

Performance of broilers fed mash or pelleted diets containing different soybean meal particle sizes








Abstract – The objective of this work was to evaluate the effect of different soybean meal particle sizes in pelleted or mash diets on broiler performance. A total of 1,440 male Cobb500 broilers, with 1 to 35 days of age, were evaluated. The experimental design was completely randomized, in a 2x4 factorial arrangement, consisting of two feed physical forms and four soybean meal particle sizes (625, 775, 1,053, and 1,406 μm), totaling eight treatments, with nine replicates of 20 birds each. Feed intake, weight gain, and feed conversion ratio were evaluated. There was a significant interaction between diet physical form and soybean meal particle size. From 1 to 21 days of age, the lowest feed intake and weight gain values were obtained with the mash diet containing 1,406 μm soybean meal particle size. From 1 to 35 days of age, the greatest weight gain is achieved when broilers are fed the pelleted diet with 1,406 μm soybean meal particle size.

Index terms: *Glycine max*, Cobb500, feed conversion ratio, feed intake.

Desempenho de frangos de corte alimentados com dietas fareladas e peletizadas contendo diferentes tamanhos de partícula de farelo de soja


Resumo – O objetivo deste trabalho foi avaliar o efeito de diferentes tamanhos de partícula de farelo de soja, em dietas fareladas e peletizadas, no desempenho de frangos de corte. Foram avaliados 1.440 pintos de corte machos da linhagem Cobb500, com 1 a 35 dias de idade. O delineamento experimental foi inteiramente casualizado, em arranjo fatorial 2x4, com duas formas físicas da dieta e quatro granulometrias de farelo de soja (625, 775, 1.053 e 1.406 μm), tendo totalizado oito tratamentos, com nove repetições com 20 aves cada uma. Foram avaliados consumo de ração, ganho de peso e conversão alimentar. Houve interação significativa entre as formas físicas das dietas e o tamanho das partículas do farelo de soja. De 1 a 21 dias de idade, os menores valores de consumo de ração e ganho de peso foram obtidos com a dieta farelada contendo partículas do farelo de soja de 1.406 μm . Já de 1 a 35 dias de idade, o maior ganho de peso é alcançado quando os frangos são alimentados com dietas peletizadas com tamanho de partícula do farelo de soja de 1.406 μm .

Termos para indexação: *Glycine max*, Cobb500, taxa de conversão alimentar, consumo de ração.

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Introduction

Soybean [*Glycine max* (L.) Merr.] meal (SBM) is typically the main protein feedstuff included in livestock diets (Félix et al., 2010; Oliveira et al., 2020). After subjected to an adequate heat treatment, SBM has a high crude protein content, as well as a high digestible energy and low fiber contents (Félix et al., 2010).

In general, SBM makes up 30% of broiler diets (Duarte & Junqueira, 2013). However, broiler performance is strongly influenced by feed particle size and physical form (Shabani et al., 2015). Feed particle size affects feed manufacturing, besides feed intake, diet digestibility, and, consequently, broiler performance (Teixeira Netto et al., 2019). Studies have shown that broiler live performance is improved by the supply of coarser feed particles, compared with that of finer ones (Pacheco et al., 2013; Lv et al., 2015). However, age and digestive tract development stage should also be considered when evaluating broiler response to feed particle size (Kheravii et al., 2018).

Regarding physical forms, the main ones are mash and pellet. For mash feeds, the ingredients are grinded and homogeneously mixed, whereas, for pelleted feeds, the feed mash is subjected to a thermal-mechanical process combining high temperature, humidity, and pressure (Amerah et al., 2011; Santos et al., 2020). One of the greatest benefits of feeding broilers with pelleted diets is the increase in feed intake and consequent better live performance (Massuquetto et al., 2020). Abdollahi et al. (2011) reported a 14% increase in the feed intake of starter broilers fed pelleted diets, compared with those fed mash diets.

Several authors have investigated corn (*Zea mays* L.) particle sizes in poultry feeds (Chewning et al., 2012; Naderinejad et al., 2016; Kheravii et al., 2017). However, although SBM is typically the main protein source in poultry diets, only a few studies (Kilburn & Edwards, 2004; Pacheco et al., 2013) have aimed to determine the adequate SBM particle size for broilers according to rearing phase.

The objective of this work was to evaluate the effect of different soybean meal particle sizes in pelleted or mash diets on broiler performance.

