R. Bras. Zootec., 53:e20230087, 2024
https://doi.org/10.37496/rbz5320230087

Non-ruminants
Full-length research article

Revista Brasileira de Zootecnia

Brazilian Journal of Animal Science
e-ISSN 1806-9290
www.rbz.org.br

Evaluation of the effects of an emulsifier and two lipid sources on growth performance and intestinal morphology of broiler chickens

Marcus Vinícius Garcia de Oliveira[1], Júlia Marixara Sousa da Silva[1], João Marcos Monteiro Batista[1], Marcos Barcellos Café[1], Heloisa Helena de Carvalho Mello[1], Helder Freitas de Oliveira[1]*, Marília Ferreira Pires[1], Nadja Susana Mogyca Leandro[1], David Vanni Jacob[2]

[1] Universidade Federal de Goiás, Escola de Veterinária e Zootecnia, Goiânia, GO, Brasil.
[2] Adisseo, Campinas, SP, Brasil.

***Corresponding author:**
hfoliveirazoo@gmail.com

Received: July 13, 2023
Accepted: March 8, 2024

How to cite: Oliveira, M. V. G.; Silva, J. M. S.; Batista, J. M. M.; Café, M. B.; Mello, H. H. C.; Oliveira, H. F.; Pires, M. F.; Leandro, N. S. M. and Jacob, D. V. 2024. Evaluation of the effects of an emulsifier and two lipid sources on growth performance and intestinal morphology of broiler chickens. Revista Brasileira de Zootecnia 53:e20230087.
https://doi.org/10.37496/rbz5320230087

Editors:
Ines Andretta
Mahmoud Mohamed Alagawany

ABSTRACT - This study aimed to evaluate the effect of including an emulsifier (soybean lecithin) and two lipid sources (soybean oil and chicken fat) on the performance and intestinal morphology of broiler chickens. A total of 576 one-day-old Cobb® 500 male chicks were housed in a completely randomized design, with treatments divided in a 2 × 2 factorial arrangement (with and without emulsifier and two lipid sources – soybean oil or chicken fat), totaling four treatments with eight replications and 18 chicks per plot. The experimental diets were formulated to be isoenergetic and isoproteic. The use of chicken fat improved the live weight at the starter rearing stage. However, the use of the emulsifier improved the live weight at the grower and finisher phases. No interaction effect was observed between treatments for performance. The intestinal morphology showed an increase in duodenal villus height with the use of chicken fat and emulsifier. The ileum had an increase in villus height in chickens fed the diet with soybean oil and emulsifier. Supplementation of the emulsifier resulted in positive results in the live weight of chickens at 35 and 42 days of age, in addition to increasing the villus height in the small intestine.

Keywords: chicken fat, lecithin, performance, poultry farming, soybean oil

1. Introduction

The inclusion of fat in the diet of broiler chickens is a common practice in animal nutrition to meet the high energy requirements of fast-growing animals. According to Wu et al. (2020), diet energy is one of the most important points to be considered in feed formulation for broiler chickens, as it acts to maintain the physiological functions, growth, and performance of animals and enables higher protein deposition in the carcass.

Ravindran et al. (2016) reported that the use of different fat sources has been studied to increase the energy of the diet, as fats contain more than twice as much energy (2.5 times) when compared with carbohydrates and proteins. The fatty acid profile of an oil or fat directly influences the digestibility and development of birds, since the digestibility and absorption rate of unsaturated fatty acids are higher than those of saturated fatty acids (Ravindran et al., 2016). Unsaturated fatty acids are more easily found in plant sources, such as soybean, canola, olive, and corn oils, while saturated fatty acids are more present in animal sources. However, there are some exceptions, such as poultry fat, which despite being from an animal source, is mostly composed of about 60% unsaturated fatty acids (Lee and Foglia, 2000).

The price of lipid sources conventionally used in feed has been increasing in recent years due to the increased demand for vegetable fats for biodiesel production, requiring the development of commercial additives that result in higher utilization of dietary lipids (Serpa et al., 2023).

