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RESEARCH ARTICLE

Effect of Emulsifier Additive on Nutrient Digestibility and Growth Performance in Broiler Chickens

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Abstract

Objective: This study aimed to investigate the effects of graded levels of soybean oil, with or without emulsifier supplementation, on growth performance, nutrient digestibility and Apparent Metabolizable Energy (AMEn) in broiler chickens during the starter and finisher phases.

Materials and Methods: Five dietary soybean oil levels (0, 15, 30, 45 and 60 g/kg) were evaluated in the presence or absence of an emulsifier, resulting in 10 dietary treatments. A total of 600 one-day-old male Cobb 500 broilers (starter phase, 14-21 days) and 360 thirty-five-day-old males (finisher phase, 35-42 days) were randomly allocated to treatments with six replicates. Total excreta collection was conducted to determine the Coefficient of Total Tract Apparent Digestibility (CTTAD) of Dry Matter (DM), Crude Protein (CP), ether extract (EE) and AMEn corrected for nitrogen. Data were analyzed using ANOVA and contrast procedures.

Results: Emulsifier supplementation significantly improved body weight gain and feed conversion ratio in both the starter and finisher phases. In the starter phase, DM digestibility increased at 30 and 60 g/kg soybean oil (0.747 vs. 0.729; 0.740 vs. 0.722) and AMEn increased by 0.26-0.29 MJ/kg in diets containing 30-60 g/kg oil. In the finisher phase, DM digestibility improved at 45 and 60 g/kg oil (0.763 vs. 0.741; 0.743 vs. 0.724), while AMEn increased by 0.34-0.42 MJ/kg within the same oil range. Crude protein digestibility was not influenced by dietary treatments in either phase.

Conclusion: Dietary emulsifier supplementation enhances growth performance, DM digestibility and AMEn in broilers, particularly in diets containing 30-60 g/kg soybean oil. These findings highlight the potential of emulsifiers to improve energy utilization and support more efficient formulation strategies in commercial broiler feeding programs.

INTRODUCTION

Energy constitutes the primary cost component in diets for monogastric animals, with vegetable oils and animal fats serving as major contributors due to their high energy density. However, lipids are hydrophobic and insoluble in aqueous environments, requiring emulsification prior to effective digestion and absorption. The efficiency of lipid emulsification and subsequent utilization is influenced by several physicochemical properties, including fatty acid chain length, positional distribution on the glycerol backbone and degree of saturation[1,2].

Nutritional emulsifiers are amphipathic compounds that function analogously to bile salts by increasing the surface area of lipid droplets, facilitating micelle formation and enhancing pancreatic lipase activity[3]. The Hydrophilic-Lipophilic Balance (HLB) system, which ranges from 0 to 20, is commonly used to characterize emulsifier solubility. Lower HLB values indicate greater affinity for lipids, whereas higher values reflect increased water solubility, an important consideration given that poultry typically consume approximately twice as much water as feed[4,5].

Recent research has demonstrated that emulsifier supplementation in diets with reduced energy or protein levels can improve ileal digestibility of fat, protein and dry matter; increase apparent metabolizable energy corrected for nitrogen (AMEn) and enhance intestinal mucosal development[6,7]. Glyceryl Polyethylene Glycol Ricinoleate (GPGR) has been reported to improve weight gain, feed conversion ratio and overall nutrient utilization, even in energy restricted diets[8]. Moreover, emulsifiers based on lysophospholipids have been shown to maintain broiler performance under heat stress[9].

Despite these findings, the interactive effects of emulsifiers and varying levels of vegetable oils in broiler diets remain insufficiently characterized, particularly with respect to performance, digestibility and AMEn. Therefore, the present study aimed to evaluate the effects of an emulsifier additive on growth performance, nutrient digestibility and AMEn in broilers fed diets containing different inclusion levels of soybean oil during the starter and finisher phases.

MATERIALS AND METHODS

Ethical approval: All experimental procedures were approved by the Institutional Animal Care and Use Committee of the Federal University of Lavras and were conducted in accordance with established guidelines for the ethical use of animals in research.

