Performance and economic analysis of broilers fed diets containing acerola meal in replacement of corn

Desempenho e análise econômica de frangos de corte alimentados com dietas contendo farelo de acerola em substituição ao milho

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Abstract

It was aimed with this research to evaluate the performance of broiler chickens fed diets containing increasing levels of acerola meal in replacement of corn and analyze the economic viability of that production system. A total of 980 day-old male Cobb chicks were used, allotted in a completely randomized design, with four treatments - inclusion levels (0%, 5%, 10% and 15%) of acerola meal in replacement of corn – and seven replications with 35 birds per experimental unit. The birds were weighed at 21 and 42 days of age to measure the performance data. In the period between 1 and 21 days of age, differences were observed in the feed intake and feed:gain only, in which the inclusion of acerola meal linearly decreased feed intake and improved feed:gain up to a level of 10.25%. For the total rearing period, the control treatment showed higher body weight. The feed:gain showed linear effect, worsening the results with increasing amounts of acerola meal in the diets. In the same period, there was no significant difference in feed intake and productive efficiency index. With regard to the economic analysis, it was found that the lowest final cost per broiler was observed in diets with 10% of acerola meal inclusion in replacement of corn.

Keywords: Alternate ingredient. Broiler nutrition. By-products.

Resumo

Objetivou-se com a pesquisa avaliar o desempenho de frangos de corte alimentados com dietas contendo níveis crescentes de inclusão de farelo de acerola em substituição ao milho e analisar a viabilidade econômica deste sistema de produção. Foram utilizados 980 pintos de corte com um dia de idade, machos, da linhagem Cobb, distribuídos num delineamento inteiramente casualizado, com quatro tratamentos – níveis de inclusão (0, 5, 10 e 15%) de farelo de acerola em substituição ao milho - e sete repetições com 35 aves por unidade experimental. Aos 21 e 42 dias de idade, as aves foram pesadas para a mensuração dos dados de desempenho. No período de 1 a 21 dias de idade, foram observadas diferenças somente no consumo de ração e na conversão alimentar, nos quais a inclusão de farelo de acerola diminuiu linearmente o consumo de ração e melhorou a conversão alimentar até o nível de 10,25%. No período total de criação, o tratamento controle apresentou maior peso corporal. A conversão alimentar apresentou efeito linear, piorando os resultados com o aumento da quantidade de farelo de acerola nas dietas. Nesse mesmo período, não houve diferença significativa no consumo de ração e no fator de produção. Quanto à análise econômica, verificou-se que o menor custo final por frango foi observado nas dietas com 10% de inclusão de farelo de acerola em substituição ao milho.

Palavras-chave: Ingrediente alternativo. Nutrição de frangos. Subprodutos.

Introduction

Brazil has a variety of agricultural crops which generate a large production volume in the different regions of the country. In 2010 the Brazilian fruit production was 42 million tons and is considered the third largest world production, behind only China and

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India (PARANÁ, 2012). With all this production, it is estimated that the total processed fruits, are generated in the production of juices and pulps, between 30-40% of agro-industrial waste (MARTINS; FARIAS, 2002), and when they are deposited incorrectly are numerous and very serious consequences for the environment (JERÔNIMO, 2012). Thus, adding value to this waste is an economic and environmental interest, requiring scientific and technological research that enables its efficient, economic and safe use (SCHIEBER; STINTZING; CARLE, 2001).

In this context, the reuse of regionally adapted vegetal raw materials becomes an option to partially or totally replace certain feed ingredients. Some authors have reported that waste of by-products from the processing of fruits can be used with satisfactory results in broiler diets (SILVA et al., 2005; TOGASHI et al., 2007), especially after the first few weeks (BASTOS et al., 2007; LIRA et al., 2010).

Among the fruit waste with potential to be used in animal feed, stands out from the acerola, which is cultivated on a large scale, especially in the western region of São Paulo. According to Lourenzani et al. (2009), for the state of São Paulo, data on the Agricultural Census 2008 (SÃO PAULO, 2008), indicate that there are throughout the state about 340 Agricultural Production Units (APUs), and the region with greater concentration of production is Alta Paulista, and the city with the highest concentration is Junqueirópolis, known as the Capital of Acerola, which has 117 APUs and 176.8 ha with production of 4500 tonnes of fruit (PONTES et al., 2013).

