EFFECTS OF DIFFERENT LEVELS OF RAPE SEEDS IN THE DIET ON PERFORMANCE, BLOOD AND BONE PARAMETERS OF BROILER CHICKENS

WPŁYW RÓŻNEGO POZIOMU NASION RZEPAKU W DIECIE NA WSKAŹNIKI PRODUKCYJNE, PARAMETRY KRWI I KOŚCI KURCZĄT BROJLERÓW

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ABSTRACT

The aim of the study was to investigate the effects of different levels of rape „00" seeds in the diet on the performance, blood and bone parameters of broilers. A total of 180 1-day-old male Ross 308 chicks were divided into four groups. Group I (the control) was fed on a maize, wheat and soybean diet. Different levels of rape seeds were used in the experimental diets (low, medium and high level in II, III and IV groups, respectively) instead of a soybean meal. The amount of MJ AME_N from rape seeds in total AME_N was as follows: 0.19-1.51 group II, 0.28-2.26 group III and 0.38-3.01 group IV. The highest level of rape seeds resulted in a lower ($P<0.05$) body weight gain. The birds from group IV had the lowest feed intake and the poorest ($P<0.05$) value of FCR at 21 d. The highest level of rape seeds positively influenced ($P<0.05$) the content of HDL. There were no differences in protein metabolism indices, VLDL, Ca, Pi, bone resistance parameters among dietary treatments at 37 day of age. The results demonstrated that the influence of the increasing level of dietary rape seeds on performance, blood and bone parameters was much more evident in younger birds.

KEY WORDS: rape seeds, broiler, performance, serum indices, bone

STRESZCZENIE

Celem badań było określenie wpływu różnego poziomu nasion rzepaku "00" w diecie na wskaźniki produkcyjne, parametry krwi i kości kurcząt brojlerów. 180 jednodniowych kogutków Ross 308 podzielona na 4 grupy. Grupę I (kontrolną) żywiono dietą kukurydziano-pszenno-sojową. W dietach eksperymentalnych w miejsce śruty sojowej wprowadzono różne poziomy nasion rzepaku (niski, średni i wysoki, odpowiednio w grupach II, III i IV). Udział MJ AME_N z nasion rzepaku w całkowitej AME_N wynosił: 0.19-1.51 grupa II, 0.28-2.26 grupa III i 0.38-3.01 grupa IV. Najwyższy poziom rzepaku obniżył ($P<0,05$) przyrosty masy ciała. Ptaki z grupy IV charakteryzowały się najmniejszym pobraniem paszy i najwyższym wskaźnikiem FCR w 21 dniu. Najwyższy poziom rzepaku korzystnie wpłynął ($P<0,05$) na zawartość HDL. Nie stwierdzono różnic w poziomie wskaźników przemiany białkowej, VLDL, Ca, Pi i w parametrach wytrzymałościowych kości w 37 dniu życia. Uzyskane wyniki wykazały, że wpływ wzrastającego poziomu nasion rzepaku w diecie na wskaźniki produkcyjne, parametry krwi i kości silniej zaznacza się u ptaków młodszych.

SŁOWA KLUCZOWE: nasiona rzepaku, brojler, wskaźniki produkcyjne, parametry krwi, kości