Lipids need to be emulsified by bile salts before the action of the lipases produced in the pancreas and intestine to be better digested (Doreau and Chiliard, 1997). The inclusion of additives that act as emulsifiers in broiler feed can improve fat digestibility and increase energy availability in diets (Siyal et al., 2017). Soybean lecithin is among the emulsifiers used in broiler diets that has a lipid profile with a high degree of restoration and is amphipathic, an important factor for fat emulsification (Morgado et al., 1995; Viñado et al., 2019). Regarding the physiological aspect of the gastrointestinal tract, the use of emulsifiers as additives in the diet of chickens is justified mainly up to 21 days of life, as chickens in the early rearing stages have low bile production, hindering fat emulsification, digestion, and absorption of fatty acids (Bontempo et al., 2016). Thus, the use of emulsifiers in the diet of chickens aims to improve the digestibility of the different lipid sources, increasing the energy availability in the broiler feed, which may improve performance (Siyal et al., 2017).

The objective of this study was to evaluate the effect of including an emulsifier (soybean lecithin) and two lipid sources (soybean oil and chicken fat) on the performance and intestinal morphology of broiler chickens.

2. Material and Methods

The experiment was conducted in Goiânia, Goiás, Brazil (16°35'48.3" S, 49°17'08.8" W). Research on animals was conducted according to the institutional committee on animal use (083/2020).

A total of 576 one-day-old male chicks of the Cobb® 500 lineage, at an average initial weight of 46 ± 2 g, were used. The experimental design was completely randomized, with treatments divided in a 2 × 2 factorial arrangement (with and without emulsifier and two lipid sources – soybean oil or chicken fat), totaling four treatments with eight replication/treatment.

The chicks were housed in a masonry shed built in the east-west orientation, measuring 125 × 12 m, with an area of 1,824 m^2, a ceiling height of 4.20 m, side openings controlled by curtains, and foggers and three exhaust fans installed at one end of the shed. Thirty-two fixed boxes measuring 0.9 × 1.6 m were installed inside the shed, totaling an area of 1.44 m^2. Each box contained 18 animals, and a density of 12.5 chickens/m^2.

The control and measurement of climate factors were carried out automatically by a control panel that recorded the minimum and maximum values of temperature and humidity every 5 min. The shed was completely sealed for the entry of light (dark house), and the chickens received 23 h of light and 1 h of darkness within 24 h.

The chickens received water and feed *ad libitum* in nipple drinking troughs and pendulum feeders, respectively. Each box had five drinking troughs and feeders. The offered diets were composed mainly of corn and soybean meal (Tables 1 and 2), which met the nutritional requirements recommended by the Rostagno et al. (2017) at the different rearing stages.

The experimental diets were formulated to be isoenergetic and isoproteic. The inclusion of the emulsifier (Nutri-Lyso®) was 0.05% and on top (added to the feed after its formulation), being composed of 500 g of soybean lecithin/kg of the product, starch, antioxidant (BHT, BHA, and propyl gallate), and wheat flour.

The intestinal morphology was determined using a sample of each segment of the small intestine (duodenum, jejunum, and ileum) for each replication with a 3-cm cut, which was opened and washed by the mesenteric edge, fixed in 10% formaldehyde for 24 h. Then, the material was dehydrated in 70% ethanol, and the samples were cleared in xylenol and placed in paraffin blocks, which were stained in hematoxylin and eosin (HE) (Luna, 1968). The samples were sectioned into 4-µm sizes, which were digitized under an optical microscope, and the morphometric parameters villus height and crypt depth were determined using the software Image J. Eight measurements of villus height and crypt depth of the different segments of the small intestine were performed, totaling 64 readings per treatment.

The data were analyzed using SAS (Statistical Analysis System, 2010) statistical package. To assess the statistical assumptions of normality of residuals, the Shapiro-Wilk test was employed, and the homogeneity of variances was evaluated using the Levene's Test. Analysis of variance (ANOVA) was conducted on the data, and in the presence of a significant effect, means were compared using the F test at a 5% significance level. In cases where significant effects of interactions between lipid sources and emulsifiers were observed, Student's t test was used for mean comparisons. The significance level for all analyses conducted was set at 5%.