In its processing is generated agroindustrial residue that usually ends up as accumulated waste and causing environmental impacts. Skin and seeds are usually the main components of fruits, but are often ignored; these materials are not reused or recycled, likely due to their lack of commercial value (SOONG; BARLOW, 2004).

Acerola meal, is a by-product of acerola, that originates from the processing of acerola for juice production or frozen concentrate pulp. In this process, the squeezing produces a residue (meal), still intensely red, which is often discarded, creating large volumes of organic waste during harvests (JACOB; BURRI, 1996).

The proposal of studying the inclusion of acerola meal in broiler feeds aims to reuse that by-product and reduce production costs in the poultry sector, particularly in regions where acerola crops are abundant (FÁVARO, 2002). Therefore, it was aimed with this research to evaluate the performance and perform an economic analysis of broilers fed diets with increasing levels of acerola meal in replacement of corn.

Material and Methods

In total, 980 one-day-old male Cobb chicks were raised and kept in an experimental rearing house divided into twenty-eight 2.5 m^2 cages, with 35 birds/cage, in a density of 14 birds/m^2. The experimental design was completely randomized, with four treatments and seven replications. The birds were subjected to the following experimental treatments: T0- basal feed (control treatment), with no added acerola meal in replacement of corn; T_{5-} 5% inclusion of acerola meal in replacement of corn; T_{10-} 10% inclusion of acerola meal in replacement of corn; T_{15-} 15% inclusion de acerola meal in replacement of corn. The chemical composition of acerola meal was performed by the Laboratory Analysis of Foods and Nutrition Animal - LANA, the State University of Maringá - PR, is shown in table 1.

Table 1 – Chemical composition of acerola meal – Brazil – 2013

Components	%
Dry matter	90,15
Crude protein	8,11
Neutral detergent fiber	50,86
Acid detergent fiber	41,33
Crude fiber	43,34
Ether extract	5,68
Mineral matter	4,72

Feed and water were provided *ad libitum*. The feeding regimen was divided into four stages: pre-initial (1 to 7 days); initial (8 to 21 days); growth, (22 to 35 days); and final (36 to 42 days) (Table 2); feeds were formulated based on corn and soybean meal as recommended in Rostagno et al. (2005). In order to determine the metabolizable energy of acerola meal, a metabolism experiment was previously performed in which a value of 754 kcal/kg was obtained (ZANETTI et al., 2011).

Temperature were measured and ventilation were controlled manually by adjusting the side curtains of the shed. Lighting was constant. The average maximum and minimum environmental temperatures, black globe temperatures, dry and wet bulb were 38,1 ± 5,0ºC, 17,8 ± 6,3ºC, 29,7 ± 3,3ºC, 28,6 ± 3,7ºC and 23,3 ± 2,6ºC, respectively.

The birds were weighed at 1, 21 and 42 days of age to obtain performance data: body weight (mean weight of the birds in each coop); feed intake (obtained through the difference between total feed provided and leftovers collected at the end of each period); feed:gain ratio (calculated as the ratio between total feed intake and weight gain, corrected by the weight of dead birds), viability (expressed as percentage, 100 – mortality), and productive efficiency index (calculated at the end of the experiment as the ratio between average daily weight gain multiplied by the viability, divided by feed:gain, multiplying that total by 100). The results were subjected to analysis of variance (ANOVA); when significant ($P < 0.05$), the results underwent polynomial regression analysis using SAS (STATISTICAL ANALYSIS SYSTEM, 2002).

The economic study evaluated the cost of feed, gross income, operating earnings, profit margin and final cost/bird. The profitability indicators used in this work were those considered by Martin et al. (1997): Gross Income, which consists of multiplying the total kilograms obtained per treatment by the average unit price of poultry paid to producers; operating earnings, which represents the difference between gross income and total cost of production; and profit margin, which refers to the rate of gross income, which consists of available resources, in relation to the net income obtained.

The economic evaluation of including acerola meal in the diets was based on animal performance data during the experimental period. The cost of each experimental diet was calculated according to the prices of ingredients, based on quotes obtained in July 2013, when the economic analysis was carried out. The prices of ingredients/kg used to establish feed costs were: corn, R$ 0.438; soybean meal, R$ 1.043; soybean oil, R$ 2.350; dicalcium phosphate, R$ 1.500; calcitic limestone, R$ 0.138; L-lysine, R$ 5.130; DL-methionine, R$ 9,620; corn gluten meal, R$ 1.388; common salt, R$ 0.325; vitamin and mineral supplement for the pre-initial and initial stages, R$ 8.385; vitamin and mineral supplement for the growth stage, R$ 8.417; vitamin and mineral supplement for the final stage, R$ 3.648; and acerola meal, R$ 0.350. Feeding cost was determined based on total feed intake per animal multiplied by the cost of the diet used.