STRESZCZENIE SZCZEGÓŁOWE

Celem badań było określenie wpływu różnego poziomu pełnotłustych nasion rzepaku "00" na wskaźniki produkcyjne, parametry krwi i wskaźniki wytrzymałościowe kości kurcząt. Badania przeprowadzono na 180 jednodniowych kogutkach Ross 308. Ptaki podzielono na 4 grupy żywieniowe (3 powtórzenia, 15 kurcząt w klatce). Kogutki żywiono ad libitum izokalorycznymi i izobiałkowymi dietami: starter I do 7 dnia (d), starter II od 8 do 21 d, grower od 22 do 33 d i finiszer od 34 do 37 d odchowu. Grupę I – kontrolną – żywiono mieszankami kukurydziano-pszenno-sojowymi (Tabela 1). W dietach doświadczalnych, w miejsce śruty sojowej, wprowadzono różne poziomy nasion rzepaku "00" (niski, średni i wysoki, odpowiednio w grupach II, III i IV). W każdym kolejnym okresie żywieniowym (Starter I, Starter II, Grower, Finiszer) ilość EM z nasion rzepaku wzrastała dwukrotnie w stosunku do okresu poprzedniego i wynosiła odpowiednio: 0,19-1,51 grupa II, 0,28-2,26 grupa III i 0,38-3,01 MJ grupa IV (Tabela 2). W 21 i 37 d życia kurczęta ważono i określano przyrosty masy ciała, wykorzystanie paszy (FCR) oraz Europejski Wskaźnik Efektywności (EEI). W tych samych dniach od 10 ptaków z każdej grupy pobierano krew i po uboju wypreparowano kości udowe. Przy użyciu fotometru Epoll 20 oznaczono wskaźniki biochemiczne krwi, wyliczono zawartość LDL i VLDL [3] oraz określono parametry wytrzymałościowe kości z wykorzystaniem Instron 8874. Wyniki poddano analizie statystycznej z zastosowaniem jednoczynnikowej analizy wariancji (ANOVA) i testu post hoc Duncana ($P<0,05$). Kurczęta utrzymywane na dietach z najwyższym poziomem nasion rzepaku (0,38-3,01 MJ EM) uzyskały istotnie niższe przyrosty masy ciała pomiędzy 1-21 d (763 g) i w całym okresie odchowu (2050 g) w porównaniu do pozostałych grup żywieniowych (odpowiednio 808-838 g i 2161-2229 g) (Tabela 3). Jednocześnie, w całym okresie odchowu, kurczęta z grupy IV pobierały najmniejsze ($P<0,05$) ilości paszy. W okresie 1-21 d największe ($P<0,05$) zużycie paszy na 1 kg przyrostu stwierdzono w grupie IV (1,447 kg kg^{-1}). Wartości wskaźnika EEI były relatywnie wysokie i zbliżone dla kogutków kontrolnych i doświadczalnych (372 i 345-369). Diety eksperymentalne nie wpłynęły w stopniu istotnym na zawartość białka ogólnego i albumin w 21 d. Zawartość kreatyniny była istotnie mniejsza u ptaków żywionych dietami z największą ilością nasion rzepaku (15,91 µmol l^{-1}). Badane wskaźniki przemiany białkowej w 37 d życia nie różniły się istotnie. U kurcząt z grup doświadczalnych w obu przedziałach wiekowych stwierdzono nieznacznie wyższy poziom triglicerydów (1,39-1,67 mmol l^{-1}) w porównaniu do grupy kontrolnej (1,14-1,35 mmol l^{-1}). Ptaki z grupy IV charakteryzowały się najwyższym poziomem cholesterolu całkowitego i frakcji HDL (2,87 i 1,34 mmol l^{-1}) w 37 d odchowu. U kogutków z grup doświadczalnych odnotowano niższe poziomy frakcji LDL w porównaniu do ptaków kontrolnych (odpowiednio 24,3-30.3 i 40,9 % TCHL). Rodzaj diety nie wpłynął istotnie na zawartość VLDL, Ca i Pi oraz na wartość maksymalnej siły obciążającej (Fmax) i wielkość ugięcia kości przy Fmax (U) (Tabela 5) w 37 d życia kurcząt.

Uzyskane wyniki wykazały, że wysoki poziom (0,38-3,01 MJ EM) nasion rzepaku w mieszankach dla kurcząt brojlerów prowadzi do ograniczenia pobierania paszy i zmniejszenia przyrostów masy ciała, co silniej zaznacza się u ptaków młodszych. Nasiona rzepaku w dietach dla brojlerów nie wpływają na wskaźniki przemiany białkowej i mineralnej w krwi, natomiast korzystnie oddziałują na frakcje lipoprotein.