The following statistical model was used:

$$Y_{ijk} = \mu + A_i + B_j + AB_{ij} + \varepsilon_{ijk},$$

in which Y_{ijk} = observation values that obtained a combination of treatment with or without emulsifier for i and lipid source for j, μ = overall mean, A_i = effect of treatment with or without emulsifier for i, B_j = effect of lipid source treatment for j, AB_{ij} = effect of interactions of treatment with or without emulsifier for i and lipid source for j, ε_{ijk} = error in treatment, i = number of treatments, and j = number of replicates.

Table 1 - Percent composition and calculated nutritional levels of the reference diet for diets with soybean oil as a lipid source

Ingredient (%)	Period (days)			
	1 to 7	8 to 21	22 to 35	36 to 42
Corn	55.08	57.59	66.61	66.93
Soybean meal	35.56	33.39	25.63	23.74
Soy oil	2.44	2.68	2.15	4.08
Monocalcium phosphate	1.74	1.60	1.44	1.31
Calcitic limestone	1.28	1.20	1.16	1.17
Salt	0.43	0.38	0.37	0.375
L-Lysine, HCL	1.573	1.438	1.194	1.077
DL-Methionine	0.817	0.737	0.575	0.569
L-Threonine	0.788	0.719	0.571	0.504
Biocholine	0.024	0.019	0.025	0.021
Mineral premix[1]	0.050	0.050	0.050	0.050
Vitamin premix[2]	0.050	0.050	0.050	0.050
Total	100	100	100	100
Nutri-Lyso®	0.05	0.05	0.05	0.05
Calculated nutritional levels				
Crude protein (%)	23.00	22.50	19.30	18.30
Metabolizable energy (kcal/kg)	3000	3050	3120	3250
Digestible methionine (%)	0.885	0.811	0.666	0.661
Digestible lysine (%)	1.330	1.230	1.060	0.970
Digestible threonine (%)	0.865	0.810	0.700	0.694
Digestible tryptophan (%)	0.028	0.029	0.034	0.034
Linoleic acid (%)	2.372	2.551	2.436	3.481
Calcium (%)	0.960	0.900	0.830	0.800
Chlorine (%)	0.285	0.258	0.254	0.257
Available phosphorus (%)	0.470	0.440	0.400	0.370

[1] Mineral supplement per kg of feed (Mineral mix): Mn, 60 g; Fe, 80 g; Zn, 50 g; Cu, 10 g; Co, 2 g; I, 1 g; vehicle up to 500 g.
[2] Vitamin supplement per kg of feed (Protein mix): vit. A (min), 2,000,000 IU; vit. D3, 500,000 IU; vit. E (min), 5000 IU; vit. B1 (min), 500 mg; vit. B2 (min), 1500 mg; vit. B6 (min), 700 mg; vit. B12 (min), 1500 mg; nicotinic acid (min), 9000 mg; pantothenic acid (min), 3500 mg; vit. K3 (min), 450 mg; folic acid (min), 250 mg; biotin (min), 15 mg; zinc bacitracin, 10 g; selenium, 75 mg; vehicle up to 1000 g.
Nutri-Lyso®: 500 g of soy lecithin/kg, starch, antioxidant (BHT, BHA, and propyl gallate), and wheat flour.

Table 2 - Percent composition and calculated nutritional levels of the reference diet for diets with chicken fat as a lipid source

Ingredient (%)	Period (days)			
	1 to 7	8 to 21	22 to 35	36 to 42
Corn	54.96	57.50	66.46	66.72
Soybean meal	35.58	33.80	25.66	23.78
Chicken fat	2.51	2.75	2.23	4.20
Monocalcium phosphate	1.74	1.60	1.44	1.31
Calcitic limestone	1.28	1.20	1.168	1.17
Salt	0.37	0.37	0.279	0.27
L-Lysine, HCL	1.574	1.438	1.195	1.07
DL-Methionine	0.817	0.737	0.575	0.570
L-Threonine	0.788	0.720	0.571	0.504
Biocholine	0.024	0.020	0.020	0.021
Mineral premix[1]	0.050	0.050	0.050	0.050
Vitamin premix[2]	0.050	0.050	0.050	0.050
Total	100	100	100	100
Nutri-Lyso®	0.05	0.05	0.05	0.05
Calculated nutritional levels				
Crude protein (%)	23.50	22.50	19.30	18.30
Metabolizable energy (kcal/kg)	3000	3050	3120	3250
Digestible methionine (%)	0.886	0.811	0.666	0.661
Digestible lysine (%)	1.330	1.230	1.060	0.970
Digestible threonine (%)	0.865	0.810	0.700	0.640
Digestible tryptophan (%)	0.028	0.029	0.034	0.034
Linoleic acid (%)	1.570	1.667	1.731	2.144
Calcium (%)	0.960	0.900	0.830	0.800
Chlorine (%)	0.250	0.250	0.200	0.200
Available phosphorus (%)	0.470	0.440	0.400	0.370