For initial bird value, the unit price per day-old chick (R$1.50) was used. The final value received for each bird was obtained by dividing the final gross weight of the bird by the average price per kg of live broiler (R$ 2.10), as practiced in southeastern Brazil in July 2013.

Results and Discussion

In the period from 1 to 21 days of age (Table 3), the addition of acerola meal in replacement of corn in the feeds influenced feed intake and feed:gain. Body weight and viability were not affected by the treatments.

Table 2 – Percentage and calculated composition of feeds given to birds according to each treatment – Brazil – 2013

Ingredients, %	Acerola meal levels in replacement of corn, %															
	0				5				10				15			
	Age, Days															
	1-7	8-21	22-33	34-42	1-7	8-21	22-33	34-42	1-7	8-21	22-33	34-42	1-7	8-21	22-33	34-42
Corn, grain	59.78	60.86	63.91	68.16	55.38	56.34	59.22	63.11	51.55	52.51	55.14	58.77	48.23	49.12	51.56	54.98
Soybean, Meal	30.45	28.57	24.66	20.64	30.70	28.86	24.92	20.96	30.93	29.06	25.18	21.23	31.15	29.28	25.43	21.45
Corn gluten meal	4.50	4.50	4.70	4.70	4.50	4.50	4.70	4.70	4.50	4.50	4.70	4.70	4.50	4.50	4.70	4.70
Acerola meal	0.00	0.00	0.00	0.00	2.77	2.82	2.96	3.16	5.16	5.25	5.51	5.88	7.23	7.37	7.73	8.25
Calcitic limestone	0.97	0.93	0.88	0.84	0.95	0.91	0.87	0.82	0.93	0.90	0.85	0.81	0.92	0.88	0.84	0.80
DL-methionine	0.34	0.23	0.21	0.20	0.35	0.24	0.22	0.22	0.36	0.25	0.23	0.23	0.37	0.26	0.23	0.24
Dicalcium phosphate	1.96	1.85	1.71	1.56	1.95	1.85	1.70	1.55	1.95	1.84	1.70	1.54	1.94	1.84	1.69	1.54
L-lysine	0.54	0.37	0.37	0.43	0.54	0.37	0.38	0.43	0.55	0.38	0.38	0.44	0.55	0.38	0.38	0.44
Soybean oil	0.56	1.78	2.68	2.62	1.94	3.20	4.15	4.20	3.14	4.40	5.43	5.56	4.18	5.46	6.55	6.75
Common salt	0.52	0.51	0.48	0.46	0.52	0.51	0.48	0.46	0.53	0.51	0.49	0.46	0.53	0.51	0.49	0.46
Vit./min. premix[1,2,3]	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Composition																
ME, kcal/kg	2,960	3,050	3,150	3,200	2,960	3,050	3,150	3,200	2,960	3,050	3,150	3,200	2,960	3,050	3,150	3,200
CP, %	22.11	21.14	19.73	18.31	22.11	21.14	19.73	18.31	22.11	21.14	19.73	18.31	22.11	21.14	19.73	18.31
CF, %	2.73	2.65	2.49	2.35	3.95	3.89	3.79	3.74	5.00	4.96	4.92	4.93	5.92	5.89	5.90	5.98
Ca, %	0.94	0.90	0.84	0.78	0.94	0.90	0.84	0.78	0.94	0.90	0.84	0.78	0.94	0.90	0.84	0.78
Avail. P, %	0.47	0.45	0.42	0.39	0.47	0.45	0.42	0.39	0.47	0.45	0.42	0.39	0.47	0.45	0.42	0.39
Met, %	0.66	0.55	0.52	0.49	0.67	0.56	0.52	0.50	0.68	0.56	0.52	0.50	0.68	0.57	0.52	0.51
Met + Cys, %	0.97	0.85	0.80	0.76	0.97	0.84	0.80	0.76	0.97	0.84	0.79	0.76	0.97	0.85	0.79	0.76
Lys, %	1.36	1.19	1.10	1.05	1.37	1.19	1.10	1.05	1.37	1.19	1.10	1.05	1.37	1.19	1.10	1.05
Potassium, %	0.73	0.70	0.64	0.57	0.72	0.69	0.63	0.57	0.72	0.68	0.62	0.56	0.71	0.68	0.62	0.55
Sodium, %	0.22	0.22	0.21	0.20	0.22	0.22	0.21	0.20	0.23	0.22	0.21	0.20	0.23	0.22	0.21	0.20
Chlorine, %	0.36	0.35	0.33	0.32	0.36	0.35	0.33	0.32	0.36	0.35	0.33	0.32	0.36	0.35	0.33	0.31
Linoleic acid, %	1.65	2.32	2.84	2.86	2.32	3.00	3.55	3.62	2.90	3.58	4.16	4.27	3.40	4.09	4.70	4.85