INTRODUCTION

Researchers have been concerned over the recent years to find solutions for poultry feeding which would support high broiler performance at lower feeding costs. Rape seeds can be economically justified to be used as a plant protein substitute for part of a soybean meal protein [5, 6, 18, 22, 23]. Full-fat rape seeds contain approximately 40% oil and 22% protein and are, therefore, a valuable source of energy and protein for poultry diets. Rape seeds protein has a physiologically suitable amino acids composition, including high content of essential amino acids like lysine, threonine, tryptophan and sulphur containing amino acids [15, 19]. Moreover, its oil is rich in unsaturated fatty acids like omega-3 fatty acids which are currently of interest in animal nutrition because of possible health promoting effects [5, 19]. However, rape seeds contain nutritionally unfavorable substances such as glucosinolates, sinapin, tannin and phytate which may negatively influence many physiological processes and a health status by reducing the level of thyroid hormones, decreasing mineral absorption and changing the activities of liver enzymes in the blood of poultry [5, 21, 24]. The results of experiments on using full-fat rape seeds in broiler chicken feeding are diversified and they mainly depend on the amount of rape seeds incorporated into the diet [1, 8, 11, 13, 14, 18, 22, 23]. According to some authors, the already low proportions of rape "00"seeds reduce the broiler performance data significantly, which is still more intensified with higher proportions of rape seeds in mixtures [7, 18, 23].

The present study was conducted to investigate the effects of the replacement of a soybean meal with different levels of full-fat "00" rape seeds on the performance, selected

parameters of protein, lipid and mineral metabolism in the blood serum as well as bone resistance indices in broiler chickens.

MATERIAL AND METHODS

BIRDS AND DIETS

A total of 180, 1-day-old male Ross 308 meat-type chickens were obtained from a commercial hatchery. After delivering the birds to an experimental hen house, they were individually weighed and placed randomly in 12 cages (15 chicks per pen; floor space: 0.56 m^2) with litter – free floor covered with a mat made of cast plastic. The chicks had a similar initial body weight (43.0 – 43.3 g) so that each pen of chicks had a similar weight distribution. The hen house had automatically controlled temperature, humidity and air exchange. The birds were provided with continuous light. The rearing was conducted according to the technological recommendations for the breed. During the experiment, chickens' health was monitored.

There were four dietary treatments (experimental groups) with three replicates (pens) each. During 37 days of the experiment, all the birds were fed ad libitum with isocaloric and isonitrogenous diets formulated to meet or exceed the minimum nutrient requirements for broiler chickens [12]. All chicks were fed: starter I up to 7 day (d), starter II from 7 to 21 d, grower from 22 to 33 d and finisher diets from 34 to 37 d. The calculated nutrient content in the basal diets is presented in Table 1. Group I – the control – was fed on a typical mixed maize, wheat and soybean diet (basal diets). Different levels of full-fat rape "00" seeds were used in the experimental diets (low, medium and high level in II, III, IV groups, respectively) instead of a soybean meal. The share of AME_N and crude protein from rape seeds in dietary total metabolizable energy and protein in experimental diets is presented in Table 2. In every subsequent feeding period (Starter I, Starter II, Grower, Finisher), the amount of AME_N from rape seeds increased twice compared to the previous period. The content of crude protein from rape

Table1. Calculated nutrient content in the basal diets [%]
Tabela 1. Wyliczona zawartość składników pokarmowych w dietach bazowych [%]

Nutrient Składnik	Diet Dieta			
	Starter I	Starter II	Grower	Finisher
AME_N, EM_N [MJ kg^{-1}]	12.40	12.70	13.10	13.30
Crude protein, Białko surowe	21.90	21.20	19.40	18.30
Crude fibre, Włókno surowe	3.50	3.60	3.70	3.80
Lys	1.18	1.11	1.11	0.95
Met + cys	0.93	0.86	0.79	0.73
Trp	0.27	0.26	0.24	0.22
Ca total, Ca całkowity	1.02	1.08	0.97	0.90
P available, P przyswajalny	0.43	0.43	0.43	0.40