Birds and housing: A total of 600 one-day-old male Cobb 500 broilers, vaccinated against Marek's disease at the hatchery, were randomly allocated to 60 wire cages (0.70×0.50×0.35 m). Each cage was equipped with a feeder and a drinker. Birds were provided *ad libitum* access to water and mash diets. At 14 days of age, all birds were individually weighed and subsequently assigned to 10 dietary treatments with 6 replicates of 10 birds per replicate.

For the finisher phase, 360 newly hatched male broilers were reared on wood-shavings litter and fed a standard Maize–soybean Meal (SBM) diet until 34 days of age. At 35 days of age, birds were individually weighed and redistributed into 10 treatments with 6 replicates of 6 birds each. The environmental temperature was maintained at 25±2°C during the starter phase and 23±2°C during the finisher phase. Continuous lighting was provided throughout the experimental period.

Experimental diets: The study followed a completely randomized design consisting of 10 dietary treatments arranged to evaluate five inclusion levels of soybean oil (0, 15, 30, 45 and 60 g/kg diet) with or without emulsifier supplementation (0 or 0.35 g/kg diet). The emulsifier, based on glyceryl polyethylene glycol ricinoleate with a high hydrophilic-lipophilic balance (Excential Energy Plus, Orffa, Werkendam, The Netherlands), was incorporated into the designated diets.

A standard maize-SBM pre-starter diet was fed from 1 to 13 days (12.56 MJ/kg AME, 218 g/kg CP, 8.8 g/kg Ca and 4.4 g/kg available P), followed by a grower diet from 22 to 34 days (13.18 MJ/kg AME, 198 g/kg CP, 7.6 g/kg Ca and 3.5 g/kg available P). The experimental diets evaluated during the starter (14-21 days) and finisher (35-42 days) phases are presented in Table 1 and Table 2, respectively.

Performance parameters: Body weight and feed intake (FI) were recorded at the beginning and end of the starter (14–21 days) and finisher (35-42 days) phases. These measurements were used to calculate Body Weight Gain (BWG) and feed conversion ratio (FCR).

Total excreta collection and chemical analysis: Following a 5-days diet adaptation period, total excreta were collected twice daily using plastic collection trays during 19-21 days and 40-42 days. Excreta from each cage were pooled, homogenized and stored at -20°C until laboratory analysis. Feathers and scales were removed manually to prevent sample contamination.

Excreta samples were dried in a forced air oven at 55°C for 72 hrs and subsequently ground to pass through a 0.5 mm sieve. Dry Matter (DM) was determined after oven drying at 105°C for 16 hrs (Method 934.01[10]). Ether Extract (EE) was analyzed by petroleum ether extraction using a Soxhlet apparatus (Method 920.39[10]). Gross Energy (GE) was measured using an adiabatic bomb calorimeter standardized with benzoic acid (IKA Werke GmbH and Co. KG, Staufen, Germany). Crude Protein (CP) was quantified as N×6.25 using the combustion method (Method 968.06[10]) with an FP-528 nitrogen analyzer (LECO Corporation, St. Joseph, MI, USA).

Table 1: Ingredient composition of starter diets fed to broilers from 14 to 21 days of age

