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Farelo de crambe na alimentação de frangos

Crambe meal in broiler feeding

Salvado de crambe en la alimentación de pollos de engorde

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Resumo

Este estudo objetiva avaliar o desempenho de frangos de corte alimentados com dieta em que a proteína total foi substituída pela proteína do farelo de crambe. Foram utilizados 630 pintos

machos (Cobb 500) de 8 a 42 dias de idade distribuídos no delineamento experimental inteiramente casualizado com cinco tratamentos, seis repetições de 21 aves por parcela. Os tratamentos foram: dieta controle (0%) e dietas contendo 3, 6, 9 e 12% de proteína do farelo de crambe em substituição da proteína total da ração. O desempenho foi avaliado na fase inicial (8 a 21 dias), crescimento (22 a 42 dias) e total (8 a 42 dias). A carcaça e cortes foram avaliados aos 43 dias de idade. Dietas contendo farelo de crambe promoveu baixo consumo de ração comparado com a dieta controle em todas as fases avaliadas. Para o ganho de peso observou-se pior resultado com aumento da inclusão da proteína do crambe, com decréscimo linear comparado aos que não receberam o crambe no período total de criação. Verificou-se que para o período total a melhor conversão alimentar foi obtida com 6% da inclusão da proteína do crambe em comparação à dieta isenta de crambe. Os pesos da carcaça, de peito e de coxa reduziram com a dieta contendo 12% da proteína do crambe. Os dados indicam que é possível a substituição parcial da proteína bruta da ração até 6% pela proteína do farelo de crambe.

Palavras-chave: Alimento alternativo; *Crambe abyssinica*; Fatores antinutricionais; Fibra bruta; Proteína bruta.

Abstract

This study aimed to evaluate the performance of broilers fed a diet in which the total protein has been replaced by the protein of the crambe meal. The experiment was used 630 male chickens (Cobb® 500) from 8 to 42 days of age, distributed in a completely randomized design with five treatments, six replications of 21 birds per plot. The treatments were: control diet (0%) and diets containing 3, 6, 9 and 12% of crambe meal protein in replacement of the total protein of the feed. The performance was evaluated in the initial phase (8 to 21 days), growth (22 to 42 days) and total (8 to 42 days). Carcass and cuts was evaluated at 43 days of age. Diets containing crambe meal promoted lower feed intake compared with to the control diet in all evaluated phases. For weight gain, a worse result was observed with increased inclusion of crambe protein, with a linear decrease compared to those who did not receive crambe in the total breeding period. It was found that for the total period the best feed conversion was obtained with 6% of the inclusion of crambe protein in comparison to the crambe-free diet. Carcass, breast and thigh weights decreased with a diet containing 12% of the crambe protein. The results indicate that it is possible to partially replace the crude protein of the feed up to 6% with the protein of the crambe meal.

Keywords: Alternative feedstuffs; Antinutritional factors; *Crambe abyssinica*; Crude fiber; Crude protein.

Resumen

Este estudio tiene como objetivo evaluar el rendimiento de los pollos de engorde alimentados con una dieta en la que la proteína total fue reemplazada por la proteína del salvado de crambe. Se utilizaron 630 pollitos machos de la línea Cobb 500 de 8 a 42 días de edad, distribuidos en un diseño completamente al azar con cinco tratamientos, seis repeticiones de 21 aves por parcela. Los tratamientos fueron: dieta de un grupo testigo (0%) y dietas que contenían 3, 6, 9 y 12% de proteína de salvado de crambe en reemplazo de la proteína total del alimento. El rendimiento se evaluó en la fase inicial (8 a 21 días), crecimiento (22 a 42 días) y total (8 a 42 días). La carcasa y los cortes fueron evaluados a los 43 días de edad. Las dietas que contienen salvado de crambe promovieron una baja ingesta de alimento en comparación con la dieta de control en todas las fases evaluadas. Para el aumento de peso, se observó un peor resultado con un aumento en la inclusión de la proteína del crambe, con una disminución lineal en comparación con aquellos que no recibieron crambe en el período de cría total. Se encontró que para el período total se obtuvo la mejor conversión alimenticia con un 6% de la inclusión de proteína crambe en comparación con la dieta libre de crambe. Los pesos en canal, pechuga y muslo se redujeron con la dieta que contenía el 12% de la proteína crambe. Es posible el reemplazo parcial de proteína cruda en la dieta de hasta 6% por proteína de salvado de crambe.

