird. The purpose of the experiment was to determine the effects of the food industry vegetal by-products given to broilers. Four by-products (rapeseeds meal, flax meal, grape meal and buckthorn meal) with different properties were tested during a feeding trial on broilers, monitoring broiler performance, carcass development and broiler welfare.

2. Materials and methods

A feeding trial was conducted on 75, ROSS 308 broiler chickens during the age period 0-42 days. The experiment was performed in agreement with the Romanian laws (Law 206/2004, ordinance 28/31.08.2011, Law 43/11.04.2014, Directive 2010/63/EU). The day-old chicks were weighed individually and assigned to 3 groups (C, E1 and E2), homogenous as body weight: 42.39±0.18g (C); 42.616±0.24g (E1); 42.748±0.21g (E2). The chicks were housed in an experimental hall with controlled environmental conditions, according to ROSS 308 management guide: average temperature 27.07±2.75^{o}C; humidity 64.80±9.57%; ventilation/broiler 0.50±0.24%; CO2 concentration 686.39±104.38 ppm was below the maximal level set by the "Sanitary-veterinary norm setting the minimal protection norms for broiler chicken, approved by Order 30/2010". The ammonia (NH3) concentration was measured with a portable device (Automatic analyser MultiRAE), the values being under the detection limit of the instrument. The chicken had free access to the feed and water.

The diet was formulated on the basis of the chemical analysis of the feed ingredients, in agreement with the feed requirements [25] using a mathematical model for poultry diets formulation. For 10 days, in the first phase (starter), all chicks received a conventional compound feeds formulation which provides a good appetite necessary to reach the standard bodyweight at 7 days. For the other two phases (grower and finisher), unlike the conventional formulation given to group C, the formulations for groups E1 and E2 included different proportions, depending on the growth stage, of the studied by-products (Table 1).

One batch/group/phase was manufactured in the pilot station of IBNA, the bags being labelled for each group/phase, and stored, under special conditions of humidity and temperature, in the storage facilities. Before labelling the bags, compound feeds samples (500 g/group) were collected and assayed chemically to determine the concentration of minerals and fatty acids. Because the compound feeds had a high level of fat (Table 1), fat quality had to be determined. Standardised methods (according to ISO and to Regulation CE 152/2009) were used to determine the concentration of the main nutrients (dry matter, protein, fat, fibre, ash, cadmium, chromium, copper, iron, manganese, nickel, lead, selenium and zinc), as follows: dry matter (DM), by the gravimetric method, drying at 1030C, using Sartorius scales and BMT drying oven, ECOCELL Blueline Comfort; crude protein (CP), by Kjeldahl, method using the semiautomatic KJELTEC auto 2300 system – Tecator (Sweden); ether extractives (EE) by extraction in organic solvents, with SOXTEC-2055 FOSS system – Tecator (Sweden); crude fibre (CF) by the method with intermediary filtration, using FIBERTEC 2010 system – Tecator; ash (Ash) by the gravimetric method, using Caloris CL 1206 furnace; the minerals (arsenic, cadmium, chromium, copper, iron, manganese, nickel, lead, selenium and zinc) were determined by

inductively coupled plasma optical emission spectrometry, using Optima 5300 DV Perkin Elmer ICP-EOS spectrometer. The fatty acids were determined by gas chromatography by transforming the fatty acids from the sample in methyl esters, followed by component separation in capillary column, identification by comparison with standard chromatograms and quantitative determination of the fatty acids according to SR CEN ISO/TS 17764 -2: 2008, using Perkin Elmer-Clarus 500 gas chromatograph, with capillary column injection system, high polarity stationary phase (BPX70: 60m x 0.25 mm inner diameter and 0.25µm thick film).

