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Inclusion of Dried Bakery Product in High Fat Broiler Diets: Effect on Pellet Quality, Performance, Nutrient Digestibility and Organ Weights*

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ABSTRACT : A 21- to 42-day feeding study was conducted in Ross male broilers to evaluate the use of dried bakery product (DBP) and the influence of adding fat at different points in the manufacturing process. Six dietary treatments were formulated using a factorial arrangement (3×2 design) with three levels of fat in the mixer (high: 4.8%, medium: 3.8% and low: 2.8%) with or without DBP (0 and 7%). Additional fat was sprayed on pellets in a post-pelleting liquid application to bring the fat content to a similar level in all diets. Data on pellet quality (before and after post-pelleting fat addition), broiler performance, nutrient digestibility and organ weights were studied. Pellets made with DBP showed higher hardness values when measured before post-pelleting fat addition ($p<0.001$), although DBP did not affect final pellet hardness or durability. Higher post-pelleting hardness and durability were shown by diets to which a lower level of fat had been added in the mixer ($p<0.001$). In general, post-pelleting fat application improved durability ($p<0.05$). However, broiler performance and ileal digestibility were not affected by any of the factors tested. Dietary treatments had a significant but variable effect on carcass yield ($p<0.01$), although there were no differences among treatments regarding breast and leg yield, abdominal fat or organ weights. The results indicate that up to 7% DBP could be used in the broiler diet without impairing performance, ileal digestibility or organ weights. The place or point of fat addition in the manufacturing process has a strong influence on pellet quality. (**Key Words :** Broiler, High Fat Diet, Dried Bakery Product)

INTRODUCTION

Feeding is the most important aspect of broiler production, feed costs representing about 70% of total costs. Broiler diets are based on cereals and soybean meal as major sources of energy and protein, respectively. However, the increasing demand for cereals has led to a constant rise in their price and, even their unavailability (FAO, 2007). In this context and in face of an uncertain future, the industry must look for alternatives to keep down costs or even, if possible, to reduce them. When planning a nutritional programme based on least-cost diets, the best way is a global approach covering different phases: the use of non conventional raw materials and alternative sources of energy, good manufacturing practices and the application of new processing technologies, etc., to provide greater flexibility in the formulation of diets.

Dried bakery product (DBP) is a waste comprising recycled expired bakery products (cookies, bread, crisps, etc.) and can be considered an energy source because of its digestible carbohydrate content (starch+sugars). Its basic component is wheat meal and it can partially replace cereals without affecting broiler performance (Damron et al., 1965; Saleh et al., 1996). However, its composition may vary between suppliers (Waldroup et al., 1982), depending on the quality of the initial product and processing conditions. For instance, free sugars from some products, such as cookies, might reduce the availability of amino acids trough Mallaird reactions during processing (Dale, 1992).

On the other hand, fats and oils, whose energy content is 2.25 times higher than that of cereals, are "classic" contributors of energy in feed, and will have to be used in increasing percentages in the diet if prices are to stay within

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reasonable limits. Moreover, high-fat (HF) diets increase energy density and improve broiler performance when feed intake is lower in hot climate conditions. However, such diets present practical and technological problems and, fat should be restricted to 3-4% in the mixer to avoid lower pellet hardness and durability (Richardson and Day, 1976; Benhke, 1994).

In general, and according to Reimer (1992), diet formulation is the largest contributor to pellet quality (40%). As is well-known, the inclusion of large quantities of fat decreases pellet quality because of the lubricating effect on the mash-die interface during pelleting. Nevertheless, depending on the moisture content and temperature, protein and starch might act as binding agents and improve the binding of feed particles. However, ingredients with a high level of starch vary in their "pelletability", and among the main cereals those with a higher protein content show the best pelleting quality (MacMahon and Payne, 1991). Consequently, the inclusion of wheat and wheat by-products, such as DBP, could be a way of adding a "binder" with its own nutritive value.

An important aspect of the pelleting process, which has received little attention, is the influence of the place at which fat is added. The use of post-pelleting applications could improve pellet quality (McCracken, 2002).

The aim of this work was to evaluate the effect of adding DBP to HF diets in which the fat is added before and after pelleting on broilers from 21 to 42 d of age. Pellet quality, performance, nutrient digestibility and organ weights were studied.