Materials and Methods

The research was approved by the ethics committee on animal use of the Agricultural Sciences Sector

of Universidade Federal do Paraná, under protocol number 073/2015. The experiment was conducted throughout 2016, in the municipality of Curitiba, in the state of Paraná, Brazil (25°25'40"S, 49°16'23"W). A total of 1,440 Cobb500 (Cobb-Vantress Brasil Ltda., Guapiaçu, SP, Brazil) male broiler chickens were used, aged from 1 to 35 days. The birds were housed in a masonry shed divided into 72 pens, measuring 2.06 m² each (20 birds per pen). Each pen was equipped with a tube feeder, nipple drinkers, and a brooder; the floor was covered with wood-shavings litter. Feed and water were offered ad libitum. Continuous lighting was provided during the first 24 hours, after which the number of hours of light was gradually reduced according to the management manual of the broiler breeding company (Cobb-Vantress, 2013). Environmental temperature was maintained at 32°C on the first day and then gradually reduced to approximately 21°C on the thirty-fifth day.

The experimental design was completely randomized, in a 2x4 factorial arrangement, consisting of two feed physical forms (mash or pelleted) and of four SBM particle sizes (625, 775, 1,053, and 1,406 µm), totaling eight treatments, with nine replicates of 20 birds each.

The different SBM particle sizes were obtained by using sieves with different hole sizes of 3, 4, 5, and 6 mm, during grinding in a hammer mill. Geometric mean diameter (GMD, µm) and geometric standard deviation (GSD) of corn and SBM were determined according to the methodology of Zanotto & Bellaver (1996). Initially, a 500 g sample was dried in a forced-air ventilation oven at 105°C for 24 hours, removed from the oven, allowed to reach environmental temperature, and weighed. Then, the sample was placed in the VP-01 electromagnetic sieve shaker (Bertel Ind. Metalúrgica Ltda., Caieiras, SP, Brazil) with six wire-mesh sieves, using known weights, according to standards 5, 10, 16, 30, 50, and 100 of Associação Brasileira de Normas Técnicas (ABNT) (Zanotto & Bellaver, 1996), and finally shaken for 10 min with the rheostat set at 8. After the shaking process was concluded, the weight of each sieve and its content were determined and recorded. Samples were analyzed in duplicate. Weights were entered in the GranuCalc software (Dalmédico et al., 2013), which generated a report with the calculated GMD and GSD values of each sample.

Corn particle size was maintained constant in all diets, and the values found for GMD and GSD were 1,168 μm and 1.97, respectively. For SBM ground with the sieve mesh sizes of 3, 4, 5, and 6 mm, the values obtained for GMD were 625, 775, 1,053, and 1,406 μm and for GSD, 1.76, 1.72, 1.81, and 1.94, respectively.

The experimental diets were based on corn and SBM and formulated according to the recommendations of Brazilian tables for poultry and swine (Rostagno et al., 2011), as shown in Table 1. Mash diets were pelleted in the Junior C40 steam pellet mill (Koppers Company, Inc., Pittsburgh, PA, USA). Broilers were fed starter diets from 1 to 21 days of age and grower diets from 22 to 35 days; the pelleted starter diet was crumbled after cooling.

Live performance parameters were evaluated from 1 to 21 (starter period) and from 1 to 35 (total period) days of age. During each experimental period, feed offer and leftovers were weighed weekly and recorded in spreadsheets to obtain the average feed intake (AFI) per period. Birds were weighed on days 1, 21, and 35 to determine average weight gain (AWG) and feed conversion ratio (FCR).

Data were tested for normality by Shapiro-Wilk's test, and, when this assumption was accepted, data were subjected to the analysis of variance using the GLM procedure of the SAS statistical package (SAS Institute Inc., Cary, NC, USA), according to the experimental design previously described. When significant interactions were detected, results were unfolded and compared by Tukey's test, at 5% probability. Linear and quadratic responses for SBM particle size were assessed using orthogonal polynomial contrast statements, and the statistical significance was based on 5% probability.

Results and Discussion

In the starter period, significant interactions were detected between feed physical form and SBM particle size for AFI, AWG, and FCR ($p < 0.05$). In the total experimental period, similar results were observed for AFI and AWG, but FCR was influenced only by SBM particle size (Table 2).