Table 1. Compound feeds formulation

Ingredient	Phase II – grower (14 – 28 days)			Phase III – finisher (28 – 42 days)		
	C	E1	E2	C	E1	E2
	%					
Corn	51.32	46.1	50.22	60.23	51.98	59.61
Soybean meal	38.32	32.6	35.54	30.04	24.29	23.26
Rapeseeds meal	-	8.00	-	-	8.00	-
Grape meal	-	2.00	-	-	4.00	-
Buckthorn meal	-	-	2.00	-	-	2.00
Flax meal	-	-	2.50	-	-	8.00
Vegetal oil	5.73	6.90	5.04	5.16	7.45	2,41
Lysine	0.02	0.05	0.13	0.11	0.14	0,36
Methionine	0.25	0.21	0.29	0.23	0.20	0.32
Choline	0.05	0.05	0.05	0.05	0.05	0.05
Calcium carbonate	1.67	1.46	1.58	1.63	1.35	1.45
Monocalcium phosphate	1.23	1.22	1.24	1.17	1.15	1.15
Salt	0.41	0.41	0.41	0.38	0.39	0.39
Premix	1.00	1.00	1.00	1.00	1.00	1.00
Total	100	100	100	100	100	100
Calculated						
ME, kcal/kg	3.150.80	3.211.99	3.150.99	3.200.94	3.200.86	3.200.42
CP, %	22.00	22.00	22.00	19.00	19.00	19.00
EE, %	7.53	8.71	7.31	7.06	9.37	5.64
CF, %	3.68	4.80	4.50	3.49	5.00	5.00
Lysine	1.24	1.24	1.24	1.09	1.09	1.09
Methionine	0.59	0.56	0.61	0.53	0.51	0.58
Met.+cyst.	0.95	0.95	0.95	0.85	0.85	0.85
Threonine	0.86	0.86	0.84	0.74	0.74	0.74
Tryptophan	0.25	0.25	0.23	0.21	0.20	0.17
Linoleic acid (c18:2)	0.83	0.74	3.89	1.23	0.79	9,48

1kg IBNA premix (A1) contains:=1100000 IU/kg vit. A; 200000 IU/kg vit. D3; 2700 IU/kg vit. E; 300 mg/kg Vit. K; 200 mg/kg Vit. B1; 400 mg/kg Vit. B2; 1485 mg/kg pantothenic acid; 2700 mg/kg nicotinic acid; 300 mg/kg Vit. B6; 4 mg/kg Vit. B7; 100 mg/kg Vit. B9; 1.8 mg/kg Vit. B12; 2000 mg/kg Vit. C; 8000 mg/kg manganese; 8000 mg/kg iron; 500 mg/kg copper; 6000 mg/kg zinc; 37 mg/kg cobalt; 152 mg/kg iodine; 18 mg/kg selenium; 6000 mg/kg antioxidant.

For the biochemical parameters we collected 1-2 mL venous blood, in vacutainer with not anticoagulant, with no separating el (red cap) for cholesterol, glycaemia and triglyceride assessment through spectrophotometry. The following parameters were determined for the blood count, which show the health state of the birds: haemoglobin (Hgb) concentration; haematocrit (Hct); leucocytes (WBC); blood morphology on smears: heterophils, lymphocytes, monocytes, eosinophils, basophiles (HPF); we collected 1–3 mL venous blood (depending on vacutainer volume), in vacutainers with EDTA (violet caps) and used ADVIA 2120i – Siemens: automat analyser of reference for veterinary haematology, based on flow cytometry, with peroxidase reaction and laser detection. The optical microscope was used to examine the blood smears. The following parameters were monitored throughout the experimental period: body weight (g), average

daily weight gain (g/chick/day), total gain (kg); average daily compound feed intake (g CF/chick/day), feed conversion ratio (g feed/g gain). In order to determine the influence of the dietary vegetal by-products given to broilers, in the end of the feeding trial, according to the working protocol approved by the Ethics Commission of the institute, blood sample were collected in green cap tubes (6 samples /group) for biochemical determinations. After blood sampling, the chicks were slaughtered and samples were collected to determine the development of the carcass and of the internal organs. The analytical data were compared using variance analysis (ANOVA) with STATVIEW for Windows (SAS, version 6.0). The experimental results were expressed as mean values ± standard deviation, the differences being considered statistically significant for $P < 0.05$.

3. Results and discussion

The results of the chemical analysis of the compound feeds (Table 2) showed that the compound feeds for both the growing and finishing stages were balanced as energy and protein content. The dietary concentrations of heavy metals (Table 2) were below the maximal admitted levels set by Order 358/2003*.