Palabras claves: Alimentos alternativos; *Crambe abyssinica*; Factores antinutricionales; Fibra cruda; Proteína cruda.

1. Introduction

The broilers diets formulation has corn and soybean meal as the main ingredients, whose prices increase production costs, thus it is necessary, evaluate the alternative feedstuffs that are used efficiently by the animal and with viable prices for inclusion in the diets.

Crambe (*Crambe abyssinica*) is a plant of the family Brassicaceae, of Mediterranean origin, commonly used as forage for graze and it is exotic plant in Brazil (Penha et al., 2020) and this is little known in Brazil. It is an annual low-cost crop and presents an early cycle of about 90 days, with productive potential around 1,000 and 1,500 kg ha^{-1} (Pitol et al., 2010). The grain oil yield reaches 38% (Cardoso et al., 2012) demonstrating potential for biodiesel

production, with consequent coproduct generation and rich protein. In this context, crambe meal shows potential to be used in poultry feeding by presenting high protein content. However, this family plants contain several antinutritional factors that restrict their use in animal feeding, such as phytic acid (Colodetti et al., 2012), phenolic compounds (McDougall and Stewart, 2005), glucosinolates (Figueiredo et al., 2003) and high levels of erucic acid in seed oil (Liu et al., 1994). Nevertheless, reducing the crambe antinutritional factors may be an alternative ingredient with high nutritional value as described by Moura et al. (2015).

The crambe use in animal feeding is being researched for beef cattle (Mendonça et al., 2015), dairy cattle (Oliveira et al., 2016), sheep (Dorigon and Gai, 2016; Penha et al., 2020) silver catfish juveniles (Lovatto et al., 2014; Pettro et al., 2014) and Nile tilapia (Moura et al., 2015). Few studies have been conducted with broilers, with the works exception of Silva et al. (2018), Ledoux et al. (1999) and Kloss et al. (1996), however was obtained in other country that have different climatic conditions or other birds' lineages.

This study aimed to evaluate the performance of broilers fed a diet in which the total protein has been replaced by the protein of the crambe meal.

2. Methodology

The experiments were conducted at Poultry Science Laboratory of the Universidade Federal dos Vales do Jequitinhonha e Mucuri, Diamantina, Minas Gerais, Brazil. This study was conducted in accordance with the ethical principles for animal experimentation adopted by the Brazilian College of Animal Experimentation (COBEA) and the experimental procedures were approved by the local Committee for Ethical Animal Use (CEUA - protocol n. 04/2015).

The experiment consisted in evaluating the performance and carcass and cuts yields from the inclusion of levels of crambe meal in the total dietary protein. For this were used 630 male broilers chicks (Cobb® 500) with eight days of age, (144±3.44 g). From one to seven days of age, the birds were fed from the pre-starter diet. The birds were allocated in conventional shed with fibrocement tile roofing, galvanized screens on the sides equipped with curtains and concrete floor. Were reared in pens with area of 1.62 × 1.55 m, covering 2.5 m^2 with wood shavings bed (±5 cm thicknes/ pens). The broilers were distributed in completely randomized design with five treatments and six replications of 21 birds per pens. The mean of the maximum and minimum temperatures recorded inside the shed were 28ºC and 25ºC, respectively, in the initial period (8 to 21 days of age). For the finisher period (22 to

42 days of age) the temperatures were 23 and 21º C, for maximum and minimum, respectively.

These experiment was divided in phases, initial (8 to 21 day of age), finisher (22 to 42 day of age) and total (8 to 42 days of age). The experimental treatments consisted of: control diet (without crambe meal, 0%); 3%; 6%; 9% and 12% of crambe meal inclusion in the total crude protein of diet. For the crambe meal were considered the chemical analysis (89.91% dry matter; 1.5% calcium; 0.71% phosphorus; 31.94% crude protein (green matter) and 22.25% crude fiber. Premilinary test was performed in our laboratory to determine the apparent metabolizable energy value of crambe meal and we observed that was 1646 kcal. Kg^{-1} of diet. The experimental diets (Tables 1 and 2) were formulated to meet the nutritional requirements for all nutrients of male broilers with medium performance, according to Rostagno et al. (2011). All diets were isocaloric and isoprotein, based on digestible amino acid. The feed and water were provided *ad libitum*.