[1] Mineral supplement per kg of feed (Mineral mix): Mn, 60 g; Fe, 80 g; Zn, 50 g; Cu, 10 g; Co, 2 g; I, 1 g; vehicle up to 500 g.
[2] Vitamin supplement per kg of feed (Protein mix): vit. A (min), 2,000,000 IU; vit. D3, 500,000 IU; vit. E (min), 5000 IU; vit. B1 (min), 500 mg; vit. B2 (min), 1500 mg; vit. B6 (min), 700 mg; vit. B12 (min), 1500 mg; nicotinic acid (min), 9000 mg; pantothenic acid (min), 3500 mg; vit. K3 (min), 450 mg; folic acid (min), 250 mg; biotin (min), 15 mg; zinc bacitracin, 10 g; selenium, 75 mg; vehicle up to 1000 g.
Nutri-Lyso®: 500 g of soy lecithin/kg, starch, antioxidant (BHT, BHA, and propyl gallate), and wheat flour.

3. Results

The effect of lipid sources (soybean oil or chicken fat) and emulsifier in the feed and their interaction on performance were evaluated from 1 to 7, 1 to 21, 1 to 35, and 1 to 42 days of age (Table 3). In the period from 1 to 7 days, chickens fed the diet with chicken fat as a lipid source had higher live weight and feed intake. From 1 to 7 and 1 to 21 days, there were no effects of the emulsifier and interaction of lipid sources with the presence or absence of emulsifier in the feed on the evaluated variables. However, from 1 to 21 days, we observed an effect of the lipid source used in the feed on live weight, with animals that received chicken fat as a lipid source showing a higher live weight.

In contrast, from 1 to 35 and 1 to 42 days, there was an effect only for the presence of the emulsifier in the feed, in which animals that received the emulsifier had higher live weight than those that did not receive it. Moreover, chickens that received the emulsifier presented higher feed intake considering the total rearing period (1 to 42 days). In both periods, there were no effects of lipid sources or interaction of lipid sources with the emulsifier on the evaluated variables. From 1 to 42 days, we observed no effects of the lipid source and emulsifier, as well as no interaction effect between them.

Regarding the evaluation of the intestinal morphology of chickens at 21 days of age (Table 4), the duodenum showed a significant effect of the lipid source, with chickens that received feed with chicken fat showing higher villus height and villus:crypt ratio. A similar result was observed for the emulsifier

Table 3 - Body weight (BW), feed intake (FI), and feed conversion ratio (FCR) of broilers fed diets with or without emulsifier and two different lipid sources