Table 2. Chemical composition of the compound feeds

Ingredient	Phase II–grower (14–28 days)			Phase III–finisher (28–42 days)		
	C	E1	E2	C	E1	E2
	%					
Basic chemical composition						
Dry matter (DM), %	89.17	89.03	88.81	89.10	89.40	88.92
Organic matter (OM), %	83.57	83.29	82.78	83.08	83.99	83.63
Crude protein (CP), %	22.62	20.79	22.20	18.80	19.53	18.81
Ether extractives (EE), %	7.51	8.41	6.95	7.22	9.56	6.06
Fibre (CF), %	4.06	5.88	4.03	3.87	5.66	4.62
Ash (Ash), %	5.60	5.74	6.03	6.02	5.41	5.29
Nitrogen-free extractives (NFE), %	49.38	48.21	49.6	53.19	49.24	54.14
Metallic contaminants *						
Iron (Fe), mg/kg DM	39.6	216	507	305	198	780
Manganese (Mn), mg/kg DM	116	127	139	125	127	135
Arsenic (As), mg/kg DM	1.67	0.85	0.77	<0.13	<0.13	<0.13
Cadmium (Cd), mg/kg DM	0.1	<0.02	0.12	0.2	0.1	0.12
Chromium (Cr), mg/kg DM	4.36	3.57	4.39	6.26	4.1	3.26
Copper (Cu), mg/kg DM	13.6	77	12.7	10.7	13.8	9.27
Plumb(Pb), mg/kg DM	0.75	0.66	1.23	0.91	0.7	1.28
Nickel (Ni), mg/kg DM	10.1	9.52	12.8	4.85	3.96	4.54
Selenium (Se), mg/kg DM	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Zinc (Zn), mg/kg DM	103	104	105	127	125	130

* Norms regarding the quality and salubriousness parameters for the production, import, quality inspection, selling and using simple concentrate feeds, compound feeds, feed additives, premixes, energy substances, minerals and special feeds.

Table 3 shows that the concentration of omega 3 polyunsaturated fatty acids was significantly ($P \leq 0.05$) higher in the compound feeds formulation which included buckthorn and flax meals (E2), than in the formulations for groups C and E1. The concentration of α linolenic acid (omega 3 PUFA) was 468.67% (phase II grower, Table 3) and 770.73% (phase III – finisher, Table 3) in E2 compound feed, than in the compound feed for group C. These increases are correlated, in the case of group E2, with the dietary level of flax meal: 2.5% (grower) and 8% (finisher).

Table 3 also shows that omega 6 PUFA/omega 3 PUFA ratio was 23.29% (grower) and 13.10 % (finisher) lower in E2 diet than in C diet. The corresponding values for group E2 were higher than for group C in both phases.

Table 3. Fatty acids concentration in the compound feeds

Fatty acids		Phase II–grower (14–28 days)			Phase III–finisher (28–42 days)		
		C	E1	E2	C	E1	E2
		G FAME/100g total FAME					
Caproic	C 6:0	0.06	0.05	0.05	0.19	0.27	0.21
Caprylic	C 8:0	0.18	0.15	0.27	0.07	0.10	0.09
Capric	C 10:0	0.07	0.06	0.11	-	-	0.04
Myristic	C 14:0	0.26	0.24	0.32	0.25	0.31	0.29
Pentadecanoic	C 15:0	0.04	0.04	-	-	-	0.06
Palmitic	C 16:0	8.77	8.44	9.52	10.15	9.53	10.57
Palmitoleic	C 16:1	0.20	0.21	0.55	0.17	0.17	0.61
Heptadecanoic	C 17:0	0.06	0.05	-	-	-	-
Stearic	C 18:0	2.71	2.63	2.67	2.51	2.60	2.65
Oleic cis	C 18:1	28.04	28.52	27.70	29.15	29.08	27.63
Linoleic cis	C 18:2	57.48	57.88	53.91	55.36	56.00	47.34
Linolenic α	C 18:3n3	0.83	0.74	3.89	1.23	0.79	9.48
Octadecatetraenoic	C18:4n3	0.20	0.18	0.24	0.25	0.23	0.23
Eicosadienoic	C20 (2n6)	0.15	0.17	0.14	0.23	0.17	0.17
Arachidonic	C20 (4n6)	0.43	0.22	0.19	-	0.42	0.32
Other fatty acids		0.53	0.42	0.44	0.44	0.32	0.31
Fatty acids profile							
Σ SFA		12.15	11.66	12.94	13.17	12.81	13.91
Σ MUFA		28.24	28.73	28.25	29.32	29.25	28.24
Σ PUFA, of which		59.09	59.20	58.37	57.07	57.62	57.54
Σ Ω:3		1.03	0.92	4.13	1.48	1.02	9.71
Σ Ω:6		58.06	58.27	54.24	55.59	56.60	47.83
Ω:6/ Ω:3		56.36	63.31	13.13	37.69	55.25	4.92

