Camelina meal and chromium picolinate effects on broiler thigh meat nutritional properties

**Arabela Elena Untea ^{*1}, Tatiana Dumitra Panaite¹,
Alexandra Oancea¹, Raluca Paula Turcu¹, Mihaela Saracila¹**

*corresponding author: arabela.untea@ibna.ro

National Research and Development Institute for Biology and Animal Nutrition, 077015 Ilfov, Romania

ABSTRACT

The aim of this study was to evaluate the combined effects of trivalent chromium and camelina meal on proximate composition, mineral content and fatty acids profile of broiler chicken thigh meat. An experiment with 2 x 3 factorial arrangement was performed on 240 Ross 308 broiler chicken aged 14 days. Six dietary treatments were elaborated as follows: 0 and 3% inclusion rate of Camelina meal and 0, 200 and 400 µg/kg chromium picolinate (CrPic).

Supplementation of broiler diets with 3% Camelina meal led to significantly ($P < 0.05$) increased crude fat concentrations in thigh samples compared to control group or with single chromium supplemented groups. In thigh samples, Zn and Fe concentrations increased under CrPic influence and fatty acids profile was influenced by Camelina meal presence in the diets. In Camelina meal supplemented groups, were registered significantly increased omega 3 fatty acids concentrations compared to control group or single chromium supplemented groups.

The results of the present study found that Camelina meal and chromium picolinate supplements in broilers diets improved the nutritional properties of thigh meat, especially essential minerals content and fatty acids profile.

Keywords: chromium, camelina, broiler, minerals, fatty acids

INTRODUCTION

The incidence of coronary heart disease can be prevented by nutritional strategies with the aim of reducing saturated fatty acids (SFA) and cholesterol level from diets. Chicken meat is considered an economically viable source of

polyunsaturated fatty acids (PUFA) and the lipid profile of meat can be nutritional manipulated (Mir et al., 2017).

Different nutritional strategies that imply terrestrial sources of PUFA, were applied in order to obtain PUFA enriched animal origin food. PUFA meat enrichment through animal nutrition strategy was mostly based on diets supplemented with linseed or flaxseed (Panaite et al., 2019; Kumar et al., 2020); camelina (Orczewska-Dudek & Pietras, 2019; Untea et al., 2019); safflower (Amer et al., 2021); rapeseed (Gao et al., 2020) etc. Camelina meal was used in animal nutrition as feedstuff being considered a valuable source of protein and lipids, of which linolenic acid (ALA) represents 25-30% (Panaite et al., 2016).

Nowadays, the essentiality of trivalent chromium is scientific recognized being required for a normal carbohydrate and lipid metabolism. The commercial diets for poultry cannot reach the chromium requirements and the growth performance can be affected by chromium deficiency (Mir et al., 2017). Studies on the effects of chromium supplementation on poultry diets proved beneficial effects on growth performance (Toghyani et al., 2012), reducing the cholesterol level (Anandhi et al., 2006) and improving the meat oxidative stability (Untea et al., 2019; Sahin et al., 2003).

The aim of this study was to evaluate the combined effects of trivalent chromium and camelina meal on proximate composition, mineral content and fatty acids profile of broiler chicken thigh meat.

MATERIALS AND METHODS

The experiment complied with Directive 2010/63/EU on the protection of animals used for scientific purposes and the experimental procedures were approved by Ethical Commission of National Research and Development Institute for Biology and Animal Nutrition.

Experimental design

An experiment with 2 x 3 factorial arrangement was performed on 240 Ross 308 broiler chicken aged 14 days. Six dietary treatments were elaborated as follows: 0 and 3% inclusion rate of Camelina meal and 0, 200 and 400 µg/kg chromium picolinate (CrPic) (Sigma Aldrich, Germany). The ratio structures are presented in table 1.