	Starter diets (14-21days)									
Ingredients (g/kg)	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Corn	668.99	558.09	536.32	512.05	473.96	668.99	558.09	536.32	512.05	473.96
Soybean meal	294.17	394.01	398.80	407.85	433.88	294.17	394.01	398.80	407.85	433.88
Soybean oil	0.00	15.00	30.00	45.00	60.00	0.00	15.00	30.00	45.00	60.00
Dicalcium phosphate	11.52	10.89	10.93	12.04	10.80	11.52	10.89	10.93	12.04	10.80
Limestone	8.88	8.68	8.65	8.00	8.55	8.88	8.68	8.65	8.00	8.55
NaCl	4.30	4.31	4.31	4.32	4.33	4.30	4.31	4.31	4.32	4.33
DL-Methionine	2.94	2.38	2.60	2.78	2.81	2.94	2.38	2.60	2.78	2.81
L-Lysine	3.36	0.82	1.08	1.21	0.83	3.36	0.82	1.08	1.21	0.83
Threonine	1.50	1.47	2.96	2.39	0.49	1.50	1.47	2.96	2.39	0.49
Vitamin premix[a]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Mineral premix[b]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Zinc Bacitracin	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Salinomycin 12%	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Choline chloride 60%	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Phytase[c]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Antioxidant[d]	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Emulsifier[e]	-	-	-	-	-	0.35	0.35	0.35	0.35	0.35
Inert (kaolin)	1.00	1.00	1.00	1.00	1.00	0.65	0.65	0.65	0.65	0.65
Calculated composition										
AME (MJ/kg)	12.46	12.53	12.76	13.06	13.33	12.46	12.53	12.76	13.06	13.33
CP	190.00	224.00	226.00	228.00	235.00	190.00	224.00	226.00	228.00	235.00
Ether extract[f] (g/kg)	34.17	47.45	61.82	74.58	93.10	34.17	47.45	61.82	74.58	93.10
Met, g/kg	5.63	5.44	5.65	5.84	5.96	5.63	5.44	5.65	5.84	5.96
Met/Cys, g/kg	8.20	8.40	8.60	8.80	9.00	8.20	8.40	8.60	8.80	9.00
Lys (g/kg)	11.45	11.72	12.00	12.28	12.55	11.45	11.72	12.00	12.28	12.55
Ca (g/kg)	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70	7.70
Available P (g/kg)	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30	4.30
Na (g/kg)	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90	1.90

[a]Composition per kg of feed: Vitamin A: 9000UI, Vitamin D3: 2500IU, Vitamin E: 20IU, Vitamin K3: 2500mg, Vitamin B1: 1500 mg, Vitamin B2: 6000mg, Vitamin B6: 3000 mg, Vitamin B12: 12000 mcg, Biotin: 60 mg, Folic acid: 800 mg, Nicotinic acid: 25000 mg, Pantothenic acid: 12000 mg, Selenium: 250 mg, [b]Composition per kg of feed: Manganese: 160 mg, Iron: 100 mg, Zinc: 100 mg, Copper: 20 mg, Cobalt: 2 mg, Iodine: 2 mg, [c]Ronozyme Hiphos with 10,000 fungal phytase units/g (Novozymes A/S, Bagsvaerd, Denmark), [d]Endox® 5X Concentrate Dry (Kemin Ltda, Indaiatuba, Brazil), [e]Excential Energy Plus dosage at 0.35 g/kg of feed (Orffa, Werkendam, the Netherlands), [f]Analyzed.

Table 2: Ingredient composition of finisher diets fed to broilers from 35 to 42 days of age

	Finisher diets (35-42 days)									
Ingredients (g/kg)	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Corn	646.09	614.85	585.87	557.12	528.39	646.09	614.85	585.87	557.12	528.39
Soybean meal	314.44	330.89	344.92	358.74	372.54	314.44	330.89	344.92	358.74	372.54
Soybean oil	0.00	15.00	30.00	45.00	60.00	0.00	15.00	30.00	45.00	60.00
Dicalcium phosphate	1.39	1.34	1.30	1.27	1.24	1.39	1.34	1.30	1.27	1.24
Limestone	8.58	8.53	8.48	8.44	8.39	8.58	8.53	8.48	8.44	8.39
NaCl	4.05	4.06	4.06	4.07	4.08	4.05	4.06	4.06	4.07	4.08
DL-Methionine	1.50	1.58	1.68	1.78	1.87	1.50	1.58	1.68	1.78	1.87
L-Lysine	0.54	0.40	0.33	0.23	0.15	0.54	0.40	0.33	0.23	0.15
Threonine	0.06	0.00	0.01	0.01	0.00	0.06	0.00	0.01	0.01	0.00
Vitamin premix[a]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Mineral premix[b]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Zinc Bacitracin	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Salinomycin 12%	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Choline chloride 60%	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Phytase[c]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Antioxidant[d]	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Emulsifier[e]	-	-	-	-	-	0.35	0.35	0.35	0.35	0.35
Inert (kaolin)	20.00	20.00	20.00	20.00	20.00	19.65	19.65	19.65	19.65	19.65