Table 2. The share of AME_N and crude protein from rape seeds in total AME_N and total protein content in 1 kg of experimental diets
Tabela 2. Udział EM_N i białka surowego pochodzących z nasion rzepaku w całkowitej EM_N i białku ogólnym diet doświadczalnych

Nutrient / diet Składnik / dieta	Group Grupa		
	II	III	IV
AME_N, EM_N [MJ]			
Starter I	0.19	0.28	0.38
Starter II	0.38	0.56	0.76
Grower	0.76	1.13	1.51
Finisher	1.51	2.26	3.01
Crude protein, Białko surowe [%]			
Starter I	0.94	1.41	1.88
Starter II	1.97	2.96	3.94
Grower	4.36	6.54	8.72
Finisher	9.20	13.8	18.4

seeds in the experimental diets increased in proportion to metabolizable energy. The experiment was conducted under a research protocol approved by the Local Ethical Committee in Bydgoszcz, Poland.

DATA COLLECTION

The body weight (BW) of individual chickens within each replicate group and feed intake per pen were recorded 12 h after the removal of feed at 21 and 37 d of age. Mortality was recorded throughout the experiment and used to adjust the feed consumption data. The feed conversion (FCR) was determined as the ratio between the feed intake and weight gain. European Efficiency Index (EEI) was calculated for each pen replicate as follows:

EEI = (livability × live weight, kg / length of rearing period, days × FCR) × 100

At 21 d of age 7 chickens per pen were randomly selected to reduce the number of chicks in each cage, so from that day each group consisted of 24 birds (8 chicks per pen). At 21 and 37 d of age after the body weight measurement, prior to slaughter, blood samples were obtained from the pterygoid canal vein from 10 selected chicks per group. After the birds were killed by cervical dislocation, femoral bones from the left side were dissected immediately.

ANALYTICAL METHODS

After coagulation, blood samples were centrifuged at 3,000 rpm for 10 min, and the obtained serum was stored in a freezer at -20°C for analyses. In the blood serum the content of total protein, albumin, uric acid, creatinine, triglycerides (TG), total cholesterol (TCHL), HDL fraction, calcium (Ca), inorganic phosphorus (Pi) was determined with the use of an Epoll 20 photometer with the original Alpha Diagnostics kits. The content of LDL and VLDL lipoprotein fractions in the blood serum was calculated on the basis of the Friedewald equation [3]. The test of bone strength was conducted in 3-points banding conditions. The bones were arranged on supports in the same position all the time and the distance among supports for 21-day-old chickens was 30 mm and for 37-day-old chickens was 40 mm. The force was applied in the middle of the bone. The speed of the actuator of the hydraulic machine Instron 8874 on which the investigation was conducted carried up 2 mm per minute. The load force (F max) and the size of bones deflection (U) were measured.

STATISTICAL ANALYSIS

The results were analysed statistically with the use of the Statistica 8.0 PL program [20] for the Windows operating system with one way analysis of variance (ANOVA). The post hoc Duncan test was applied. The significance of differences was set at $P<0.05$.