A poultry experimental hall, digestibility pens and control monitoring system were as infrastructure in order to conduct the broiler experiment; 23h light/1h darkness light regimen and each treatment was replicated 4 times. Free access to the water and ad libitum feeding was applied during experimental period. At the end of the experiment 6 chicks from each group

were slaughtered and samples of thigh meat were collected for further analysis.

Table 1. Structure of recipes used in experiment

Diet composition (%)	Stage II grower (14-28 days)		Stage III finisher (29-42 days)	
	Cam 0%	Cam 3%	Cam 0%	Cam 3%
Maize	34.17	34.98	39.77	39.75
Wheat	15.00	15.00	15.00	15.00
Rice bran	8.00	8.00	7.12	8.00
Soybean meal	22.00	21.83	16.05	15.82
Rapeseed meal	8.00	5.00	9.00	6.00
Gluten	4.00	4.00	4.00	4.00
Soybean oil	4.20	3.50	4.90	4.20
DL- Methionine	0.15	0.15	0.13	0.14
Lysine	0.27	0.29	0.30	0.32
Calcium carbonate	1.25	1.27	1.11	1.14
Calcium phosphate	1.54	1.56	1.37	1.39
Sodium chloride	0.37	0.37	0.20	0.20
Choline	0.05	0.05	0.05	0.05
Camelina meal	-	3.00	-	3.00
Premix *	1.00	1.00	1.00	1.00
Total	100	100	100	100
<i>Chemical composition</i>				
Dry matter	88.02	88.26	87.96	88.23
M.E. poultry, (kcal/kg)	3097.76	3101.75	3200.00	3200.00
Crude protein	21.53	21.50	19.50	19.50
Crude fat	6.15	5.78	6.86	6.51
Calcium	0.87	0.87	0.78	0.78
Available phosphorous	0.44	0.43	0.39	0.39
Lysine	1.20	1.20	1.08	1.08
Methionine	0.52	0.52	0.48	0.49
Met+cis	0.92	0.91	0.85	0.85
Threonine	0.73	0.72	0.65	0.64
Triptopan	0.21	0.21	0.18	0.18

*One level of Camelina meal inclusion was split in 3 levels of Chromium inclusion: 0, 20 and 40 mg/kg premix. The chemical structure of premix was published before by Untea et al., 2019.

Chemical analysis

Proximate composition of thigh meat was determined as follows: crude protein by Kjeldahl method according SR EN ISO 5983-2, 2009 (Kjeltek auto 1030 – Tecator); crude fat by continuous solvent extraction (SR ISO 6492, 2001) and crude ash by gravimetric method.

Trace minerals determinations (Cu, Fe, Mn, Zn) was performed using a Thermo Electron – SOLAAR M6 Dual Zeeman Comfort (Cambridge, UK) equipment and the method published by Untea et al., (2012).

Fatty acids determinations: A system consists of Perkin-Elmer Clarus 500 (Massachusetts, United States) gas chromatograph, Flame Ionization Detector (FID), capillary separation column with high polar stationary phase TRACE TR-Fame, (Thermo Electron, Massachusetts, United States), dimensions 60m X 0.25 mm X 0.25 µm and a determination method described by Turcu et al, 2020 was used for determination of fatty acids composition.

Statistics

General Linear Model (GLM; Minitab version 13; Minitab Inc., State College, PA, USA) followed by Tukey's HSD test ($P < 0.05$) was applied for statistical comparisons between treatments.

RESULTS

No significant differences between groups were noticed regarding performance parameters during experimental period (Untea et al., 2019). In table 2 are presented results regarding the proximate composition of thigh meat. Supplementation of broiler diets with 3% Camelina meal led to significantly ($P < 0.05$) increased crude fat concentrations in thigh samples compared to control group or with single chromium supplemented groups. Inversely effect was noticed for chromium supplemented groups: increased concentrations of crude protein (but not statistically sustained) and decreased concentrations of crude fat compared to Camelina meal supplemented groups. Crude ash was significantly increased for Camelina meal ($P > 0.05$) groups, compared with others.