Table 1. Composition of the experimental diets of broilers fed replacement of part of the crude protein of the diet by the protein from crambe meal during the initial phase of eight to 21 days.

Ingredients	Crude protein crambe meal (%)				
	0	3	6	9	12
Corn (7.88%)	58.709	58.003	57.295	56.590	55.895
Crambe meal	0.000	1.954	3.910	5.862	7.815
Soybean meal (46%)	34.824	33.337	31.850	30.365	28.867
Dicalcium phosphate	1.509	1.528	1.548	1.568	1.588
Soybean oil	2.317	2.454	2.592	2.729	2.862
Limestone	1.114	1.062	1.010	0.958	0.768
Salt	0.481	0.483	0.484	0.485	0.486
DL-Methionine (99%)	0.288	0.307	0.326	0.345	0.365
L-Lysine HCl (78%)	0.216	0.267	0.318	0.369	0.421

L-Threonine (96%)	0.063	0.091	0.119	0.147	0.175
L-Valine (96.5%)	0.026	0.058	0.093	0.127	0.161
Mineral/ vitamin premix[a]	0.400	0.400	0.400	0.400	0.400
Choline chloride (60%)	0.040	0.040	0.040	0.040	0.040
Antioxidant[b]	0.010	0.010	0.010	0.010	0.010
Total	100,00	100,00	100,00	100,00	100,00
Calculated composition					
Metabolizable energy (Kcal)	3.000	3.000	3.000	3.000	3.000
Crude protein (%)	20.80	20.80	20.80	20.80	20.80
Calcium (%)	0.891	0.891	0.891	0.891	0.891
Sodium (%)	0.210	0.210	0.210	0.210	0.210
Availabe phosphorus (%)	0.391	0.391	0.391	0.391	0.391
Crude fiber (%)	2.861	3.161	3.461	3.761	4.060
Digestible threonine (%)	0.763	0.763	0.763	0.763	0.763
Digestible methionine+cystine (%)	0.846	0.846	0.846	0.846	0.846
Digestible lysine (%)	1.174	1.174	1.174	1.174	1.174
Digestible tryptophan (%)	0.231	0.222	0.213	0.204	0.200
Digestible valine (%)	0.904	0.904	0.904	0.904	0.904

[a]Per kg of diet: Manganese 70.4 mg; iron 50 mg; zinc 60 mg; copper 10 mg; cobalt 0.8 mg; iodine 1 mg; selenium 0.3 mg. Vitamin A 7500 UI; vit. D3 2.000 UI; vit. E 12 UI; vit. B2 4.8 mg; vit. B6 2 mg; vit. B12 10 mcg; pantothenic acid 10 mg; vit, K3 10 mg; folic acid 0.7 mg; biotin 0.015 mg; choline 150 mg; niacina 30 mg; vit. B1 1 mg; lincomycin 4.4 mg, monensin sodium 120 mg. [b]Butylated hydroxytoluene 4 mg. Source: Authors.

Table 2. Composition of the experimental diets of broilers fed replacement of part of the crude protein of the diet by the protein from crambe meal during the growing-finishing phase of 22 to 42 days.

Ingredients	Protein crambe meal (%)				
	0	3	6	9	12
Corn (7.88%)	63.180	62.443	61.718	61.005	60.292
Crambe meal	0.00	1.832	3.663	5.495	7.327
Soybean meal (46%)	30.254	28.920	27.577	26.221	24.864
Dicalcium phosphate	1.330	1.346	1.363	1.379	1.395
Soybean oil	2.904	3.046	3.186	3.321	3.455
Limestone	0.767	0.723	0.679	0.634	0.590
Salt	0.456	0.457	0.458	0.459	0.460
DL-methionine (99%)	0.267	0.285	0.302	0.320	0.338
L-lysine HCl (78%)	0.241	0.287	0.333	0.379	0.426
L-threonine (96%)	0.057	0.082	0.108	0.134	0.160
L-valine (96.5%)	0.030	0.069	0.100	0.131	0.162
Mineral/ vitamin premix [(a)]	0.400	0.400	0.400	0.400	0.400
Anticoccidial[(b)]	0.055	0.055	0.055	0.055	0.055
Choline chloride (60%)	0.040	0.040	0.040	0.040	0.040
Antioxidant[(c)]	0.010	0.010	0.010	0.010	0.010
Total	100.00	100.00	100.00	100.00	100.00
Calculated composition					
Metabolizable energy (Kcal/kg)	3.100	3.100	3.100	3.100	3.100
Crude protein (%)	19.50	19.50	19.50	19.50	19.50

