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RESEARCH ARTICLE OPEN ACCESS

Effect of Different Particle Sizes and Oil Inclusion in Pre-Starter and Starter Broilers Diets

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ABSTRACT
The size of particles of feed and ingredients is important in the regulation of food intake and consequently the performance of broilers. Similarly the presence of oil in the diet can stimulate feed intake and improve the productive characteristics of birds. It was studied the influence of texture (DGM) of the diet (360 μm, 473 μm, or 768 μm) and levels of inclusion of soybean oil in the diets (0 or 3%) in breeding performance at 7, 14, 21 and 28 days of age. The same diets were given to 15 birds housed individually in metabolic cages, and in each cage was provided to 6 treatments to evaluate the feeding preference of birds by means of feed intake at 7, 14 and 21 days of age. Diets with higher DGM resulted in higher feed intake at 7, 14, 21 and 28 days of age. More over, increasing the texture of the diet improved feed conversion at 14, 21 days and 28 days of age. The birds fed diets with lower DGM showed lower weight gain at 14, 21 and 28 days of age. The inclusion of oil in the diet promoted increased feed intake at 21 days of age, higher weight gain at 14, 21 and 28 days, and better feed conversion, 7, 14, 21 and 28 days of age. When the 6 treatments provided the birds preferred the diet with higher DGM at 7, 14 and 21 days, and those with addition of oil at 21 days of age. Increasing the size of rations and the use of oil improves the performance of broilers in the first weeks of age, however, the fat used to be high quality.
Key words: feed intake, free choice, grinding and oil level

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I. INTRODUCTION

Birds are capable of selecting their diet when exposed to a free-choice situation. An important factor related to poultry nutrition and feeding, besides the nutritional composition of the diet, is the physical structure of feeds, which induces considerable changes in metabolic parameters, in feed intake, in the capacity of gastrointestinal emptying, in the activity of digestive enzymes, and also in feeding behavior (Lott et al., 1992; Nir et al., 1994a; Dahlke et al., 2001b; Engberg et al., 2002).

There is a preference for diets consisting of larger particles as compared to finely ground diets (Nir et al., 1994a). The ability to select different feed particles is already detected in the first week of age of broilers, and it increases as the bird ages (Nir et al., 1990).

The presence of fat in the diet can increase preference, with consequent higher feed intake and better broiler performance. However, despite 80% of the lipid content of the yolk being mobilized and absorbed during the last 7 days of incubation, which indicates that lipids are the main energy source for embryo for their development, the use of fat by the gastrointestinal tract of young birds seems to be inefficient (Seel, 1996).

In the early post-hatching period birds have an immature entero-hepatic circulation, and this results in an accumulation of taurocholate in ileum (Jeanson & Kellogg, 1992). This immature entero-hepatic circulation could negatively affect the digestion of lipids, since it reduces fat emulsification (Serafin & Nesheim, 1970). In addition, the production and activity of pancreatic and intestinal membrane enzymes of the young birds are not also fully developed.

However, fat digestion improves as the bird ages, as well as the activity of pancreatic lipase. This is sustained by (Carew et al., 1972), who asserted that during the first days of life the capacity of poultry to utilize corn oil or animal fat is low, but that it increases as the bird ages.

Vegetable oils and animal fats are currently a valuable tool for the formulation of feeds in order to supply the high energy requirements needed for the optimal performance of birds. In addition to allowing the formulation of high energy density feeds at a lower cost per energy unit, the use of oils and fats in broiler diets provide benefits in performance.

These experiments aimed at evaluating feed intake preference and performance of broiler chicks fed diets with oil inclusion and different GMD during the first four weeks of life.

II. MATERIALS AND METHODS

Birds were distributed into 6 dietary treatments using a completely randomized experimental design in a factorial arrangement of treatments structure using 2 oil levels (0% or 3%) and 3 particle sizes (360 μm, 473 μm or 768 μm). The tested treatments (feeds) were T1= feed with GMD of 360 μm, with 0% of oil, T2= feed with GMD of 473 μm, with 0% of oil, T3= feed with GMD of 768 μm, with 0% of oil, T4= feed with GMD 360 μm, with 3% of oil, T5= feed with GMD of 473 μm, with 3% of oil, T6= feed with GMD 768 μm, with 3% of oil. The experimental diets had the same calculated nutrient composition, except for oil levels and texture (Table 1). The determinate nutrient composition (Fat and Crude Protein) of the diet treatment were 55.3 g/kg and 209g/kg of feed, respectively