RESULTS AND DISCUSSION

The effects of different levels of full-fat rape seeds on the performance indices in the broiler chickens are presented in Table 3. Full-fat rape seeds resulted in a significant ($P<0.05$) depression in body weight gain at the highest level of inclusion (0.38-3.01 MJ AME_N from rape seeds) during 1-21 d and in the whole experimental period (1-37 d). There were no significant differences among the birds from the control group and the chickens fed the diet with low (0.19-1.51 MJ AME_N from rape seeds) and medium (0.28-2.26 MJ AME_N from rape seeds) level of rape seeds. At the same time, in the whole experimental period, the birds from group IV had the lowest feed intake and the differences were statistically significant ($P<0.05$) in the period of 22-37 d and 1-37 d. The results of the present study demonstrated that increasing level of rape seeds added to the diet for broiler chickens leads to the gradual reduction of feed intake. Compared to the birds fed on the diet with the lowest content of rape seeds, the chickens from groups III and IV consumed, respectively, by 2.8 and 6.8% less feed from 0 to 37 d. Significant differences in FCR value among feeding groups were only noted in the first period of rearing (1-21 d). The best value gave diets I and III (1.400 and 1.403 kg kg^{-1} weight gain) while diet IV gave the poorest value of FCR (1.447 kg kg^{-1} weight gain). Live weight, livability and feed conversion ratio influence the total efficiency of broiler chicken production. In the present study, the value of EEI was relatively high for male broiler chickens and similar for control and experimental birds. The lowest level of EEI was determined for the group fed the highest level of rape seeds but statistical analysis did not reveal any significant differences. The results of experiments on using full-fat rape seeds in broiler chicken feeding are diversified and they mainly depend on the amount of rape seeds incorporated into the diet [1, 8, 11, 13, 14, 18, 22, 23]. Talebali and Farzinpour [23], feeding broilers for 6 weeks with mixtures containing relatively low levels (3-12%) canola seeds, did not note any differences in body weight gain. At the same time chickens fed on rape seeds mixtures consumed more feed, which resulted in poorer feed conversion ratio. The data presented by other authors [1, 4] who used the comparable levels (3-10%) of full-fat rape seeds did not show any effects on body weight, feed consumption and FCR in broiler chickens. However, according to Roth-Maier and Kirchgessner [18], the already low proportions 00-rape seeds (5 or 10%) reduce the broiler performance data significantly, which is still more intensified with higher proportions of rape seeds in mixtures. In that experiment, the depressing effect of the seeds occurred already after the first week and continued during the whole fattening period. From

Table 3. Performance indices of broiler chickens [$\bar{x}$ ± SD]

Tabela 3. Wskaźniki produkcyjne kurcząt brojlerów [$\bar{x}$ ± SD]

Indices Wskaźniki	Group Grupa			
	I	II	III	IV
1-21 d	(n = 45)	(n = 45)	(n = 45)	(n = 45)
Weight gain [g] Przyrosty masy ciała [g]	838^{a} ±29	808^{a} ±25	824^{a} ±18	763^{b} ±26
Feed intake [g/bird] Spożycie paszy [g/szt]	1172.3 ±42.4	1133.0 ±53.8	1155.3 ±30.3	1076.0 ±25.5
FCR [kg kg^{-1}] Zużycie paszy [kg kg^{-1}]	1.400^{a} ±0.01	1.437^{bc} ±0.03	1.403^{ac} ±0.01	1.447^{b} ±0.02
Mortality [%] Śmiertelność [%]	0.0	2.2	0.0	2.2
22-37 d	(n = 24)	(n = 24)	(n = 24)	(n = 24)
Weight gain [g] Przyrosty masy ciała [g]	1391.7 ±60.9	1385.0 ±46.6	1337.0 ±14.9	1287.3 ±36.6
Feed intake [g/bird] Spożycie paszy [g/szt]	2404.7^{ab} ±19.3	2452.3^{a} ±76.1	2331.3^{bc} ±52.7	2267.0^{c} ±30,5
FCR [kg kg^{-1}] Zużycie paszy [kg kg^{-1}]	1.730 ±0.08	1.771 ±0.05	1.743 ±0.02	1.762 ±0.03
Mortality [%] Śmiertelność [%]	0.0	0.0	0.0	0.0
1-37 d				
Weight gain [g] Przyrosty masy ciała [g]	2229.3^{a} ±33.5	2193.0^{a} ±55,8	2161.0^{a} ±29.6	2050.0^{b} ±44.6
Feed intake [g/bird] Spożycie paszy [g/szt]	3577.0^{ab} ±48.5	3585.3^{a} ±31.5	3486.7^{b} ±77.0	3343.0^{c} ±7.0
FCR [kg kg^{-1}] Zużycie paszy [kg kg^{-1}]	1.605 ±0.05	1.635 ±0.03	1.613 ±0.02	1.631 ±0.03
Mortality [%] Śmiertelność [%]	0.0	2.2	0.0	2.2
EEI EWW	372 ±32	368 ±16	369 ±3	345 ±11

^{abc} means in the rows with different letters differ significantly [P<0.05]