Table 2. The Camelina meal and chromium effect on proximate composition of broiler thigh meat

	Cam 0%			Cam 3%			SEM	P Cr	P Cam	P Cr x Cam
	Cr 0 ppb	Cr 200 ppb	Cr 400 ppb	Cr 0 ppb	Cr 200 ppb	Cr 400 ppb				
DM	24.46 ^{ab}	24.0	24.6 ^{ab}	25.46 ^a	25.09 ^{ab}	25.48 ^a	0.15	0.188	0.001	0.933
Crude protein (%)	18.46	18.8	18.75	18.50	18.30	18.11	0.14	0.787	0.127	0.199
Crude fat (%)	4.34 ^b	4.0 ^b	4.48 ^b	5.06 ^a	4.75 ^a	5.35 ^a	0.18	0.280	0.007	0.966
Crude ash (%)	0.98 ^b	0.96 ^b	0.98 ^b	1.01 ^a	1.07 ^a	1.09 ^a	0.026	0.679	0.03	0.675

In our study, the crude protein concentrations range between 18.11 and 18.84% for thigh samples. Regarding fat content we found 4.02 to 5.35% in thigh samples. Bogosavljević-Bošković et al. (2010) established based on a literature review that the protein content of thigh muscle ranges between 15.8 to 17.9% respectively. Some authors consider that dietary fat generally suggested a higher effect on adipose tissue composition than on the meat fat content (Bogosavljević-Bošković et al., 2010). In our study, the groups supplemented with Camelina meal, presented higher fat concentration in thigh muscle, than other groups. Other authors also observed a higher rate of lipids deposition on tissues like breast or thigh when the diets were supplemented with increasing doses of Camelina meal (Aziza et al., 2010)

proving that the lipid biosynthesis is related to fat dietary origin (Cherian, 2012).

Mineral composition of broiler thigh meat is presented in Table 3. In thigh samples, Zn and Fe concentrations increased under CrPic influence. The retention of Cu in thigh samples show no difference between groups.

Table 3. Effect of supplemental CrPic and Camelina meal on mineral composition of broiler thigh meat

mg/kg	Cam 0%			Cam 3%			SEM	P Cr	P Cam	P Cr x Cam
	Cr 0 ppb	Cr 200 ppb	Cr 400 ppb	Cr 0 ppb	Cr 200 ppb	Cr 400 ppb				
Zn	57.59 ^b	62.30 ^a	61.55 ^a	56.92 ^b	57.70 ^b	57.14 ^b	5.3	0.042	0.076	0.594
Cu	2.40	2.36	2.45	2.52	2.35	2.52	0.3	0.689	0.648	0.913
Fe	35.45	43.66	39.11	38.41	37.01	40.1	3.8	0.027	0.387	0.001

Chromium effect on mineral utilization and deposition was reported in the scientific literature: in cold stress conditions it was reported an improved utilization of zinc and iron in laying hens (Sahin & Sahin, 2002); zinc deposition in organs and muscle of laying hens was also reported by Sahin et al., (2002). Some authors considered that chromium and iron are antagonist elements and the presence of chromium may impair the iron absorption (Pechova and Pavlata, 2007). Our results proved a positive effect of trivalent chromium on iron and zinc absorption and deposition. The antioxidant properties of chromium are recognized due to improving insulin metabolism (Sahin et al, 2010) but our results also sustain the hypothesis that a potential mechanism of action can be the stimulating effect on zinc absorption (Untea et al., 2019).

The effects of diets supplementation with chromium and Camelina meal on fatty acids composition of thigh samples (Table 4) revealed a significant decrease of SFA concentrations for the mixture of additives (200 ppb Cr and 3% Camelina meal) due to the decreasing effect on palmitic acid and stearic acid. Omega 6 fatty acids concentrations were positive influenced by Chromium presence (200 ppb) both single or in combination. The effect can be attributed to the increased concentrations of linoleic acid in chromium (200 ppb) supplemented groups compared to others. The presence of Camelina meal in the broilers diets, led to increasing omega 3 fatty acids concentrations compared to control group or single chromium supplemented groups.