The different particle sizes were obtained by grinding the corn in hammer mill using 0.8 mm, 4.0 mm and 8.0 mm screen sizes. Geometric Mean Diameter (GMD) was determined according to the procedure (Zanotto & Bellaver, 1996): a 100-200 g feed sample was dried in an oven at 105°C for 12 hours, screened in a set of seven overlapping screens measuring 0.15, 0.30, 0.60, 1.0, 2.0 and 4.0 mm, coupled to a "Producast" vibration equipment for 10 minutes at 80% of maximum vibration capacity. The percentage of feed retained in each screen was multiplied by the K factor (standardized and constant values). The values of each screen were summed up and divided by 100. The obtained value, designated as FINESS MODULE (FM), was then used in the following formula: GMD = 104.14 x $(2)^{FM}$μm.

Table 1 - Compositions of experimental diets

Ingredients (%)	T1	T2	T3	T4	T5	T6
Yellow corn	48.77	48.77	48.77	48.77	48.77	48.77
Soybean meal	34.32	34.32	34.32	34.32	34.32	34.32
Gluten meal	4.50	4.50	4.50	4.50	4.50	4.50
Soybean oil	-	-	-	3.00	3.00	3.00
Starch	8.01	8.01	8.01	0.72	0.72	0.72
Dicalcium phosphate	1.64	1.64	1.64	1.64	1.64	1.64
Limestone	1.42	1.42	1.42	1.42	1.42	1.42
Mineral and vitamin premix*	0.50	0.50	0.50	0.50	0.50	0.50
Salt (NaCl)	0.46	0.46	0.46	0.46	0.46	0.46
DL-Methionine	0.20	0.20	0.20	0.20	0.20	0.20
L-Lysine	0.17	0.17	0.17	0.17	0.17	0.17
Sand	0.01	0.01	0.01	4.30	4.30	4.30
Calculated analysis						
ME. kcal/kg	2900	2900	2900	2900	2900	2900
Crude Protein %	22.00	22.00	22.00	22.00	22.00	22.00
Calcium %	1.00	1.00	1.00	1.00	1.00	1.00
Available P %	0.45	0.45	0.45	0.45	0.45	0.45
Sodium %	0.20	0.20	0.20	0.20	0.20	0.20
Methionine + Cystine %	0.88	0.88	0.88	0.88	0.88	0.88
Lysine %	1.10	1.10	1.10	1.10	1.10	1.10

* Provides per kg of diet: Vit A 8.000 IU; Vit D3 2.400 IU; Vit and 16.65 mg; Vit K 1.5 mg; Vit B1 0.6 mg; Vit B2 2.36 mg; Vit B6 0.6 mg; Vit B12 1.320 mcg; biotin 0.15 mg; choline 1.54 g; pantothenic acid 9.32 mg; niacin 30.12 mg; folic acid 1.42 mg; Se 0.65 mg; I 0.35 mg; Fe 57.72 mg; Cu 12.30 mg; Zn 141.48 mg; Mn 173.0 mg; K 7.88 g; S 0.72 g; Mg 0.90 g.

The statistical analysis used a factorial arrangement of treatments using a completely randomized design (2 X 3). Data were submitted to analysis of variance, using the General Linear

Models procedure (GLM) of SAS® (SAS, 2000) according to the following general model:

$$Yijk= \mu+\alpha_i + \beta_j + \alpha \times \beta_{ij} + \varepsilon_{ij}$$

Where Yijk was the observed dependent value; μ the general mean; α_i the effect of grinding (360 μm, 473 μm or 768 μm); β_j the effect of oil level (0 or 3%); $\alpha \times \beta_{ij}$ the effect of the interaction between grinding and oil level; ε_{ij} the random error associated to each observation. A normality test was carried out to ensure that measured variables were similar in variance ($P<0.05$).

Experiment I: Two hundred eighty eight day-old male Cobb-500 chicks were randomly distributed into 6 treatments, with 4 replications each. The birds were housed in 24 cages in an experimental house, with temperature controlled (in accordance with the age), 24 hours light and feed and water provided *ad libitum*. Each cage of 12 birds was an experimental unit.

Birds were daily inspected and dead birds were removed, recording the date and body weight. The body weight of dead birds was taken into account when calculating feed conversion (kg diet/kg weight).

At 7, 14, 21, and 28 days of age, birds and feed were weighed in order to determine feed intake (FI), weight gain (WG) and feed conversion (FC).