Table 2: Continue

	Finisher diets (35-42 days)									
Ingredients (g/kg)	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Calculated composition										
AME (MJ/kg)	12.33	12.60	12.87	13.17	13.46	12.33	12.60	12.87	13.17	13.46
CP	193.00	198.00	202.00	206.00	210.00	193.00	198.00	202.00	206.00	210.00
Ether extract[f] (g/kg)	36.25	48.28	64.97	72.68	92.95	36.25	48.28	64.97	72.68	92.95
Met, g/kg	4.28	4.40	4.52	4.65	4.77	4.28	4.40	4.52	4.65	4.77
Met/Cys (g/kg)	6.94	7.10	7.26	7.42	7.57	6.94	7.10	7.26	7.42	7.57
Lys (g/kg)	9.69	9.93	10.16	10.37	10.59	9.69	9.93	10.16	10.37	10.59
Ca (g/kg)	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50	6.50
Available P (g/kg)	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70
Na (g/kg)	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80

[a]Composition per kg of feed: Vitamin A: 9000UI, Vitamin D3: 2500UI, Vitamin E: 20UI; Vitamin K3: 2500 mg, Vitamin B1: 1500 mg, Vitamin B2: 6000 mg, Vitamin B6: 3000 mg; Vitamin B12: 12000 mcg, Biotin: 60 mg, Folic acid: 800 mg, Nicotinic acid: 25000 mg, Pantothenic acid: 12000 mg, Selenium: 250 mg, [b]Composition per kg of feed: Manganese: 160 mg, Iron: 100mg, Zinc: 100 mg, Copper: 20 mg, Cobalt: 2 mg, Iodine: 2 mg, [c]Ronozyme Hiphos with 10,000 fungal phytase units/g (Novozymes A/S, Bagsvaerd, Denmark), [d]Endox® 5X Concentrate Dry (Kemin Ltda, Indaiatuba, Brazil), [e]Excential Energy Plus dosage at 0.35g/kg of feed (Orffa, Werkendam, the Netherlands), [f]Analyzed

Calculation: Coefficients of Total Tract Apparent Digestibility (CTTAD) and Apparent Metabolizable Energy Corrected for Nitrogen (AMEn) were calculated using the following equations:

$$\text{CTTAD (\%)} = \frac{\text{nutrient}_{\text{diet}} - \left(\text{excreta}/_{\text{feed}} \times \text{nutrient}_{\text{excreta}}\right)}{\text{Nutrient}_{\text{diet}}} \times 100$$

$$\text{AME (kcal/kg diet)} = \text{GE}_{\text{diet}}\text{-}(\text{GE}_{\text{excreta}} \times {}^{\text{excreta}}/_{\text{feed}})$$

where, GE_{diet} and $GE_{excreta}$ are the analyzed gross energy values of the diet and excreta samples respectively. The N-corrected AME (AMEn) values were calculated by correcting for N retention by using a factor of 0.034 MJ/g N retained in the body[11].

Statistical analysis: Data were analyzed using one-way ANOVA within the General Linear Model (GLM) procedure of SAS (SAS Institute Inc., Version 9.3). Orthogonal contrasts were employed to evaluate the effects of emulsifiers at each soybean oil level in the diets. Statistical significance was established at p<0.05.