Calcium (%)	0.732	0.732	0.732	0.732	0.732
Sodium (%)	0.200	0.200	0.200	0.200	0.200
Availabe phosphorus (%)	0.342	0.342	0.342	0.342	0.342
Crude fiber (%)	2.897	3.171	3.445	3.718	3.992
Digestible threonine (%)	0.701	0.701	0.701	0.701	0.701
Digestible lysine (%)	1.078	1.078	1.078	1.078	1.078
Digestible methionine+cystine (%)	0.787	0.787	0.787	0.786	0.786
Digestible tryptophan (%)	0.207	0.199	0.194	0.194	0.194
Digestible valine (%)	0.841	0.841	0.841	0.841	0.841

[(a)]Per kg of diet: Manganese 70.4 mg; iron 50 mg; zinc 60 mg; copper 10 mg; cobalt 0.8 mg; iodine 1 mg; selenium 0.3 mg. Vitamin A 7500 UI; vit. D3 2.000 UI; vit. E 12 UI; vit. B2 4.8 mg; vit. B6 2 mg; vit. B12 10 mcg; pantothenic acid 10 mg; vit, K3 10 mg; folic acid 0.7 mg; biotin 0.015 mg; choline 150 mg; niacina 30 mg; vit. B1 1 mg.[(b)]Coxistac. [(C)]Butylated hydroxytoluene 4 mg. Source: Authors.

Feed intake, weight gain, feed conversion ratio data were recorded in the periods from 8 to 21, 22 to 42 and 8 to 42 days of age. At 42 days of age, three birds per experimental plot were slaughtered for the evaluation of carcass and cuts (breast, drumstick, and thigh) yield. Birds were stunned, slaughtered and followed by bleeding, after they were scalded (water at 60 ºC for 43 min), plucked, and eviscerated. The carcass and cuts weight were determined by hot weight of each part.

As statistical procedures the data collected were submitted to ANOVA and quadratic polynomial and, or simple linear regression models considered at the significance level of 5%. Dunnett's test was applied to compare the results obtained between control diet and each one of the levels of replacement of the total dietary crude protein by the crude protein from crambe meal.

3. Results

The inclusion of 9% and 12% of the crambe protein in the broilers chicken's diets resulted in lower feed intake ($P<0.01$), and decreasing linearly ($FI= 874.753 – 4.2281X$, $R^2= 0.24$) by Dunnett´s test and linear model, respectively, from 8 to 21 days of age in comparison

with birds that were not replaced the protein from the diet (Table 3). Similarly, after Dunnett's test was applied to compare control diet with the other treatments, a difference was found (P≤0.01) for feed intake and a negative effect, i.e., lower intake, was observed in all treatments in which the dietary crude protein was substituted for the protein from crambe meal from 22 to 42 days of age. During the total rearing period (8 to 42 days) comparing control diet with the others, feed intake was found to be negatively affected by inclusion of the crambe in diet, by Dunnett´s test (P<0.01).

Table 3. Average ± standard error mean of feed intake (FI), weight gain (WG), feed conversion ratio (FC) of broilers chickens fed with replacement of part of the crude protein of the diet by the protein from crambe meal in 8 to 21, 22 to 42 and 8 to 42 days of age.