[1] Vitamin and mineral supplement M. Cassab Comércio e Indústria Ltda (per kg of feed), for the stage between 1 and 21 days: Met. 42.075 %; Met + Cys 42.075 %; Choline 65,250 mg; Vit. A 2,750 IU; Vit. D3 500 IU; Vit. E 4,000 mg; Vit. K3 375 mg; Vit. B1 300 mg; Vit. B2 1,125 mg; Vit. B6 500 mg; Vit. B12 4,000 µg; Niacin 8,750 mg; Ca Pantothenate 2,500 mg; Folic Acid 100 mg; Biotin15 mg; Fe 7,500 mg; Cu 2,250 mg; Mn 15,000 mg; Zn 15,000 mg; I 250 mg; Se 62.5 mg; Halquinol 7,500 mg; Narasin 12,500 mg; Nicarbazin 12,500 mg

[2] Vitamin and mineral supplement M. Cassab Comércio e Indústria Ltda (per kg of feed), for the stage between 22 and 33 days: Met. 38.61 %; Met + Cys 38.61 %; Choline 54,810 mg; Vit. A 2,250 IU; Vit. D3 400 IU; Vit. E 3,500 mg; Vit. K3 375 mg; Vit. B1 250 mg; Vit. B2 1,000 mg; Vit. B6 450 mg; Vit. B12 3,000 µg; Niacin 7,500 mg; Ca Pantothenate 2,250 mg; Folic Acid 75 mg; Biotin 12,5 mg; Fe 7,500 mg; Cu 2,250 mg; Mn 15,000 mg; Zn 15,000 mg; I 250 mg; Se 62.5 mg; Halquinol 7,500 mg; Monensin 30,000 mg

[3] Vitamin and mineral supplement M. Cassab Comércio e Indústria Ltda (per kg of feed) for the stage between 34 and 42 days: Met. 30.195 %; Met + Cys 30.195 %; Choline 43,480 mg; Vit. A 900 IU; Vit. D3 150 IU; Vit. E 1,500 mg; Vit. K3 150 mg; Vit. B1 90 mg; Vit. B2 300 mg; Vit. B6 120 mg; Vit. B12 900 µg; Niacin 1,500 mg; Ca Pantothenate 1,200 mg; Biotin 4,5 mg; Fe 10,000 mg; Cu 3,000 mg; Mn 20,000 mg; Zn 20,000 mg; I 333.33 mg; Se 60

Table 3 – Performance of broilers from 1 to 21 and 1 to 42 days old, fed different levels of acerola meal in replacement of corn – Brazil – 2013

Variables[1]	Treatments				Probability	CV (%)
	0%	5%	10%	15%		
			1 to 21 days of age			
IW (g)	44.53	44.57	44.49	44.57	0.9861	1.08
BW (g)	831	821	811	810	0.1669	3.07
FI (g) *	1103	1061	1051	1053	0.0003	2.08
F:G **	1.41	1.37	1.37	1.38	0.0273	2.09
VIAB (%)	98.78	98.37	98.78	98.37	0.9329	1.76
			1 to 42 days of age			
BW (g) *	2226	2159	2127	2101	0.0010	3.07
FI (g)	3621	3483	3499	3532	0.0677	3.23
F:G *	1.69	1.68	1.72	1.74	<0.0001	1.74
VIAB (%) *	89.72	89.72	93.81	92.48	0.0041	8.06
IEP	246.99	241.77	262.56	249.56	0.3262	9.48

[1] IW – initial weight, BW – body weight, FI – feed intake, F:G – feed:gain, VIAB – viability, IEP – productive efficiency index (((Average daily weigh gain x VIAB)/FC)x100). * L – Linear. ** Q – Quadratic

Feed intake reduced linearly with inclusion of acerola meal in diet (Figure 1), in agreement with Bastos et al. (2007) and Sundu, Kumar and Dingle (2006), who demonstrated a linear reduction in feed intake by broilers fed diets containing various inclusions of coconut by-products. Likewise, Lira et al. (2010) observed a decline in feed intake during the initial stage of broilers as tomato residue was added to the diet.