RESULTS

Growth performance: The results for FI, BWG and FCR are presented in Table 3. Feed intake (FI) during both the starter and finisher phases was not influenced (p>0.05) by emulsifier supplementation across the different soybean oil levels. However, orthogonal contrasts comparing diets with and without emulsifier supplementation at varying soybean oil levels showed that broilers receiving emulsifiers exhibited improved BWG (p<0.05) and FCR (p<0.05). These improvements corresponded to increases of 3.2% and 2.9% in the starter phase and 4.5 and 3.9% in the finisher phase, respectively. In the finisher phase, BWG was further improved (p<0.05) by 8.6 and 7.2% when comparing T2 vs T7 and T4 vs T9. Similarly, diets containing 0 and 45 g/kg soybean oil supplemented with emulsifier resulted in better FCR (P<0.05), with improvements of 5.5 and 5.2% in contrasts T1 vs T6 and T4 vs T9, respectively.

Coefficient of total tract apparent digestibility and AMEn: Results for CTTAD of nutrients and AMEn are summarized in Table 4. Crude Protein (CP) digestibility at both evaluated ages was not affected (p>0.05) by emulsifier supplementation across soybean oil levels. In contrast, emulsifier addition significantly increased (p<0.05) the digestibility of DM and EE as well as AMEn. Improvements were observed as follows: 2.0, 2.5 and 1.7% in the starter phase and 2.2, 2.6 and 2.2% in the finisher phase, respectively. Dry matter digestibility increased (P<0.05) by 2.5% in the contrasts T3 vs T8 and T5 vs T10 during the starter phase and by 3.0 and 2.6% in the contrasts T4 vs T9 and T5 vs T10 in the finisher phase. Birds fed diets with 30, 45 and 60 g/kg soybean oil supplemented with emulsifier exhibited higher AMEn values (p<0.05) than those fed unsupplemented diets in both phases. AMEn improved (p<0.05) by 1.9, 1.9 and 2.1% in the starter phase and by 2.4, 2.6 and 2.9% in the finisher phase, respectively.

DISCUSSION

Growth performance: In the present study, feed intake (FI) was not influenced by the inclusion of emulsifier at any level of soybean oil. Similar observations have been reported in

Table 3: Growth performance of broilers fed corn-soybean meal diets containing five levels of soybean oil, with or without emulsifier[a] supplementation

			Day 14-21			Day 35-42		
Oil level (g/kg)	Emulsifier	Treatments	FI (g)	BWG (g)	FCR (g/g)	FI (g)	BWG (g)	FCR (g/g)
0	-[b]	T1	557	385	1.45	1043	498	2.10
	+[c]	T6	573	405	1.41	1016	508	1.99
15	-	T2	576	404	1.43	1020	533	1.91
	+	T7	581	407	1.42	1065	579	1.84
30	-	T3	576	409	1.41	1051	541	1.95
	+	T8	581	425	1.37	1039	540	1.93
45	-	T4	580	431	1.34	1038	570	1.82
	+	T9	579	437	1.33	1054	611	1.73
60	-	T5	581	401	1.46	1096	611	1.79
	+	T10	578	419	1.38	1106	643	1.72
CV (%)	3.65	4.74	3.71	5.52	5.27	4.26		
Orthogonal contrasts			p-value					
T1 vs T6			0.198	0.0750	0.2360	0.4216	0.5300	0.037
T2 vs T7			0.702	0.7800	0.7032	0.1793	0.0106	0.126
T3 vs T8			0.712	0.1456	0.1535	0.7293	0.9460	0.626
T4 vs T9			0.956	0.5970	0.5188	0.6282	0.0200	0.043
T5 vs T10			0.774	0.1167	0.0186	0.7630	0.0690	0.134
T1 to T5 vs T6 to T10			0.446	0.0138	0.0086	0.6585	0.0016	0.001

[a]Means were obtained from 6 replicate cages of 10 birds each in the starter and 6 replicates of 6 birds each in the finisher phase, [b]-Represents without emulsifier supplementation and [c]+Represents supplementation with 0.35 g/kg diet of emulsifier

Table 4: Total tract retention coefficients of dry matter, crude protein, ether extract and energy in broilers fed corn–soybean meal–based diets containing five levels of soybean oil, with or without emulsifier supplementation