^{abc} średnie w wierszach oznaczone różnymi literami różnią się istotnie [P<0.05]

0 to 42 days, live weight gains of broilers were reduced by 6.7 to 24%, which resulted from a lower feed intake and feed efficiency [18]. In our study, during the whole experimental period, only the highest level of rapes seeds (diet IV) reduced body weight gain significantly (by 8.0%) compared to the birds fed on maize, wheat and soybean diet. It should also be noticed that in the present study negative effect of highest level of rape seeds was much clearer in younger birds (1-21 d), which is in agreement with Summers et al. [22]. There are several factors influencing depression of performance indices in broilers fed on diets with relatively high levels of rape seeds. One of them is the content of intact glucosinolates and also their degradation products, which may induce many metabolic disturbances [15, 18]. Another factor responsible for worse performance results can be a lower apparent total and ileal digestibility of dry matter, protein, fat and, consequently, a lower apparent metabolizable energy value determined in diets containing 00-rape seeds [11, 14]. Summers et al. [22] report that feeding 17.5% full-fat canola seed to broiler chickens resulted in depressed fat use and body weight gain. According to Lee et al. [6] and Meng et al. [11], lower fat digestibility is caused by the incomplete energy use from rape seeds, which is attributable to the nutrient-encapsulating effect of cell wall polysaccharides.

The protein and lipid metabolism indices and the content of calcium and phosphorus in the blood serum of chicks are given in Table 4. The level of rape seeds used in the experimental diets did not show any significant effects

Table 4. Serum biochemical indices of broiler chickens [$\bar{x}$ ± SD]

Tabela 4. Wskaźniki biochemiczne krwi kurcząt brojlerów[$\bar{x}$ ± SD]

Indices Wskaźniki	Group Grupa			
	I	II	III	IV
21 d of age, 21 d życia	(n = 10)	(n = 10)	(n = 10)	(n = 10)
Total protein, Białko całkowite [g l^{-1}]	47.10 ±13.58	49.70 ±5.98	49.10 ±10.82	52.10 ±4.25
Albumins, Albuminy [g l^{-1}]	15.50 ±1.18	16.10 ±2.33	14.70 ±2.21	15.60 ±2.80
Uric acid, kwas moczowy [mmol l^{-1}]	0.52^{a} ±0.06	0.59^{a} ±0.07	0.76^{b} ±0.14	0.49^{a} ±0.17
Creatinine, Kreatynina [µmol l^{-1}]	21.22^{a} ±4.56	21.22^{a} ±4.56	21.22^{a} ±4.56	15.91^{b} ±5.59
Trigliceride,Triglicerydy [mmol l^{-1}]	1.35 ±0.29	1.44 ±0.22	1.62 ±0.41	1.53 ±0.19
TCHL [mmol l^{-1}]	2.07 ±0.29	2.55 ±0.76	2.55 ±0.36	2.64 ±0.46
HDL [mmol l^{-1}]	1.20^{a} ±0.20	1.05^{b} ±0.18	1.27^{a} ±0.12	1.00^{b} ±0.14
LDL [mmol l^{-1}]	0.25^{a} ±0.18	0.85^{b} ±0.69	$0.55^{a,b}$ ±0.34	0.94^{b} ±0.43
VLDL [mmol l^{-1}]	0.61 ±0.13	0.66 ±0.10	0.74 ±0.19	0.69 ±0.09
Calcium, Wapń [mmol l^{-1}]	1.48 ±0.22	1.47 ±0.09	1.61 ±0.13	1.57 ±0.27
Phosphorus, Fosfor [mmol l^{-1}]	2.97^{a} ±0.25	2.98^{a} ±0.17	2.75^{b} ±0.18	$2.87^{a,b}$ ±0.16
37 d of age, 37 d życia	(n = 10)	(n = 10)	(n = 10)	(n = 10)
Total protein, Białko całkowite [g l^{-1}]	63.80 ±10.28	66.80 ±3.82	63.30 ±8.84	68.78 ±651
Albumins, Albuminy [g l^{-1}]	17.50 ±4.72	18.60 ±2.67	18.10 ±4.20	17.56 ±3.64
Uric acid, Kwas moczowy [mmol l^{-1}]	0.60 ±0.08	0.68 ±0.11	0.71 ±0.13	0.66 ±0.21
Creatinine, Kreatynina [µmol l^{-1}]	20.33 ±4.27	15.91 ±3.73	17.68 ±4.17	17.68 ±4.42
Trigliceride, Triglicerydy [mmol l^{-1}]	1.14 ±0.25	1.56 ±0.48	1.39 ±0.57	1.67 ±0.71
TCHL [mmol l^{-1}]	$2.47^{a,b}$ ±0.51	$2.58^{a,b}$ ±0.75	2.10^{b} ±0.32	2.87^{a} ±0.51
HDL [mmol l^{-1}]	0.94^{a} ±0.25	1.09^{a} ±0.18	0.96^{a} ±0.28	1.34^{b} ±0.17
LDL [mmol l^{-1}]	1.01 ±0.54	0.78 ±0.71	0.51 ±0.20	0.78 ±0.50
VLDL [mmol l^{-1}]	0.52 ±0.11	0.71 ±0.22	0.63 ±0.26	0.76 ±0.32
Calcium, Wapń [mmol l^{-1}]	2.01 ±0.34	2.28 ±0.26	2.44 ±0.36	2.30 ±0.38
Phosphorus, Fosfor [mmol l^{-1}]	2.53 ±0.14	2.65 ±0.20	2.55 ±0.40	2.94 ±0.84