Acerola meal has 43.34% of crude fiber, which reduces feed density and compromises intake. It is also possible that the fibrous portions of acerola meal are able to retain water, which limits ingestion due to the space they occupy within the gastrointestinal tract (BASTOS et al., 2007). The fiber content in the feeds may also affect intestinal peristalsis, due to the contact of the soluble portion of fiber with water, forming gels that reduce transit time and promote the sensation of satiety, reducing intake (CLASSEN, 1996; LIRA et al., 2010; PHILIP; GILBERT; SMITHARD, 1995).

Feed:gain showed a quadratic effect (Figure 2), decreasing with inclusion of acerola meal to the diet up to a level of 10.25%. Beyond that level, the feed:gain of the birds tends to worsen, showing undesirable results with further inclusion. These results corroborate with Nascimento et al. (2005), who observed a quadratic response in feed:gain when using cassava scrapings during the growth period of birds.

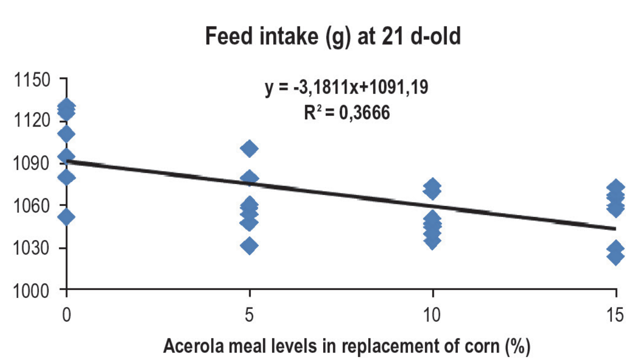

Figure 1 – Effects of acerola meal levels on feed intake from 1 to 21 days old, Brazil – 2013
Source: (ZANETTI, 2014)

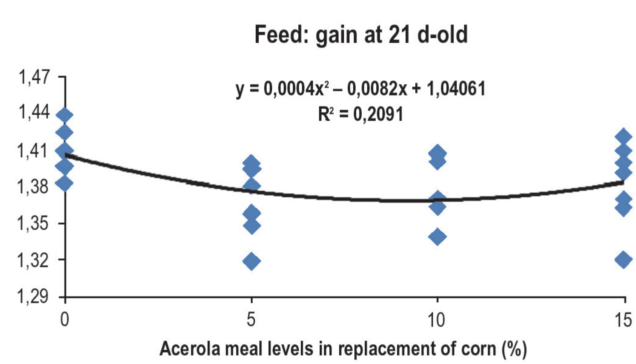

Figure 2 – Effects of acerola meal levels on feed:gain ratio from 1 to 21 days old, Brazil – 2013
Source: (ZANETTI, 2014)

In the total period from 1 to 42 days (Table 2), a significant difference was observed in body weight, feed:gain and viability of broilers.

The body weight decreased linearly as the amount of acerola meal in the diet increased (Figure 3). These results agree with Sundu, Kumar and Dingle (2006), who observed a linear reduction in weight gain of broilers fed levels of coconut by-product in feed, in the period between 4 and 14 days. Bastos et al. (2007) and Lira et al. (2010) observed linear reductions in weight gain for the total rearing period as the amounts of coconut by-product and tomato residue increased in feed, respectively.

inclusion of acerola meal, as the birds primarily seek to fulfill their energy needs, except when the capacity of the digestive tract or other factors constituting a limitation. Such fact seems to have been determinant in the initial stage, but did not apply to the total rearing period due to the development of the birds' digestive tract.

In regression analysis, it was observed that feed:gain worsened linearly as the percentage of acerola meal increased in the diets (Figure 4). The effects of acerola meal on average weight gain of the broilers influenced feed:gain, situation more evident in the treatments with the highest amounts of acerola meal.