			Day 14-21				Day 35-42			
Oil level (g/kg)	Emu	Tre	DM	CP	EE	AMEn (MJ/kg)	DM	CP	EE	AMEn (MJ/kg)
0	-[b]	T1	0.72	0.63	0.69	12.79	0.733	0.62	0.77	13.23
	+[c]	T6	0.73	0.63	0.70	12.92	0.739	0.61	0.78	13.40
15	-	T2	0.73	0.64	0.74	13.10	0.743	0.64	0.83	13.83
	+	T7	0.74	0.65	0.75	13.28	0.758	0.66	0.84	14.06
30	-	T3	0.72	0.63	0.79	13.46	0.740	0.65	0.85	14.07
	+	T8	0.74	0.65	0.80	13.72	0.758	0.65	0.87	14.41
45	-	T4	0.73	0.66	0.81	13.94	0.741	0.66	0.87	14.12
	+	T9	0.74	0.66	0.83	14.21	0.763	0.67	0.89	14.48
60	-	T5	0.72	0.63	0.84	13.90	0.724	0.64	0.89	14.28
	+	T10	0.74	0.65	0.85	14.19	0.743	0.64	0.91	14.70
CV (%)	1.94	3.46	2.25	1.44	2.12	2.98	2.11	1.71		
Orthogonal contrasts			p-value							
T1 vs T6			0.11	0.84	0.55	0.23	0.5	0.40	0.56	0.23
T2 vs T7			0.24	0.34	0.59	0.13	0.0	0.08	0.31	0.10
T3 vs T8			0.03	0.23	0.14	0.02	0.0	0.77	0.08	0.01
T4 vs T9			0.14	0.65	0.05	0.01	0.0	0.15	0.13	0.01
T5 vs T10			0.03	0.28	0.15	0.01	0.0	0.92	0.08	0.00
T1 to T5 vs			0.01	0.08	0.01	<0.01	0.0	0.34	0.01	<0.01
T6 to T10							0.0			

[a]Means were obtained from 6 replicate cages of 10 birds each in the starter and 6 replicates of 6 birds each in the finisher phase, [b]-Represents without emulsifier supplementation, [c]+Represents supplementation with 0.35g/kg diet of emulsifier, Emu: Emulsifier and Tre: Treatments

previous studies[12-14]. This lack of effect may be attributed to the ability of broilers to regulate feed intake primarily according to energy requirements, rendering them less responsive to variations in lipid digestibility when dietary energy density is adequate. Consequently, even with emulsifier supplementation aimed at optimizing lipid utilization, no adjustment in intake was necessary. Additionally, diet palatability remained unchanged, consistent with reports indicating that emulsifiers do not alter the organoleptic characteristics of feed[15].

Overall, emulsifier supplementation resulted in increased Body Weight Gain (BWG) and improved Feed Conversion Ratio (FCR) across both rearing phases, demonstrating benefits independent of the soybean oil inclusion level. These findings are in agreement with Dabbou *et al.*[16], who observed enhanced feed efficiency with emulsifier addition. Such results suggest that the emulsifier contributes to the optimization of dietary energy utilization, even in diets with relatively low vegetable oil content.

The mechanisms underlying the positive effects of emulsifiers are primarily related to their capacity to reduce fat globule size, thereby increasing the surface area for lipase activity, enhancing micelle formation and consequently improving fatty acid absorption[17]. This hypothesis is supported by several studies. Oketch *et al.*[18] reported that the beneficial effects were observed predominantly during the starter phase, indicating that younger birds may benefit more due to their limited lipolytic activity. Moreover, Kaczmarek *et al.*[19] emphasized that emulsifier supplementation enhances the utilization of energy and nutrients even in diets of lower energy density.