Protein crambe meal (%)	8 to 21 days of age		
	Parameter		
	FI (kg)	WG (kg)	FC (kg/kg)
0	0.885* ± 5.92	0.625 ± 13,29	1.418 ± 0.03
3	0.863 ± 6.54	0.622 ± 4.54	1.388 ± 0.01
6	0.860 ± 6.39	0.641 ± 8.73	1.342 ± 0.02
9	0.811* ± 9.63	0.603 ± 10.80	1.347 ± 0.02
12	0.837* ± 12.14	0.619 ± 14.33	1.382 ± 0.01
P value	0.0001[(b)]	0.205	0.056
CV*(%)[(a)]	2.44	4.30	3.40
	22 to 42 days of age		
0	3.347* ± 0.04	1.981 ± 0.06	1.698 ± 0.06
3	3.040* ± 0.07	1.893 ± 0.03	1.606 ± 0.03
6	3.073* ± 0.03	1.965 ± 0.04	1.567 ± 0.04
9	3.062* ± 0.06	1.860 ± 0.03	1.648 ± 0.04
12	3.029* ± 0.05	1.813 ± 0.05	1.674 ± 0.03
P value	0.001[(b)]	0.062	0.227
CV*(%)[(a)]	4.19	5.67	6.37

	8 to 42 days of age		
0	4.232* ± 0.04	2.607* ± 0.06	3.116 ± 0.06
3	3.904* ± 0.08	2.515 ± 0.03	2.994 ± 0.03
6	3.933* ± 0.04	2.606 ± 0.04	2.910 ± 0.05
9	3.873* ± 0.06	2.463 ± 0.04	2.996 ± 0.06
12	3.867* ± 0.05	2.432* ± 0.04	3.027 ± 0.03
P value	0.005[(b)]	0.022[(b)]	0.082
CV*(%)[(a)]	3.51	4.19	3.93

[(a)]CV= Coefficient of variation. [(b)*]Significant by Dunnet test at 5% probability. Souce: Author.

The inclusion of 12% of the crambe protein in the broilers diets resulted in lower weight gain (P<0.05) comparing with control diet, by Dunnett´s test from 22 to 42 days and 8 to 42 days. According to linear equation (WG = 2.6021-0.0130X; R^2=0.44) broilers from 8 to 42 days of age (total phase) showed lower weight gain (P<0.05) while increase crambe in diet. We did not find any differences between experimental treatments for feed consversion (P >0.05) in all evaluated phases.

The results showed that 12% of crambe meal protein impairs carcass weight, breast weight (P<0.01) and thigh weight (P<0.05) of broiler chickens compared with control diet, by Dunnett´s test (Table 4). The replacement levels of 3, 9 and 12% compared with control treatment, provided worse live weight, according to the applied test (P<0.01). Body weight, carcass weight (P<0.01) and breast weight (P<0.05) decreased linearly as the dietary crude protein was substituted for the crude protein from crambe meal, according with equations: BW = 2.7727-0.0106X (R^2 = 0.55), CW = 2.2468−0.01068X (R^2 = 0.57) and (BreW = 0.8022−0.0049X (R^2 = 0.58).

Table 4. Average ± standard error mean of broilers at 42 days of age, fed diets with replacement of dietary protein by crambe meal protein.

	Protein crambe meal (%)						
Parameter[a]	0	3	6	9	12	P value	CV[b] (%)
BW (kg)	2,84±0.05*	2,71±0.03*	2,76±0.04	2,69±0.03*	2,62±0.02*	0.014	2.99
CW (kg)	2,26±0.04*	2,18±0.02	2,23±0.02	2,16±0.01	2,10±0.02*	0.003	3.06
BreW (g)	793±0.02*	772±0.02	791±0.01	766±0.01	731±0.01*	0.032	4.49
TW (g)	277±0.01*	259±0.01	275±0.01	258±0.01	256±0.01*	0.019	4.94
DW (g)	337±0.01*	323±0.01	324±0.01	321±0.01	304±0.01*	0.070	5.68

[a]Body weight (BW). Carcass weight (CW). Breast weight (BreW). Thigh weight (TW). Drumstick weight (DW). [b]CV= Coefficient of variation. *Significant by Dunnett test at 5% probability. Source: Authors.