Treatment	1 to 7 days			1 to 21 days			1 to 35 days			1 to 42 days		
	BW (g)	FI (g)	FCR (g/g)	BW (g)	FI (g)	FCR (g/g)	BW (g)	FI (g)	FCR (g/g)	BW (g)	FI (g)	FCR (g/g)
	Effect of lipid source											
Soy oil	184b	167b	0.908	857b	1.059	1.235	2.055	3.026	1.476	2.610	4.101	1.571
Chicken fat	190a	176a	0.928	886a	1.087	1.228	2.097	3.081	1.470	2.650	4.148	1.568
	Effect of emulsifier											
With emulsifier	189	171	0.908	872	1.079	1.240	2.136a	3.106	1.455	2.714a	4.216a	1.554
Without emulsifier	185	172	0.928	871	1.066	1.223	2.016b	3.000	1.491	2.546b	4.032b	1.585
	Effect of interaction											
Soy oil × with emulsifier	186	167	0.900	854	1.070	1.254	2.134	3.080	1.443	2.729	4.254	1.559
Soy oil × without emulsifier	182	167	0.917	860	1.047	1.217	1.977	2.972	1.508	2.492	3.948	1.584
Chicken fat × with emulsifier	192	176	0.917	889	1.089	1.225	2.138	3.133	1.466	2.699	4.179	1.549
Chicken fat × without emulsifier	189	177	0.939	883	1.085	1.230	2.056	3.029	1.474	2.600	4.117	1.587
	P-value											
Lipid source	0.003	0.041	0.411	0.014	0.233	0.767	0.241	0.320	0.835	0.375	0.542	0.888
Emulsifier	0.093	0.913	0.417	0.992	0.554	0.544	0.002	0.061	0.202	0.001	0.023	0.235
Interaction	0.889	0.892	0.941	0.582	0.674	0.422	0.289	0.972	0.319	0.125	0.123	0.796
CV	2.77	6.84	6.99	3.43	5.88	5.93	4.66	4.95	5.24	4.51	5.05	4.48
SEM	0.001	0.002	0.011	0.006	0.012	0.013	0.020	0.043	0.021	0.026	0.076	0.016

CV - coefficient of variation; SEM - standard error of the mean.
Means followed by different letters in the column differ by Student's t test (5%).

Table 4 - Villus height (VH), crypt depth (CD), and villus: crypt ratio (V:C) of the small intestine of broilers fed diets with or without emulsifier and two different lipid sources at 21 days of age

Treatment	Duodenum			Jejunum			Ileum		
	VH (µm)	CD (µm)	V:C (µm/µm)	VH (µm)	CD (µm)	V:C (µm/µm)	VH (µm)	CD (µm)	V:C (µm/µm)
	Effect of lipid source								
Soy oil	1.198b	300	4.0b	932	278a	3.4b	671a	223a	3.0a
Chicken fat	1.566a	316	5.0a	904	241b	3.8a	557b	200b	2.8b
	Effect of emulsifier								
With emulsifier	1.497a	325a	4.6a	901b	261	3.5b	629	205b	3.0a
Without emulsifier	1.267b	292b	4.3b	936a	258	3.7a	599	218a	2.7b
	Effect of interaction								
Soy oil × with emulsifier	1.480b	306b	4.8b	876c	268b	3.3d	743a	223a	3.3a
Soy oil × without emulsifier	916c	295b	3.1d	989a	288a	3.5c	600b	223a	2.7b
Chicken fat × with emulsifier	1.513ab	343a	4.4c	925b	255c	3.7b	515c	188b	2.7b
Chicken fat × without emulsifier	1.618a	290b	5.5a	883c	227d	3.9a	598b	212c	2.8b
	P-value								
Lipid source	<0.001	0.092	<0.001	0.053	<0.001	<0.001	<0.001	<0.001	<0.001
Emulsifier	<0.001	<0.001	<0.001	0.014	0.478	<0.001	0.147	<0.001	<0.001
Interaction	<0.001	0.030	<0.001	<0.001	<0.001	0.821	<0.001	<0.001	<0.001
CV	12.11	11.60	7.29	12.41	16.25	6.40	25.00	12.61	16.08
SEM	17.68	1.97	0.05	6.07	2.35	0.02	8.43	1.53	0.03

CV - coefficient of variation; SEM - standard error of the mean.
Means followed by different letters in the column differ by Student's t test (5%).

effect, in which chickens that received emulsifier in the feed presented higher villus height, crypt depth, and villus:crypt ratio. The effect of the interaction shows that chickens that received feed with soybean oil and without emulsifier had lower villus height than chickens of the other treatments, as well as a lower villus:crypt ratio than chickens that received feed with soybean oil and without emulsifier, showing the positive effect of the emulsifier in diets with soybean oil.

The jejunum showed an effect of the emulsifier, in which chickens fed feed with emulsifier had lower villus height and villus:crypt ratio. Furthermore, an effect of the lipid source on crypt depth was observed in this segment, with animals fed feed containing soybean oil having higher crypt depth than birds fed feed containing chicken fat. The analysis of the interaction effect showed a lower villus height in the jejunum of animals that received soybean oil and emulsifier in the feed and those that received chicken fat without adding the emulsifier in the feed. The lowest villus:crypt ratio values were found in animals fed soybean oil with and without emulsifier.