MATERIALS AND METHODS

General procedures

A 3×2 factorial experiment with ninety Ross 308 male broilers was conducted from 21 to 42 d of age and involving six dietary treatments. Broilers, from a commercial hatchery, were raised in a conventional environment and fed a common diet until 20 d of age. At 21 d, animals were individually weighed and divided into 18 groups of five birds each. A total of three groups were assigned to each treatment according to a totally randomized design, providing six treatments with three replicates per treatment.

Each group of five birds, which was defined as the experimental unit or unit of statistical analysis, was placed in a 70×60 cm battery cage with a 1×1 cm wire mesh floor. Each cage was equipped with a feeder, a water cup and an individual floor waste tray to collect excreta. Feed and water were provided *ad libitum*.

The trial was carried out in an experimental laboratory with heating and ventilation systems, gradually reducing the temperature from 26°C on day 21 to 20°C on day 40. The lighting cycle was 21 h/d from day 21 to 35 and 23 h/d from day 36 to 42.

During the course of this study, broilers were handled according to the guidelines for experimentation animal care (BOE, 2005).

Experimental diets, manufacturing process and pellet quality

The feeding study was carried out from 21 to 42 d with six grower-finisher diets, because they are usually in pelleted form and they have a higher fat content than starter diets. Dietary treatments were formulated using a factorial arrangement with three levels of fat in the mixer with or without DBP (3×2 factorial design).

The fat was added in the mixer at three levels: high (H; 4.8%), medium (M; 3.8%) and low (L; 2.8%). Additional fat was coated on pellets by post-pelleting liquid application in order to obtain a similar fat content in all the diets, approximately 9%. Two percentages of DBP inclusion (Bakery by-product, Promic, S.A., Spain.) were compared: 0 and 7%. Consequently, the diets are referred to as 0H, 0M and 0L when DBP was not included, and 7H, 7M and 7L when DBP was present.

Grinding and feed processing was performed at a feed manufacturing plant in Murcia, Spain. Ingredients were ground through a 2 mm hammermill screen. The hammer mill was driven by a 160 kW electric motor with a rotational speed of 1,475 rpm (Bühler AG, model DFZC-1,155, Uzwill, Switzerland). Then, the ground material was mixed with the remaining ingredients and fat was added in a 4,500 kg horizontal mixer for 4 min (Bühler AG, model DMCO, Uzwill, Switzerland). The mash was conditioned to a temperature near 75°C, and then conveyed to the pellet press with a 3.5×55 mm die (Bühler AG, model DPAS, Uzwill, Switzerland). Pellets were cooled in a Bühler DFKC horizontal cooler for 10 to 15 min and a further quantity of fat was added by a disc-coater system (post-pelleting).

All the experimental diets were isocaloric and isonitrogenous and formulated to meet or exceed the nutrient requirements of broiler chickens (NRC, 1994). A source of HCl-insoluble ash (Diasol®, Adiveter, Barcelona, Spain) was added to each diet at 10 g/kg as an indigestible marker.

In order to test fragmentation and abrasion effects during processing and immediately afterwards (before and after fat post-pelleting addition), a representative sample was collected and analyzed for pellet hardness and durability using standard methods (Thomas and van der Poel, 1996). Hardness was individually measured in 10 pellets per treatment with a "Kahl" type tester (Hardness tester, Mabrik, S.A., Spain). Hardness was defined as the maximum charge in kg required to break the pellet. In addition, and according to the Pfost procedure (Thomas and van der Poel, 1996), durabilitity was measured with a 500 g sample treated for 10 min using a 1.1 mm screen (grid-size of 0.8×pellet diameter) by the tumbling box method (Durabilimeter, DBM-203, Mabrik, S.A., Spain). Pellet durability was calculated by measuring the amount of fines resulting from the mechanical shaking test as a percentage of the sample.

Measurements and laboratory analyses

All broilers were weighed weekly. Feed intake (FI) was measured per cage throughout the experiment and the feed conversion ratio (FCR) was calculated weekly on a cage basis. Mortality was checked twice daily, and the weight of dead chickens was also recorded at the time of removal.