Coefficient of total tract apparent digestibility and AMEn: The results indicate that emulsifier supplementation did not affect the apparent digestibility of Crude Protein (CP) in any of the evaluated phases, suggesting that amino acid absorption was not limited by dietary fat content or by the presence of the additive. This observation is consistent with previous studies reporting that emulsifiers primarily enhance lipid digestion without significantly altering protein digestibility[12]. In contrast, the digestibility of Dry Matter (DM), Ether Extract (EE) and nitrogen corrected apparent metabolizable energy (AMEn) was significantly improved with increasing soybean oil levels.

The observed 2-3% increase in DM and EE digestibility is associated with enhanced efficiency of lipid digestion and absorption. Emulsifiers reduce fat globule size, thereby increasing the surface area for lipase activity and promoting mixed micelle formation, which facilitates the transport of fatty acids and monoglycerides into enterocytes. This mechanism is particularly critical for young broilers with limited bile and lipase secretion and it also maximizes energy utilization in diets with higher oil content. Improved lipid digestion reduces fecal nutrient losses and enhances the absorption of associated compounds, including fat soluble vitamins (A, D, E and K), contributing to the observed improvements in DM and EE digestibility and overall growth performance[12,13,17] .

Similarly, Dabbou *et al.*[16] reported increased fat and EE digestibility during the starter phase following emulsifier supplementation. An *et al.*[20] demonstrated that dietary emulsifier inclusion at 0.1-0.2% significantly enhances energy digestibility.

Apparent Metabolizable Energy Corrected for Nitrogen (AMEn) is a key parameter in diet formulation, as it reflects the energy available for maintenance and growth. The positive effect of emulsifier supplementation on AMEn suggests more efficient energy utilization, likely resulting from improved emulsification and lipolysis. This effect was pronounced in diets containing 30, 45 and 60 g/kg soybean oil, indicating that the action of the emulsifier becomes increasingly relevant with higher dietary lipid content. Nevertheless, improvements were also observed at intermediate oil levels, suggesting that the additive may exert beneficial effects even in diets with moderate fat inclusion. In older broilers, despite a more developed digestive system, emulsifier supplementation continued to enhance AMEn, indicating a sustained role of these additives in optimizing energy utilization throughout the production cycle.

In the present study, Ether Extract (EE) retention in broilers did not differ significantly when treatments were compared individually throughout the experimental period. Similarly, Jansen *et al.*[15] reported only numerical improvements in fat retention in diets containing 53 g/kg soybean oil supplemented with an emulsifier. However, when all treatments were considered collectively, EE retention was significantly enhanced by emulsifier supplementation. This effect was observed irrespective of the soybean oil level, suggesting that the emulsifier also improves fat digestibility in diets with low or no soybean oil, potentially enhancing lipid utilization from other ingredients, such as corn.

From a physiological perspective, increased availability of energy and lipids optimizes muscle growth, which can reduce excessive abdominal fat deposition and improve overall body composition, thereby directly contributing to higher carcass yield[21]. Additionally, improved fat digestibility supports intestinal health, as undigested fat can promote undesirable fermentations and intestinal inflammation[22]. In young birds, fat digestion and absorption are limited primarily by insufficient bile salt secretion rather than lipase activity[23], favoring the efficacy of exogenous emulsifiers. Nonetheless, broilers in the finishing phase, with a fully developed digestive system and greater feed intake capacity, also demonstrated enhanced energy utilization attributable to emulsifier mediated improvements in nutrient absorption.

The emulsifier evaluated in this study possesses a high Hydrophilic-lipophilic Balance (HLB)[24], indicating substantial water solubility. Given that broilers consume approximately twice as much water as feed, which contains only a small proportion of fat, the intestinal environment contains considerably more aqueous medium than lipid. Therefore, a high-HLB emulsifier is particularly suitable[18]. According to Bancroft's rule, an emulsifier should be soluble in the continuous phase (aqueous phase) and a high HLB emulsifier is desirable because the small intestinal environment is predominantly aqueous[25].

CONCLUSION

The emulsifier effectively enhanced overall growth performance, nutrient retention and nitrogen corrected apparent metabolizable energy (AMEn) in diets containing 30, 45 and 60 g/kg soybean oil.

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