Experiment II: Fifteen Cobb-500 broilers were randomly assigned to 15 cages on hatching day and were reared from 1 to 21 days of age. Birds were individually housed in a cage equipped with six feeders, where six different diets were offered so that the birds could choose the diet. For statistical analysis, each feeder of each cage was one replicate of the 6 treatments. The diets studied in this assay were the same as the previous study.

Feeders were weighed when birds were 7, 14, and 21 days of age for feed intake measurement and determination of diet preference.

III. RESULTS AND DISCUSSION

Birds fed diets with the largest particle size presented higher feed intake at 7, 14, 21, and 28 days of age (P= 0.046, P= 0.019, P= 0.017, and P= 0.041 respectively). Feed intake increased with the increase of feed particle size (Table 2).

Table 2 - Feed intake, weight gain and feed conversion of broiler fed fine, intermediate and coarse texture mash diets with or without oil

	Tratament						Tratament effects		Interaction	CV
	360 μm		473 μm		768 μm		Texture	Oil	Texture* oil	
Oil level	0%	3%	0%	3%	0%	3%				
Weight Gain (g/bird)										
1-7 dias	111	128	114	133	1195	142	0.145	0.062	0.848	11.62
1-14 dias	346	369	362	400	358	397	0.012	0.001	0.513	6.53
1-21 dias	633	689	705	635	675	737	0.001	0.001	0.897	6.97
1-28 dias	903	1036	1032	1113	1002	1099	0.001	0.001	0.501	7.83
Feed Intake (g/bird)										
1-7 dias	153	172	151	166	175	173	0.046	0.071	0.263	8.57
1-14 dias	537	558	544	548	597	571	0.019	0.970	0.231	5.66
1-21 dias	811	889	856	898	905	932	0.017	0.012	0.506	5.24
1-28 dias	1617	1712	1627	1734	1724	1758	0.041	0.006	0.484	4.61
Feed Conversion (g feed/g gain)										
1-7 dias	1.24	1.30	1.28	1.25	1.53	1.26	0.005	0.023	0.001	5.90
1-14 dias	1.36	1.38	1.32	1.21	1.49	1.31	0.006	0.007	0.059	7.89
1-21 dias	1.39	1.32	1.36	1.26	1.49	1.35	0.003	0.001	0.390	6.05
1-28 dias	1.93	1.76	1.73	1.66	1.92	1.71	0.001	0.001	0.059	6.47

Weight gain was negatively influenced with the reduction of particle size, with the lowest weight gain for birds fed diets with the smallest particle size at 14, 21, and 28 days of age (P= 0.01, P= 0.001, and P= 0.001 respectively). Feed particle size influenced this variable, with feed intermediate particle size promoting the highest weight gain. Feed particle size also effected feed conversion ratio at 7, 14, 21 and 28 days of age (P=0.005, P=0.006, P= 0.003 and P= 0.001 respectively).

Birds fed diets with the highest level of oil inclusion had the highest intake at 21 and 28 days of age (P= 0.012 and P= 0.006, respectively). The inclusion of oil also improved weight gain at 14, 21, and 28 days of age (P= 0.001) and feed conversion ratio at 7 (P= 0.023) 14 (P= 0.007), 21, and 28 days of age (P= 0.001).

There was a significant interaction between feed particle size and level of oil inclusion in the diet for feed conversion ratio at 7 days of age (P= 0.001). Chicks fed feeds with the largest particle size showed the worst feed conversion ratio as compared to those fed diets with small and intermediate particle size, with no oil addition. However, when diets with different particle sizes and oil addition were compared, feed conversion ratios were not different (Table 3).

Table 3 - Interactions between texture and oil level on feed conversion at 1-7 days of age

Texture	Oil level 0%	Oil level 3%
	1-7 days	
Fine (360 μm)	1.236 ± 0.15 $^{b\,A}$	1.305 ± 0.18 $^{a\,A}$
Intermediate (473 μm)	1.286 ± 0.20 $^{b\,A}$	1.254 ± 0.21 $^{a\,A}$
Coarse (768 μm)	1.535 ± 0.12 $^{a\,A}$	1.263 ± 0.20 $^{a\,B}$

a-b – Means within a column for each variable with no common superscript differ significantly (*P<0.05*);
A-B- Means within a row for each variable with no common superscript differ significantly (*P<0.05*).

At 7 and 14 days of age, feed intake already increased as particle size increased, independent of oil inclusion (Table 4).