Our presented findings are in agreement with scientific literature. Other authors noticed the positive influence of Camelina cakes and oils (Orczewska-Dudek and Pietras, 2019, Ciurescu et al., 2018), Camelina seeds (Zajac et al.,

Table 4. Fatty acids profile of thigh meat samples

Fatty acids		Cam 0%			Cam 3%			SEM	P Cr	P Cam	P Cr x Cam
		Cr 0 ppb	Cr 200ppb	Cr 400 ppb	Cr 0 ppb	Cr 200 ppb	Cr400 ppb				
Capric acid	C10:0	0.03 ^a	0.00 ^b	0.02 ^{ab}	0.02 ^{ab}	0.03 ^a	0.02 ^{ab}	0.007	0.245	0.234	0.004
Lauric acid	(C12:0)	0.02	0.00	0.05	0.05	0.03	0.03	0.022	0.185	0.111	0.175
Miristic acid	(C14:0)	0.57 ^a	0.55 ^{ab}	0.52 ^{ab}	0.51 ^b	0.52 ^{ab}	0.55 ^{ab}	0.007	0.880	0.089	0.005
Miristoleic acid	C14:1	0.19	0.16	0.18	0.17	0.18	0.21	0.006	0.231	0.407	0.155
Pentadecanoic acid	(C15:0)	0.40	0.28	0.32	0.34	0.34	0.33	0.019	0.183	0.840	0.187
Pentadecenoic acid	(C15:1)	0.59 ^a	0.38 ^{ab}	0.35 ^b	0.47 ^{ab}	0.38 ^{ab}	0.46 ^{ab}	0.029	0.017	0.930	0.079
Palmitic acid	(C16:0)	21.82 ^a	20.85 ^{ab}	20.44 ^{ab}	20.02 ^b	20.17 ^b	21.13 ^{ab}	0.206	0.504	0.049	0.006
Palmitoleic acid	(C16:1)	3.14	2.79	2.83	2.88	2.90	3.03	0.165	0.615	0.910	0.332
Heptadecanoic acid	(C17:0)	0.20	0.18	0.20	0.18	0.21	0.17	0.008	0.801	0.833	0.095
Heptadecenoic acid	(C17:1)	0.19	0.20	0.14	0.20	0.19	0.22	0.012	0.655	0.089	0.118
Stearic acid	(C18:0)	7.15 ^a	7.19 ^a	7.34 ^a	6.95 ^b	6.48 ^b	6.95 ^b	0.130	0.386	0.026	0.528
Oleic acid	(C18:1)	37.51 ^a	36.28 ^b	36.45 ^{ab}	37.36 ^a	36.17 ^b	37.38 ^{ab}	0.258	0.037	0.544	0.400
Linoleic acid	(C18:2n-6)	22.63 ^b	26.26 ^a	24.86 ^{ab}	24.83 ^b	26.95 ^a	24.67 ^{ab}	0.469	0.005	0.186	0.345
Arachidic acid	C20:0	0.18	0.08	0.16	0.16	0.13	0.08	0.017	0.098	0.496	0.149
Linolenic acid	(C18:3n-3)	0.34 ^b	0.43 ^b	0.40 ^b	0.73 ^a	0.83 ^a	0.68 ^a	0.024	0.060	0.001	0.260
CLA	C18:2	0.18 ^{ab}	0.02 ^b	0.31 ^a	0.14 ^b	0.07 ^b	0.02 ^b	0.021	0.004	0.004	0.001
Octatetraenoic acid	C18:4n3	0.41	0.35	0.39	0.34	0.30	0.37	0.021	0.241	0.133	0.878
Eicosadienoic acid	(C20:2n-6)	0.39 ^b	0.31 ^b	0.36 ^b	0.57 ^a	0.55 ^a	0.50 ^a	0.012	0.050	0.001	0.125
Eicosatrienoic acid	(C20:3n-6)	0.27 ^a	0.22 ^a	0.25 ^a	0.16 ^b	0.09 ^b	0.14 ^b	0.033	0.581	0.021	0.987
Erucic acid	C22: 1n9	0.21 ^{ab}	0.19 ^b	0.17 ^b	0.24 ^{ab}	0.20 ^b	0.44 ^a	0.031	0.135	0.027	0.043
Eicosatrienoic acid	(C20:3n-3)	0.14 ^b	0.25 ^a	0.25 ^a	0.24 ^a	0.27 ^a	0.20 ^{ab}	0.010	0.002	0.136	0.001