The ileum showed a significant effect for the lipid source, in which animals fed the diet containing soybean oil had higher villus height, crypt depth, and villus:crypt ratio than those fed the diet with chicken fat. Also, a significant effect of the addition of emulsifier in the feed was observed, as it reduced the crypt depth and increased the villus:crypt ratio. The interaction effect showed a higher villus height, crypt depth, and villus:crypt ratio in chickens that received soybean oil and emulsifier in the feed.

4. Discussion

The digestive system at the initial stage has limitations in the production of bile and pancreatic enzymes, reducing the effectiveness of lipid degradation (Sell, 1996; Sklan, 2001; Tancharoenrat et al., 2013). Ravindran et al. (2016) pointed out that the interaction of the emulsifier with bile salts and pancreatic lipase is essential to emulsify fat globules, facilitating their digestion and absorption. Therefore, age is a limiting factor in the digestion and absorption of lipids, which may have influenced the result observed in this experiment for diets using emulsifier.

Majdolhosseini et al. (2019) included 0.1% soybean lecithin in the diet of seven-day-old broilers and did not find any effect on weight gain. Sarpunja and Kim (2019) observed a similar result. Dabbou et al. (2019) and Guerreiro Neto et al. (2011) used sodium stearoyl-2-lactylate (80%) and tween 20 (20%), globin, and casein as emulsifiers, respectively, and also did not obtain a significant improvement in weight gain in seven-day-old chickens. However, Zhao and Kim (2017) observed a different result when including lipidol, an emulsifier based on hydrolyzed soybean lecithin in the diet of chickens up to 14 days of age, with a positive effect on weight gain, as the emulsifier was effective in the digestion and absorption of fat micelles. Therefore, the immaturity of the gastrointestinal tract of chickens up to seven days may have been a limiting factor in the action of the emulsifier, as verified in this study.

The higher weight verified for chickens that consumed feed with chicken fat at seven days of age can be explained by the fact that, among the fats of animal origin, chicken fat presents the highest degree of unsaturation (around 60%) (Pesti et al., 2002). In addition, according to Ravindran et al. (2016), lipid chains with a higher degree of unsaturation are better metabolized by bile acids and pancreatic lipase. Although the degree of unsaturation of refined soybean oil is higher than that of chicken fat, Brue and Latshaw (1985) pointed out a higher intake for chicks fed a feed containing chicken fat (higher palmitic or stearic saturated fatty acid concentration) than those fed corn oil (higher concentration of linoleic and oleic unsaturated fatty acids), since the unsaturated fatty acid is an appetite regulator and has lower palatability. Thus, we can infer that soybean oil may have made the feed less attractive for intake even with a higher degree of unsaturation than chicken fat (Ravindran et al., 2016). The higher feed intake in diets with chicken fat may have influenced the higher weight gain, as verified in this study, which may also explain the result found in this study for chickens at 21 days, in which higher weight was observed for those that had chicken fat as a lipid source in their diet. Kamran et al. (2020) and Majdolhosseini et al. (2019) found that soybean oil had better feed conversion for chickens fed soybean oil when compared with chicken fat due to the higher degree of unsaturation in soybean oil, different from what was observed in this study.

Haetinger et al. (2021), Kamran et al. (2020), and Saleh et al. (2020) also observed an improvement in the weight of 35-day-old chickens that had soybean lecithin included in their diet. The authors also used an emulsifier in the diet of broiler chickens at the grower stage. Therefore, as the digestive tract of the chickens matured, which increased the production of bile and pancreatic lipase, there may have been an increase in the emulsifier action, which led to an improvement in the digestion of the micelles. Tancharoenrat et al. (2013) showed that the digestibility of different fat sources increased significantly between the first and fifth week of life in broiler chickens. Thus, age and the type and concentration of emulsifier are suggested to be important for the weight improvement in the animals, as the result was similar for 42-day-old chickens (Tan et al., 2016).