[ab] means in the rows with different letters differ significantly [P<0.05]

[ab] średnie w wierszach oznaczone różnymi literami różnią się istotnie [P<0.05]

on total protein and albumins at 21 d and all examined protein metabolism indices at 37 d of age. The only significant differences (P<0.05) were noticed in the level of uric acid and creatinine at 21 d. The highest level of uric acid, the main protein metabolism product in birds, was recorded in group III. It is known that uric acid levels can show great variability which mainly depends on dietary protein quality, total food intake and kind of birds [1, 2]. According to Bielecka et al. [1], dehulled "00" rape seeds inclusion into broiler diets results in decreasing the serum uric acid level which can prove the beneficial protein metabolism. However, data from our study did not confirm the results cited above. In the present experiment, in spite of recorded differences, the concentration of uric acid in all experimental broilers was within the wide range of reference values given by Mazurkiewicz [9]. The concentration of creatinine, the indicator of muscular metabolism, was significantly lower (P<0.05) in birds fed the diets with the highest level of rape seeds. The chicks fed diets without or with a low and medium level of rape seeds had the same level of creatinine which indicates equalized protein muscular metabolism. The importance of a significantly lower level of creatinine, which was noted in birds from group IV, in this trial is not known. The available literature lacks results confirming the influence of different levels of rape seeds on muscular metabolism indices. It must be marked that in birds from all groups, the levels of creatinine were twice lower compared to the data presented by Bowes et al. [2] which can result from the different blood collection method. In the cited experiment feed was not removed prior to sampling.

The present study did not show a synonymous effect of different levels of rape seeds on the examined lipid metabolism indices (Table 4). Despite the lack of significant differences among groups in serum triglycerides content, broilers fed on rape seeds diets had a numerically higher level of TG compared to the control group. The significant difference in the content of total cholesterol between 37-days-old chicks from groups III and IV is difficult to explain and probably resulted

Table 5. Bone resistance parameters [$\bar{x}$ ± SD]

Tabela 5. Parametry wytrzymałościowe kości [$\bar{x}$ ± SD]

Indices Wskaźniki	Group Grupa			
	I	II	III	IV
21 d of age, 21 d życia	(n = 10)	(n = 10)	(n = 10)	(n = 10)
F max [kN]	0.165 ±0.017	0.166 ±0.031	0.160 ±0.019	0.151 ±0.018
U [mm]	3.921^{a} ±0.347	3.961^{a} ±0.347	4.602^{b} ±0.474	4.896^{b} ±0.475
37 d of age, 37 d życia	(n =10)	(n = 10)	(n = 10)	(n = 10)
F max [kN]	0.207 ±0.049	0.210 ±0.038	0.229 ±0.039	0.241 ±0.040
U [mm]	4.062 ±0.576	4.059 ±0.543	4.644 ±0.763	4.081 ±0.875