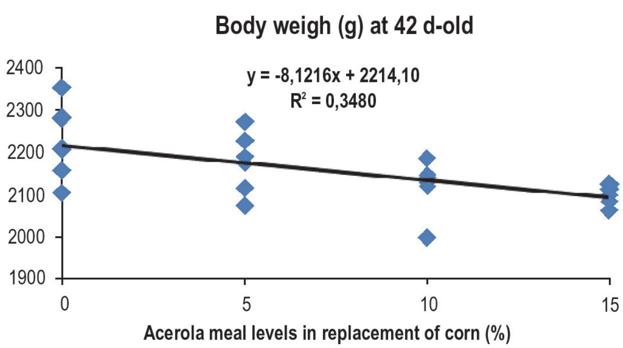

Figure 3 – Effects of acerola meal levels on mean body weight from 1 to 42 days old, Brazil – 2013
Source: (ZANETTI, 2014)

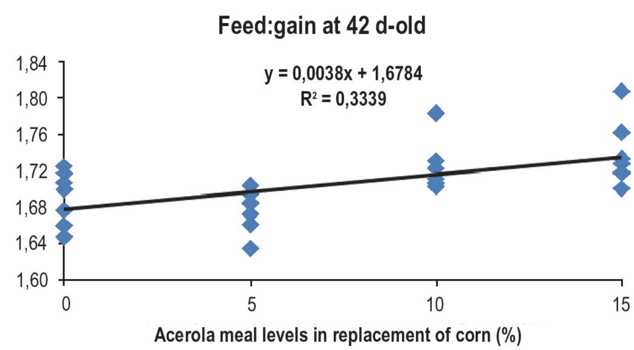

Figure 4 – Effects of acerola meal levels on feed:gain ratio from 1 to 42 days old, Brazil – 2013
Source: (ZANETTI, 2014)

High temperatures were recorded during the experimental period (average maximum environmental temperatures above 38ºC), which may have interfered on average body weight of these experimental broilers, as the bird's body adjusts physiologically to maintain homeothermia, either to conserve or dissipate heat. That requires energy expenditure, resulting in reduced productive efficiency index (RAMOS et al., 2006).

The feed intake was not influenced by the treatments, agreeing with previous studies that evaluated co-products in broiler diets (RAMOS et al., 2006; VIEIRA et al., 2008). In function of feeds were isoenergetic, it can be inferred that feed intake during the final rearing stage was not affected by the

At 42 days, viability increased with higher levels of acerola meal (T_{10} - 92.65% viability) (Figure 5), due to the lower mortality in those treatments.

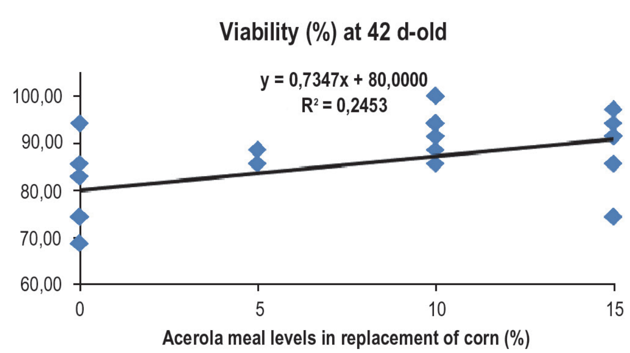

Figure 5 – Effects of acerola meal levels on viability from 1 to 42 days old, Brazil - 2013
Source: (ZANETTI, 2014)

Observing the viability weekly (Table 4), the 5th and 6th weeks showed worst viability, this fact can be justified by high temperatures were measured during the experimental period, especially in two last weeks with average maximum environmental temperatures above 38ºC, which may have contributed to increased mortality and consequently decrease in viability at 42 days. In regression analysis, it was observed that viability in the 6th week increases linearly as the percentage of acerola meal increased in the diets.