Σ= sum; PUFA = polyunsaturated fatty acids.

Although E2 diet formulation had high concentrations of polyunsaturated fatty acid, the fat degradation indices determined 14 days after CF manufacture in both experimental feeds, were comparable with those for group C (Table 4).

Table 4. Compound feeds fat degradation indices

(14 days after CF manufacture) Specification		Peroxide value (ml thiosulfate 0.01 Ng/gr	Fat acidity (mg KOH)	Kreiss reaction
Phase II (grower)	CF C	0.34	4.99	negative
	CF E1	0.25	5.12	negative
	CF E2	0.34	4.64	negative
Phase III (finisher)	CF C	0.53	11.65	negative
	CF E1	0.51	11	negative
	CF E2	0.55	12	negative

Broiler performance (Table 5) in phase II didn't show statistically significant (P≤0.05) differences for any of the measured parameters. In absolute values, the data for group C were slightly higher than those for the experimental groups, but not statistically significant. Significant differences were noticed, however, during phase III (finisher) regarding the live weight at 42 days, the average daily feed intake and the feed conversion ratio.

Thus, the final weight of E2 broilers was significantly (P≤0.05) lower than the final weight of C broilers (by 8.57%) and E1 broilers (by 5.91%). The average daily feed intake of group E2 was 5.32% lower than for group C and 4.38% lower than for group E1, which decreased

significantly the feed conversion ratio in favour of group C (1.738±0.051 kg CF/kg gain) vs. group E2 (2.052±0.200 kg CF/kg gain). The data regarding intakes are correlated with the body weight evolution data. The final bodyweight of E2 broilers was significantly (P≤0.05) lower than that of group C broilers, by 9.37% (Table 5). These results are in agreement with those reported by Ziyad Ben-Mahmoud et al., 2014, [26] who used buckthorn fruit residues in broiler diets. Table 5 data also show that E2 diet formulation (with flax meal and buckthorn meal) decreased significantly (P≤0.05) the average daily feed intake and increased the feed conversion ratio compared to C diet formulation. Similar results were reported by Murakami et al., 2009; 2010 [27, 28]. These studies showed that the broilers treated with a diet which included flax oil had lower average daily feed intakes [28] and a higher feed conversion ratio (1-42 days) [27]. At the present there is limited research on feeding sea buckthorn fruits in animal nutrition [29]. Nevertheless, it has been shown that sea buckthorn fruits and residues are suitable for animal feeding [30]. The body weight of livestock and poultry were increased considerably after feeding with leaves, seeds and fruit residues of sea buckthorn [31, 32, 3].

Table 5. Broiler performance (average values/group)