The improvement in villus height with the emulsifier inclusion in the diet may be related to a reduction in the size of the micelles caused by the addition of soybean lecithin due to its emulsifying action, which reduces the size of fat globules. In this sense, Chen et al. (2019) included an emulsifier (lysophospholipid) in the diet of 21-day-old broiler chickens and found an improvement in villus height in the duodenum. Therefore, the present study corroborates the result observed by these authors. Reece (2008) pointed out that villi are associated with higher nutrient absorption capacity. Therefore, the reduction of micelles and their higher absorption may have stimulated villous growth. Furthermore, Zhao and Kim (2017) described that the emulsifier acts in the absorption of other nutrients, as fat emulsification reduces the size of its globes, favoring the dispersion and absorption of other nutrients, contributing to an increase in the villi. Khonyoung et al. (2015) observed an increase in villus height stimulated with the inclusion of the emulsifier, in which the inclusion of lysolecithin stimulated the increase of cell mitosis in the duodenum region of broiler chickens, indicating that the emulsifier acted by promoting the growth of the villi. Thus, emulsification, by reducing and stabilizing the size of micelles to be absorbed, can stimulate mitosis and cell renewal in the villus, increasing its height.

Mitchaothai et al. (2010) also highlighted that the better absorption of nutrients due to the use of soybean lecithin can reduce fermentation in the small intestine, resulting in less damage to the villi. Liu et al. (2020) observed that the addition of soybean lecithin, used as an emulsifier, reduced the *E. coli* population in the intestine of broiler chickens, improving intestinal health.

Alzawqari et al. (2011) found that the addition of 0.025% bile acids to the diet of 21-day-old broiler chickens increased crypt depth in the jejunum compared with diets without the emulsifier. However, Chen et al. (2019) observed that the inclusion of lysolecithin in the diet of broiler chickens resulted in a reduction in crypt depth in the duodenum, with no difference in the jejunum. Majdolhosseini et al. (2019) verified that the crypt depth decreased in the jejunum when using soybean lecithin in the diet of broiler chickens.

The results found for the villus:crypt ratio differ from those observed by Oliveira et al. (2019), who found a higher relationship in the duodenum for 21-day-old broiler chickens fed soybean lecithin in the diet but with no difference in the jejunum. Bootiam et al. (2017) evaluated the villus:crypt ratio in 35-day-old broilers fed diet with inclusion of lysophospholipid (emulsifier) and did not observe a difference in the duodenum. However, the inclusion of 0.05% of the emulsifier increased the ratio in the jejunum compared with the control group.

Recce (2008) described that crypts are responsible for the renewal of the cells that make up the villi of the intestine and that villi cells need to be renewed due to friction or diseases that affect the intestine. Oliveira et al. (2019) and Bootiam et al. (2017) described that the villus:crypt ratio may be related to stress, nutrient levels, and inclusion of additives in the diet. Hence, the crypt depth and villus:crypt ratio data may have been affected by factors other than just the use of the emulsifier. One of these factors may be related to the lipid source, which can change the intestinal pH due to changes in the intestinal microbiota, leading to changes in the intestinal villus height (Józefiak et al., 2016). Therefore, these factors may have influenced the intestinal morphology data in this present study.

5. Conclusions

The use of chicken fat resulted in greater live weight only in the pre-starter and starter phases when compared with soybean oil. The inclusion of the emulsifier soybean lecithin provides positive results in the live weight of chickens at 35 and 42 days of age, in addition to increasing the villus height in the small intestine.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Conceptualization: Oliveira, M. V. G.; Café, M. B. and Mello, H. H. C. **Investigation:** Oliveira, M. V. G.; Silva, J. M. S.; Pires, M. F. and Leandro, N. S. M. **Methodology:** Oliveira, M. V. G.; Silva, J. M. S.; Batista, J. M. M.; Café, M. B.; Oliveira, H. F. and Pires, M. F. **Project administration:** Jacob, D. V. **Validation:** Mello, H. H. C. **Writing – original draft:** Oliveira, H. F. **Writing – review & editing:** Oliveira, H. F.

Acknowledgments

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brazil (CAPES) – Finance Code 001.

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