During the starter period, when mash diets were offered, birds fed 1,406 μm SBM particle size showed a lower AFI than those fed 625 μm SBM (Table 2). However, among pelleted diets, the SBM particle

size of 1,406 μm promoted a higher AFI than that of 775 μm . It is possible that the 1,406 μm SBM particle size in mash diets was excessively large for broilers of the evaluated age, decreasing AFI. According to Moran Jr. (1982), broilers are not able to apprehend feed particles larger than their beaks, as confirmed by López & Baião (2002), who concluded that broilers select the most suitable feed particle sizes during each production stage. In this line, Jacobs et al. (2010) found

Table 1. Ingredients and nutritional composition of the experimental diets fed to Cobb500 broilers from 1 to 21 and from 1 to 35 days of age.

Ingredients (%)	Diets	
	Starter	Grower
Corn	54.89	57.30
Soybean meal 45%	37.08	34.95
Soybean oil	2.73	4.24
Dicalcium phosphate	1.75	1.23
Limestone	0.85	0.93
Salt	0.48	0.46
DL-methionine	0.32	0.24
L-lysine HCl	0.25	0.20
Mycotoxin adsorbent	0.25	0.19
L-threonine	0.13	0.08
Vitamin premix ⁽¹⁾	0.12	0.07
Choline chloride	0.10	0.05
Mineral premix ⁽²⁾	0.05	0.05
BHT ⁽³⁾	0.01	0.01
Calculated nutritional levels (%)		
Crude protein	21.12	20.11
Ether extract	5.41	6.87
Crude fiber	2.93	2.84
Ashes	2.91	2.81
Calcium	0.85	0.75
Available phosphorus	0.45	0.35
Sodium	0.20	0.19
Chlorine	0.34	0.32
Digestible lysine	1.20	1.10
Digestible methionine	0.59	0.50
Methionine + cysteine	0.90	0.80
Digestible threonine	0.80	0.72
Digestible tryptophan	0.23	0.22
Metabolizable energy (kcal kg ⁻¹)	2,980	3,100

⁽¹⁾Supplementation per kilogram of diet: 15,000 IU vitamin A, 5,000 IU vitamin D3, 100 mg vitamin E, 5 mg vitamin K, 3 mg folic acid, 75 mg nicotinic acid, 25 mg pantothenic acid, 8 mg riboflavin, 5 mg thiamin, 7 mg pyridoxine, 300 μg biotin, 400 mg choline, and 20 μg vitamin B12.

⁽²⁾Concentration per kilogram of feed: 2 mg iodine, 200 mg selenium, 20 mg copper, 50 mg iron, 120 mg manganese, and 100 mg zinc. ⁽³⁾BHT, butylated hydroxytoluene.

that corn particles larger than 1,387 μm compromised the performance of 1- to 21-day-old broilers. When comparing SBM particle sizes between physical forms, the 1,406 μm SBM particle size in the pelleted diet resulted in a higher AFI (Table 2). However, there were no differences in AFI between mash and pelleted diets regarding the other evaluated particle sizes.

In the period of 1 to 21 days, the mash diet containing 1,406 μm SBM particle size resulted in a lower AWG than that with 1,053 μm SBM (Table 2). This low AWG may be attributed to the low feed intake observed and to the fact that the gizzard of young broilers is still not fully developed and, therefore, has a limited capacity to grind coarse particles (Kheravii et al., 2018).

However, when pelleted diets were fed, the coarsest SBM particle size, i.e., 1,406 μm , promoted the highest AWG, indicating that the pelletizing process has a positive influence on the assessed performance parameters, specifically on AFI and AWG (Massuquetto et al., 2019). For FCR, although an interaction between diet physical form and SBM particle size was detected, the unfolding of the interaction by Tukey's test did not

show any significant effects of either factor on this parameter (Table 2).

During the total experimental period, no differences in AFI were observed among the evaluated SBM particle sizes when broilers were fed mash or pelleted diets (Table 2). However, when comparing feed physical forms, a higher AFI was obtained with the 1,406 μm SBM particle size in the pelleted diet, while no significant differences were detected when the other particle sizes were compared between mash and pelleted diets.

The better AWG results obtained with the pelleted diet may be attributed to several benefits of the feed pelleting process. It has been reported that pelleted diets facilitate the apprehension of feed particles by birds, resulting in a higher feed intake (McKinney & Teeter, 2004). Pelleting also hinders the selection of feed particles, causes less feed waste, decreases the segregation and microbial load of feeds, increases the amount of dietary energy available for production as less time is required for the intake of pelleted feeds, and increases the digestibility of dietary fractions, such as

Table 2. Performance parameters of 1- to 35-day-old Cobb500 broilers fed mash or pelleted diets with different soybean (*Glycine max*) meal particle sizes⁽¹⁾.