Specification	C	E1	E2
Phase II, grower (14 – 28 days)			
Initial weight	422.72±53.64	404.00±60.00	406.80±54.97
Final weight	1306.36±146.72	1263.33±164.30	1248.80±187.04
Total gain (kg)	883.63±166.80	855.41±178.00	842.00±207.34
Average daily weight gain (g)	63.11±11.91	61.10±12.71	60.14±14.80
Average daily fed intake (g CF/broiler/day)	79.42±22.32	77.30±22.59	76.56±21.10
Feed conversion ratio (kg CF/kg gain)	1.375±0.056	1.476±0.199	1.406±0.056
Phase III, finisher (28 – 42 days)			
Initial weight	1306.36±146.72	1263.33±164.30	1248.80±187.04
Final weight	2435.71 ±246.2^{c}	2366.96 ±267.5	2226.96 ±271.0^{a}
Total gain (kg)	1134.29±297.16	1103.48±343.22	1011.30±320.64
Average daily weight gain (g)	81.02±21.23	78.82±24.52	72.23±22.90
Average daily fed intake (g CF/broiler/day)	142.954±15.537^{c}	141.547±12.395	135.343±14.281^{a}
Feed conversion ratio (kg CF/kg gain)	1.738±0.051^{c}	1.864±0.144	2.052±0.200^{a}
Overall broiler performance - 14-42 days (grower - finisher)			
Initial weight	422.72±53.64	404.00±60.00	406.80±54.97
Final weight	2435.71 ±246.2^{c}	2366.96 ±267,5	2226.96 ± 271.0^{a}
Total gain (kg)	2013.33±250.5 ^{c}	1978.63±295.3	1824.28±286.7 ^{a}
Average daily weight gain (g)	71.90±8.94 ^{c}	70.67±10.54	65.15±10.24 ^{a}
Average daily fed intake (g CF/broiler/day)	115.309±32.536	113.669±32.053	109.93±29.92
Feed conversion ratio (kg CF/kg gain)	1.585±0.025	1.692±0.172	1.744±0.129

*Where a,b,c, = significant differences (P≤0.05) compared to C, E1, E2.

A number of 6 broilers/group were slaughtered in the end of the experiment, to make measurements on carcass and organ development (Table 6). Blood samples were collected before slaughter to determine the health state of the broilers by biochemical and haematological determinations (Table7). Recent studies have showed the importance of plant materials by-products that are

particularly rich in polyphenols and have a wide range of biological activities. The inclusion of grape flavonoids causes a diminution of tissue lipid peroxidation in kidney, liver, and lung [33, 34].

Table 6. Physical measurements performed after broiler slaughter (age of 42 days)

Specification	C	E1	E2
Live bodyweight, (g)	2360±90.55[c]	2280±164.07	2191.67±62.74 [a]
Slaughtered broiler weight, (g)	2010±89.89 [c]	1960±169.12	1860±72.94 [a]
Carcass weight, (g)	1761.67±79.3 [c]	1701.67±151.7	1598.33±75.48 [a]
Liver, (g)	40.20±4.38	41.08±4.50	40.95±2.25
Thigh, (g)	224.73±16.16 [c]	225.08±19.63 [c]	201.28±11.9 [a,b]
Breast, (g)	249.02±16.06 [c]	226.70±30.34	219.55±13.35 [a]
Breast, width, (cm)	15.17±0.75	15.33±0.52	15.17±0.75
Breast, length, (cm)	17.17±2.04	18.33±1.37	17.00±1.79

* Where a,b,c, = significant differences (P≤0.05) compared to C, E1, E2.

Table 7. Biochemical and haematological parameters (average values/group)