Table 4 - Ration feed intake of with fine, intermediated and coarse texture, with 0% or 3% of oil at 7, 14 and 21 days of age

	Tratament						Tratament effects		Interaction	CV
	Fine		Intermediate		Coarse		Texture	Oil	Texture* oil	
Oil level	0%	3%	0%	3%	0%	3%				
Feed Intake (g/bird)										
1-7 dias	10	26	30	46	61	81	0.01	0.274	0.078	87.62
1-14 dias	36	40	61	81	97	103	0.01	0.167	0.600	61.44
1-21 dias	7	31	53	149	100	156	0.01	0.001	0.001	75.96

We observed significant results (P<0.05) for feed intake between the different sizes tested at 7, 14 and 21 days of age, and the increase in consumption occurred as the size increases. The addition of oil in the diet increased significantly (P<0.05) consumption for 21 days of age. An interaction between feed particle size and oil level inclusion at 21 days of age was observed (P=0.001). When the effect of particle size was analyzed for each oil level, it was observed that birds eating diets with no oil addition preferred feed with coarse texture followed by intermediate texture and fine texture diets (Table 5). When feed intake with and without oil inclusion was compared, it was observed that birds prefer eating feed containing oil across particle size.

Table 5 - Interactions between texture and oil level on feed intake (free choice) at 1-21 days of age

Texture	Oil level 0%	Oil level 3%
	1-21 days	
Fine	7 ± 5 $^{c\,B}$	31 ± 8 $^{b\,A}$
Intermediate	53 ± 20 $^{b\,B}$	149 ± 35 $^{a\,A}$
Coarse	100 ± 25 $^{a\,B}$	156 ± 28 $^{a\,A}$

a-b-c – Means within a column for each variable with no common superscript differ significantly (*P<0.05*);
A-B- Means within a row for each variable with no common superscript differ significantly (*P<0.05*).

The results of the present study showed that broilers fed diets with the largest particle size had the highest weight gain. Nir et al. (1990, 1994a) verified higher weight gain in birds fed coarser ground diets, with concurrent increase in feed intake.

It is commonly observed that when feeds with the proper particle size are fed, the performance of broilers is improved due to higher feed intake or to better feed utilization (Nir et al., 1994a; Dahlke et al., 2001b). The breakdown of particles in the proximal small intestine is slower when these particles are large, thus promoting slower peristalsis and, perhaps, better nutrient utilization (Nir et al., 1995). The results of the present study show that broiler chicks have the ability to select different feed particles since the first week of life. This ability increases as the bird ages (Nir et al., 1990). Nir et al. (1994b) observed the preference for intermediate-sized particles (>0.64mm<1.4 mm) during the first week of age, followed by a preference for particles larger than 1.14 mm at 21 days of age.

Similar results were found by Ribeiro et al. (2002) to observe that the smaller size (337 μm) has lower feed intake, reduced weight gain and poor feed conversion of broilers compared with sizes above 778 μm, showing a linear effect of size on the parameters of performance ($P<0.01$). Surek et al. (2008) found that broilers received diets with DGM 680μm had greater weight gain and better feed conversion when compared to broilers fed diets with DGM 430μm.

This difference can be explained by the fact that larger particles reduce peristalsis, stimulating anti peristalsis, positively encourage the reduction of gastric pH and the increase in intestinal pH, promote growth of intestinal villi of the mucosa and to improve the digestibility of nutrients (Ribeiro et al., 2002; Dahlke et al., 2001b and 2003).

Dahlke et al. (2001a) studying feed intake preference in 1 to 21-day-old broilers fed iso-energy diets (2900 kcal/kg ME) with different soybean oil inclusion levels (0, 1, 2, and 3%), observed that birds have different intakes since the first week of age. This preference followed the increase in the level of inclusion of oil in the diet, suggesting the oil increases palatability.

These beneficial effects provided by lipid sources are known as extra-calorie effects, which derive from an increase in transit time (Mateos & Sell, 1981) from the synergy between saturated and unsaturated acids (Renner & Hill, 1961), and also from the lower specific dynamic action of the fats as they reduce heat increment, resulting in higher availability of net energy for animal growth (Dale & Fuller; 1980).

IV. CONCLUSIONS

The texture of the diet has a pronounced effect on feed intake, and consequently, on weight gain of young broilers (from 1 to 21 days of age). The capacity to regulate feed intake, as a function of the oil inclusion level, depends on the age of the broiler, and that this may be related to the higher efficiency of the birds to use lipids.

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