^{ab} means in the rows with different letters differ significantly (P<0.05)

^{ab} średnie w wierszach oznaczone różnymi literami różnią się istotnie [P<0.05]

from a considerable individual variability. The content of TG and total cholesterol in the blood serum of birds of all the experimental groups was consistent with the physiological norms specified for broiler chickens [10, 17]. Similarly to our findings, Kamran Azad et al. [5] did not show a significant effect of canola seeds used in broiler diets in the amount of 7.5 and 15% on serum TG and total cholesterol concentration. High density lipoproteins, beneficial for the body and conditioning the transport of cholesterol from the peripheral tissue to the liver, were the main fraction of lipoproteins in the blood of the experimental birds. The present study revealed that increasing level of rape seeds in the diets resulted in higher level of serum HDL fraction. The content of HDL in the birds fed the highest level of rape seeds was significantly higher compared to the control group (46.7 and 38.1% of total cholesterol, respectively). At the same time the chickens fed the diets with rape seeds had lower levels of LDL fraction than those from the control group (24.3-30.3 and 40.9% of total cholesterol, respectively). The VLDL content was not affected by the type of diet. The study conducted by Pisarski and Malec [16] revealed that rape oil incorporated into broiler feeds resulted not only in a significant increase of HDL but also in falling tendency of TG which proves its positive influence on the health of these intensively used birds.

The present study did not show an effect of the dietary treatments on serum calcium concentration in the experimental birds (Table 4). There were noted significant differences in phosphorus content at 21 d of age. The medium and the highest level of rape seeds resulted in depression of Pi serum content but the differences were significant (P<0.05) only in the case of group III. Leeson et al. [7] reported that even 20% of dietary full-fat canola had no significant effect on calcium and phosphorus retention in 21-day-old male broiler chickens. On the other hand, Summers et al. [21] and Talebali and Farzinpour [23] state that the existence of phytic acid in canola seeds can cause reduction in calcium ability absorption and consequently, the feed consumption reduction.

Calcium and phosphorus are the two most abundant minerals in bone and disturbances in their absorption can influence its formation and mineralisation. According to Williams et al. [26], the rapid bone formation in fast growing meat-type chickens occurs in the first days after hatching (days 4 to 18) and is related to interactions between genetic, management and nutritional factors [25]. The results of bone resistance parameters in experimental chicks are presented in Table 5. The present study did not reveal a significant effect of dietary treatment on F max and U values at 37 d of age, however, the increasing level of dietary rape seeds resulted in a insignificant higher F max value. It should be noted that throughout the whole experimental period no leg disorders in broiler chicks were observed. At 21 d of life the U value was higher (P<0.05) in birds fed on the diets with the medium and highest level of rape seeds compared to other feeding groups. It confirms that the effect of dietary treatment on bone formation is evident in younger birds. However, Leeson et al. [7], feeding broilers with diets containing high levels (from 5 to 20%) raw ground full-fat canola for a period of three weeks, did not find any negative influence on bone ash, bone calcium or phosphorus content.

In conclusion, the present research indicated that the increasing level of full-fat rape „00" seeds added to the diet for broiler chickens lead to the gradual reduction of feed intake. Only the highest level of rapes seeds (0.38-3.01 MJ AME_N) reduced body weight gain significantly which was much clearer in younger birds. Rape seeds did not significantly influence protein and mineral metabolism indices and had a positive effect on lipoprotein fractions in the blood. The increasing level of dietary rape seeds decreased bone resistance parameters in 21-day-old

chickens, but no leg disorders were observed throughout the experiment. Further studies are required to establish the proper level of full-fat rape "00" seeds in broiler diets particularly with a view to reducing the growth, feed efficiency and bone resistance depressing factors when a dietary level is increased.

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