Specification	C	E1	E2
Serum biochemical parameters			
Energy plasma profile			
Glycaemia, (mg/dl)	234.07±8.66 [c]	233.27±9.10[c]	192.08±44.54[a,b]
Cholesterol, (mg/dl)	106.02±15.02 [c]	108.53±5.32 [c]	78.77±23.72 [a,b]
Triglycerides, (mg/dl)	40.00±9.30 [b]	27.87±4.69 [a]	23.18±6.63 [a]
Protein profile			
Total protein, (g/dl)	2.64±0.11 [c]	2.57±0.13	2.25±0.40 [a]
Albumin, (mg/dl)	1.54±0.07 [c]	1.40±0.10	1.27±0.17 [a]
Total bilirubin, (mg/dl)	0.58±0.17	0.61±0.06	0.59±0.24
Creatinine, (mg/dl)	0.41±0.15	0.31±0.06	0.37±0.16
Urea, (mg/dl)	2.18±0.42	1.97±0.42	1.91±0.50
Mineral profile			
Calcium, (mg/dl)	10.80±0.66 [c]	10.17±0.56	9.41±1.29 [a]
phosphorus, (mg/dl)	5.79±0.58	5.35±0.49	4.93±0.92
Magnesium, (mg/dl)	1.45±0.12	1.34±0.08	1.32±0.26
Iron, (ug/dl)	103.13±5.54	108.55±9.32 [c]	88.65±19.34 [b]
Enzyme profile			
Alt (TGP), U/L	37.71±11.44 [c]	31.43±3.73	26.99±2.17 [a]
Ast (TGO), U/L	313.45±49.05[c]	284.28±61.07 [c]	157.32±54.92[a,b]
Alkaline phosphatase, U/L	46.99±7.37	47.77±3.13	46.97±3.93
Gama GT, U/L	18.52±1.96 [c]	20.72±2.76 [c]	28.48±12.83 [a,b]
LDH, U/L	1456.63±311.74[c]	1150.87±180.78	832.48±210.64[a]
Haematological parameters **			
Haemoglobin, (HGB), g/dL	8.075±0.35	8.012±0.81	8.043±0.60
Haematocrit (HCT), (%)	32.50±2,43	29.50±2.43	30,00±3.22
Leucocytes (WBC), (K/µL)	21.27±4.96	23.23±1.87	21,50±3.18
Heterophils, (K/µL)	9.38±2.44	11.48±1.46	10.18±0.91
Lymphocyte, (K/µL)	10,27±2,41	10.88±1.95	10.46±2.64
Monocytes, (K/µL)	0.56±0.38	0.47±0.16	0,27±0,12
Eosinophils, (K/µL)	1.03±0.56[b]	0.42±0.21[a]	0.73±0.78
Thrombocytes (HPF), (K/µL)	5-10	5-10	5-10

* Where a,b,c, = significant differences (P≤0.05) compared to C, E1, E2.

**reference values according to: Weiss D.J., Wardrop K.J. - Schalm's Veterinary Hematology, 6th Ed., 2010, Ed. Blackwell, pp. 965 and Jain, 1993

Table 6 shows the results of the measurements on carcass and liver development. The slaughtered broilers had an average live body weight of: 2360±90.55 g (C); 2280±164.07 (E1); and

2191.67±62.74 g (E2); bodyweight was significantly (P≤0.05) different between groups C, and E2. The were no significant (P≤0.05) differences between groups regarding the average carcass weight (g), except group E2 whose carcass weight was 9.3% lower than the average carcass weight of group C (Table 6). From the same table it can be noticed that in group E2, the live weight (g/broiler) influenced the weight of the anatomical parts. The biochemical parameters determined in the serum (Table 7) revealed several benefits of feeding the broilers with compound feeds that included vegetal by-products. Thus all the parameters of the energy plasma profile (glycaemia, cholesterol and triglycerides) were significantly (P≤0.05) lower compared to group C. The most significant (P≤0.05) decrease was noticed in group E2 for triglycerides (42.05%), followed by cholesterol (25.70%) and glycaemia (17.94%). This is due to the dietary flax meal, which is rich in polyunsaturated fatty acids, particularly omega 3 (43.42%), and which has a major influence on the blood triglycerides and cholesterol levels.

The same trend was noticed in the enzymatic profile, where LDH concentration (intracellular enzyme widely spread within the organism, with a role in confirming the diagnosis of myocardium or lung infarct) was significantly (P≤0.05) lower than in group C, in group E2<E1 (Table 7).

The values determined for the haematological parameters, which show the health state of the broilers (Table 7) ranged within the normal values reported in the literature [35, 36].

4. Conclusions

The analysed compound feeds have no risk to broiler health and have no potential adverse environmental impact. From the new feeding solutions for broilers, the formulation which included buckthorn and flax meals (E2) produced the highest concentrations of omega 3 polyunsaturated fatty acids, significantly (P≤0.05) higher than in C and in E1. Omega 6 PUFA / omega 3 PUFA ration in E2 diet was significantly lower compared to group C: by 23.29 % (grower), and 13.10 % (finisher). Also, in the group E2 the serum cholesterol concentration decreased by 25.7% compared to group C respectively with 27.4% compared with group E1 (rapeseed meal and meal grape).

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