4. Discussion

According to the results of the present study, substitute of dietary protein by crambe protein alter broiler performance variable (feed intake), compared to control diet. Broilers that received the diet containing crambe meal obtained lower intake in the initial, growth and total rearing periods. This result may be related to the higher crude fiber content of the crambe meal or by presence of antinutritional factors. According Tavernari et al. (2009) higher levels of fibrous fractions in diets contribute to reducing feed intake, due to the gastrointestinal tract fill. The results of Ledoux et al. (1999) agree with present study, when observed that broilers fed diets with part of the crude protein replaced by the crude protein from crambe meal at 15% had lower feed intake compared with the other treatments, during the first phase of the experiment (8 to 21 days of age). However, throughout the experiment, feed intake at 15% of replacement was similar to the other levels of crambe inclusion. The authors reported that crambe meal has high fiber content, and the inclusion of this ingredient in diets may change their density. On the other hand, Silva et al. (2018) observed that naked necks chickens fed rations containing the test feed (crambe meal) consumed larger amounts of feed and had the lowest weight gains, resulting in the worst feed conversion during the growing (30 to 60 days) and final (61 to 90 days) phases. The same authors suggest that the antinutritional factors of

crambe impair the energy metabolizable and amino acids digestibility, like this, the feed intake increased for compensate the nutrients unavailability.

Other authors (Kloss et al., 1996; Figueiredo et al., 2003 and Mushtaq et al., 2007) studied alternatives of vegetables origin (canola and, or crambe meal) containing antinutritional factors (glucosinolate, erucic acid, tannin and sinapine) in feeding of broilers and reported a low feed intake and consequently less weight gain. It is, in general, believed that glucosinolates in poultry diets must be less than 2.5 µmol. g^{-1} (Mushtaq et al., 2007) and it is known that defatted crambe meal may have values between 50 and 160 µmol. g^{-1} (Liu et al. 1994).

The inclusion of 12% the crambe meal protein negatively influenced weight gain compared to the control diet for the total rearing period. This effect can be explained by the lower feed intake shown by the broilers fed with levels of the dietary protein replaced by the crambe meal protein, which was more marked at level of 12% (3.87 kg) that worsened in 8.5% in relation control diet (4.23 kg). However, broilers fed with 50 g/kg^{-1} crambe meal in diet no adverse effects on gain and health, according Ledoux et al. (1999). These authors mentioned that crambe meal show amino acid digestibility were 90% or greater, this indicated that high protein quality and concluded that inclusion of 15% crambe meal in the diet, during the finishing phase, did not affect weight gain, justified by the compensatory gain at the end of the period, occurrence not observed in the present study. However, they used a larger finishing period (42 to 56 days) and possibly broilers had larger adaptation the diets with crambe meal, in comparison to the present study that used period the 22 to 42 days. This significant reduction in feed intake may be justified by the fact that the broilers already presented poor feed intake in early phase, possibly due to the antinutritional factors of crambe.

Pietro (2013) evaluated the performance of Nile tilapia fingerlings fed with 6, 12, 18 and 24% of soybean meal protein replace by crambe meal protein and observed that there was no significant effect for performance up to 6% replacement. However, fish presented lower weight gain when fed at the 24% replacement level. Although, both are monogastric animals and with omnivorous alimentary habit, presenting similarities in the enzymatic system and, or metabolic, the significant reduction in performance of fishes were have been because of level evaluated be larger than the present study and fish age.

Silva et al. (2018) evaluated the performance of nacked necks broiler chicken fed with 4.37, 8.75 and 17.5% of crambe meal in substitution of soy meal and observed lower weight

gain and worse feed conversion and concludes that is impracticable the use of crambe in doses utilized.

The results showed that crambe meal protein impairs body weight, carcass weight, breast weight and drumstick weight of broiler chickens compared with control diet. This can be explained by the lower weight gain of the broilers at the replacement level of 12% and the lower use of the protein from crambe due to the antinutritional factors already mentioned.

5. Final Considerations

The replacement of part of the total protein of the feed by the protein of the crambe meal in 12% negatively affects the performance and the carcass of broilers. However, chickens fed diets containing 3, 6 and 9% protein from crambe meal were similar to those fed the control diet for most traits. This may be interesting for the production chain, in replacing part of the dietary protein with crambe protein, which is an alternative food to soybean meal. In the present study, the presence of antinutritional factors and their content in crambe meal were not evaluated, which may partly limit the interpretation of results. For future work it would be appropriate to analyze the antinutritional factors present, in order to increase knowledge and support the recommendation of its use in diets for broilers.

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