Performance parameters	Physical form (B)	Geometric mean diameter – GMD (A) (μm)				SEM	p-value		
		625	775	1,053	1,406		(A)	(B)	AxB
Age (1 to 21 days)									
Average feed intake – AFI (g)	Mash	1,142Aa	1,115Aab	1,122Aab	1,065Bb	0.016	0.581	0.001	0.001
	Pelleted	1,138Aab	1,119Ab	1,151Aab	1,195Aa				
Average weight gain – AWG (g)	Mash	797.0Aab	803.0Aab	818.0Aa	760.0Bb	0.012	0.179	0.001	0.001
	Pelleted	834.0Ab	799.0Ab	824.0Ab	891.0Aa				
Feed conversion rate – FCR	Mash	1.436Aa	1.390Aa	1.371Aa	1.403Aa	0.018	0.339	0.085	0.017
	Pelleted	1.365Aa	1.402Aa	1.398Aa	1.343Aa				
Age (1 to 35 days)									
Average feed intake – AFI (g)	Mash	2,947Aa	2,936Aa	2,922Aa	2,911Ba	0.033	0.443	0.001	0.005
	Pelleted	3,014Aa	2,984Aa	3,051Aa	3,114Aa				
Average weight gain – AWG (g) ⁽²⁾	Mash	1,998Aa	2,027Aa	2,052Aa	2,059Ba	0.019	0.001	0.001	0.031
	Pelleted	2,078Ab	2,072Ab	2,102Ab	2,182Aa				
Feed conversion rate – FCR ⁽³⁾	Mash	1.476	1.448	1.424	1.414	0.012	0.002	0.792	0.642
	Pelleted	1.451	1.440	1.451	1.429				
	GMD	1.458b	1.443b	1.422a	1.416a				

⁽¹⁾Means followed by equal letters, lowercase in the rows and uppercase in the columns, do not differ by Tukey's test, at 5% probability. ⁽²⁾Linear effect at 5% probability. ⁽³⁾Linear effect at 5% probability. SEM, standard error of the mean.

starch and protein (Behnke, 1994). Moreover, as pellets are disintegrated during digestion (Kheravii et al., 2018), SBM particle size in the pelleted diets may have contributed to the higher AWG results, particularly during the period of 1 to 35 days of age. The rate of coarse feed particles through the gastrointestinal tract can also be slower than that of fine particles, allowing a longer contact of the dietary nutrients with digestive enzymes and intestinal villi, which consequently enhances their digestion and absorption (Zaefarian et al., 2016; Siegert et al., 2018).

The effects of SBM particle size observed in the present study are consistent with the findings of Pacheco et al. (2013), who verified that 14- to 35-day-old birds fed diets with coarse SBM particles of 971 and 1,080 μm presented a higher AWG and a better FCR than those fed finer SBM particles of 465 and 352 μm . Kilburn & Edwards (2004) also reported higher digestion and absorption efficiencies when 1- to 16-day-old broilers were fed coarse SBM particles of 1,239 μm , compared with fine particles of 891 μm .

Throughout the entire experimental period, there was no influence of diet physical form on FCR ($p>0.05$). However, the 1,406 and 1,053 μm SBM particle sizes led to the best results for FCR in broilers fed both the pelleted and the mash diets. Through the orthogonal contrasts, it was possible to observe a linear effect for AWG and FCR from 1 to 35 days of age ($p<0.05$); however, AFI and other variables were not affected in the initial period. Both AWG and FCR improved linearly with increasing SBM particle sizes, which is in agreement with Pacheco et al. (2013), who observed similar effects when assessing different SBM particle sizes in mashed diets. In the present study, the combination of pelleted diets with coarser particles promoted the best results for the evaluated growth performance variables.

Conclusions

1. The particle size of soybean (*Glycine max*) meal, both in mash and pelleted diets, influences Cobb500 broiler performance, as shown by the linear improvement in average weight gain and feed conversion ratio with increasing soybean meal particle sizes.

2. The highest weight gain of 1- to 35-day-old Cobb500 broilers is achieved with the pelleted diet with 1,406 μm soybean meal particle size.

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