Arachidonic acid	(C20:4n-6)	0.97 ^b	1.30 ^a	1.18 ^{ab}	0.96 ^b	0.94 ^b	0.87 ^b	0.043	0.131	0.001	0.055
Tricosanoic acid	C23:0	0.27	0.22	0.27	0.27	0.23	0.20	0.019	0.331	0.480	0.401
Docosadienoic acid	C22:2n6	0.26	0.23	0.25	0.25	0.23	0.23	0.033	0.775	0.840	0.964
Eicosapentaenoic acid	C20:5n3	0.47 ^{ab}	0.28 ^b	0.47 ^{ab}	0.49 ^a	0.42 ^b	0.32 ^b	0.036	0.006	0.907	0.002
Lignoceric acid	C24:0	0.52 ^a	0.50 ^a	0.52 ^a	0.51 ^a	0.48 ^{ab}	0.26 ^b	0.030	0.059	0.027	0.038
Nervonic acid	C24 (1n9)	0.17 ^{ab}	0.11 ^{ab}	0.28 ^a	0.22 ^{ab}	0.05 ^b	0.04 ^b	0.026	0.037	0.037	0.012
Other fatty acids		0.78	0.43	1.05	0.74	0.64	0.50				
TOTAL		100	100	100	100	100	100				
Σ Saturated acids		31.17 ^a	29.34 ^{ab}	29.83 ^{ab}	29.02 ^{ab}	28.63 ^b	29.72 ^{ab}	0.300	0.264	0.011	0.165
Σ Unsaturated acids		68.05 ^b	69.74 ^{ab}	69.18 ^{ab}	70.28 ^{ab}	70.75 ^a	69.80 ^{ab}	0.304	0.127	0.005	0.303
Σ n-6		24.70 ^b	28.35 ^a	27.22 ^{ab}	26.91 ^{ab}	28.83 ^a	26.42 ^{ab}	0.814	0.006	0.352	0.194
Σ n-3		1.35 ^c	1.31 ^c	1.52 ^{bc}	1.80 ^a	1.82 ^a	1.56 ^b	0.028	0.773	0.001	0.001
Ratio n-6/n-3		18.39 ^b	21.73 ^a	18.11 ^b	15.00 ^c	15.91 ^{bc}	17.02 ^{bc}	0.706	0.019	0.001	0.009

2020) or Camelina meal (Untea et al., 2019) on fatty acids profile of animal origin food. Positive influence of chromium on reduction of fat percentage of meat but no significant influence on fatty acids profile, was also noticed by Mir et al., 2017. Han et al., 2021, proved that organic sources of chromium used in broilers diets led to significant increase of omega 3 fatty acids of breast meat. The use of Camelina meal in poultry diets is considered to be a successful approach for fortifying meat in omega 3 fatty acids (Cherian, 2012). In the scientific literature, linseed is known as the main source of unsaturated fatty acids in farm animals diets, but Camelina meal is another oilseed crop with similar efficiency in decreasing the ratio of n-6/n-3 fatty acids in poultry products (Zajak et al., 2020).

CONCLUSION

The results of the study showed that Camelina meal and chromium picolinate supplements in broilers diets improved the nutritional properties of thigh meat, especially essential minerals content (Zn and Fe) and fatty acids profile.

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