Table 4 – Viability weekly of broilers from 1 to 42 days old, fed different levels of acerola meal in replacement of corn, Brazil – 2013

	Treatments					CV
Week	0%	5%	10%	15%	Probability	(%)
1st (1 to 7 days)	99,59	99,18	99,18	99,18	0,167	1.33
2nd (8 to 14 days)	99,18	98,78	99,18	99,78	0,182	1.47
3rd (15 to 21 days)	93,06	93,47	93,88	93,47	0,131	2.60
4th (22 to 28 days)	92,65	93,06	93,47	93,47	0,414	2.82
5th (29 to 25 days)	79,18	78,37	89,39	85,31	0,068	9.86
6th (36 to 42 days) *, [1]	74,69	75,51	87,76	83,67	0,003	8.80

* L – Linear. [1] $Y= 0,7837x + 74,531$; $R^2 = 0,633$

There was no significant difference between treatments for the productive efficiency index. Economic evaluation data can be found in table 5. An increase was observed in feed cost as the level of acerola meal inclusion increased in the diets, which was also observed by Furlan et al. (2001) while working with inclusion of sunflower meal in broiler feeding. The control diet showed the best cost, featuring a similar value the level with 5% inclusion of acerola meal in replacement of corn. The feeds with the highest inclusion levels (10% and 15% in replacement of corn) showed higher costs, possibly due to the higher inclusion of soybean oil in order to keep the feeds isoenergetic.

Being a low energy density ingredient (756 kcal of AMEn), acerola meal should be used in broiler diets accompanied by the addition of soybean oil, thereby not causing effective reductions in the kg cost of feed.

Table 5 – Economic analysis of rearing broilers fed different inclusion levels of acerola meal in replacement of corn, Brazil – 2013

	Inclusion of acerola meal, %			
Variables	0	5	10	15
Cost of feed, R$	582.01	583.43	645.45	651.38
Other costs[1], R$	487.26	487.44	495.26	496.01
Total cost[2], R$	1069.27	1070.87	1140.71	1147.39
Gross income[3], R$	855.33	838.74	945.55	904.47
Operating earnings[4], R$	-213.94	-232.13	-195.16	-242.92
Profit margin[5], %	-25.01	-27.67	-20.63	-26.86
Final cost/bird[6], R$	4.67	4.53	4.39	4.41

[1] Day-old chicks, disinfection, immunizations and medications, electricity, heating gas, labor and taxes, social fees on production, maintenance and repairs (APA, March 2003)
[2] Value obtained by adding the cost of feed + other costs
[3] Value obtained by multiplying total final weight of each treatment by the kg value of live broiler paid to producers
[4] Value obtained by the difference between gross income and total cost
[5] Value obtained by the ratio between operating earnings and gross income, multiplied by 100
[6] Value obtained by the ratio between total cost and the final number of birds per treatment

Ramos et al. (2006), when using dehydrated cashew fruit pulp for broilers, observed a 17% increase in feeding costs with a 15% inclusion of that ingredient, due to the addition of vegetal oil in order to maintain the energy balance.

The use of acerola meal in broiler feeds can be advantageous during offseason periods, when corn and soybean meal prices are high. The use of alternative ingredients is directly linked to the price of traditional raw materials, such as corn and soybean meal, as well as the cost of possible supplementation required to maintain adequate nutritional levels for animal performance (CARNEIRO et al., 2009).

Another factor to consider regarding the cost of feeds containing acerola meal is the mode of production of that by-product in the studied region; as that modality is relatively new, it is still considered "artisanal", mostly labor-dependent and without the use of equipment and infrastructure, which results in poor price malleability and high production cost. In that regard, the producing company is undergoing a development phase, precisely to make production more efficient and acerola meal more accessible and competitive.

The best value for operating earnings, profit margin and final cost/bird was observed for the treatment with 10% inclusion of acerola meal in replacement of corn, due to the greatest viability in the experiment, making it the most economically viable.

Another recurring issue that could substantially improve the profitability of bird production in this experiment would be a real scenario in poultry farms/co-ops, locations in which production capacity is expanded without proportionally increasing the production cost (economy of scale), in which the average product cost tends to be lower as production increases. Garcia and Ferreira Filho (2005) mention that 24.7% of broiler production properties in southern Brazil and Minas Gerais state have facilities up 840 m^2 in size, and 63.1% up to 1,350 m^2; therefore, it would be possible to reduce average costs by expanding production levels, thereby enjoying the available economies of scale.

Conclusion

The inclusion of acerola meal in replacement of corn reduces the feed intake of broilers and improves feed:gain up to a level of 10.25% during the initial stage (1 to 21 days). For the total rearing period (1 to 42 days), the addition of acerola meal promotes negatively effects on body weight and feed:gain of birds, but improves the viability. Under the experimental conditions of this work, acerola meal does not result in efficient feed cost reduction, and among the treatments, the diet with 10% of acerola meal in replacement of corn provides the better economic analysis.

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