In order to determine faecal digestibility, excreta during a 24 h period was collected from an individual tray placed under the eighteen birdcages on days 27 and 34. Pooled feces from the five broilers in each cage were weighed, and a sample was dried at 80°C until constant weight in a forced-air oven and ground to pass through a 1mm sieve.

All birds were killed by cervical dislocation on day 42. After slaughter, the small intestine was immediately exposed and samples of ileal digesta were collected and pooled from animals in each experimental group or cage (three cages per treatment). The ileum was defined as that portion between the Meckel's diverticulum and a point 40 mm proximal to the ileocecal junction. The content of the ileum was collected into plastic containers, stored at -20°C, lyophilized and ground to pass through a 0.5 mm mesh.

For the dressing analysis, carcass weight (measurements after removing the digestive tract but including head, skin, feet and feathers), cuts (breast and leg yield), abdominal fat and organ weights (pancreas and liver without gland bladder) were measured in all animals. Carcass yield (CY) was determined using carcass weight as a proportion of live body weight. The weights of the different cuts, abdominal fat and digestive organs were adjusted for the body weight without digestive tract, resulting in a relative weight measurement.

Feed, excreta, and ileal digesta were analyzed for N content using Kjeldahl's method to estimate crude protein (CP) (Nx6.25) (AOAC, 1990), and for the acid insoluble ash content (AIA) (Vogtmann et al., 1975). Dry matter (DM) of feed and DBP was determined in an oven at 103°C for 8 h. In addition, DBP was also analyzed for CP, ether extract and ash content (AOAC, 1990). Apparent faecal and ileal digestibility of DM and CP were calculated using AIA as an indigestible marker.

Samples for amino acid analysis were prepared using a 24 h hydrolysis step in 6N HCl at 110°C under nitrogen atmosphere. For methionine and cystine, performic acid oxidation occurred prior to acid hydrolysis. Samples for tryptophan analysis were hydrolyzed using barium hydroxide. Amino acids in hydrolysate were determined by HPLC after postcolumn derivatization (AOAC, 1990).

Statistical analysis

Data on pellet quality, performance, nutrient digestibility and organ weights were subjected to two-way analysis of variance (ANOVA) with SPSS software (SPSS, 1997). The full factorial model used was as follows:

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

where μ is the common mean, A_i is the effect of level of fat addition in the mixer, B_j is the effect of DBP inclusion, A B_{ij} the effect of the ith A with the jth B, and e_{ijk} is the random error. Alternatively, we could write an one-way ANOVA on all possible (fat addition and DBP) combinations, which is equivalent to a full factorial model. When significant differences were found ($p<0.05$), a post-hoc test (Fisher's least-significant difference) was used to evaluate differences between diets (Snedecor and Cochran, 1980). For hardness and durability analysis, two-way comparisons were also performed to evaluate the pellet quality before and after post-pelleting fat addition.

RESULTS AND DISCUSSION

Diets and pellet quality

The chemical composition of basal diets is shown in Table 1. The diets were formulated to reach high fat levels (ranging from 9.05 to 9.31% on an as fed basis) and the estimated ME value was 3,050 kcal/kg. The amino acid content, except for cystine (0.35 vs. 0.39%), was slightly higher in the HF diet than in the HF+DBP diet. Previous studies have pointed to a possible deleterious effect of DBP on lysine availability because of Mallaird reactions during pelleting (Dale, 1992). However, Dale (1992) found no evidence to support this hypothesis, since lysine availability was not affected in feeds containing DBP (6%) and synthetic lysine. In any case, feed analysis from present study pointed to high concentrations of dietary amino acids (Table 1). The limiting amino acids were added according to the known broiler requirements (NRC, 1994). The analytical composition of DBP was of 88.03% for DM, and 11.60%, 8.37% and 6.37% on DM basis for CP, ether extract and ash content, respectively.

The effect of adding fat to the diets and DBP inclusion on pellet quality is shown in Table 2. To properly interpret the data, it must be remembered that the highest level of fat added in the mixer corresponded to the lowest level on the pellet surface (post-pelleting application).

Pellets from diets containing DBP showed higher hardness values when measured before post-pelleting fat

Table 1. Composition of experimental diets (%)

	Diets[1]	
	HF	HF+DBP
Ingredients (as-fed basis)		
Wheat	58.15	52.20
Soybean meal	30.10	29.90
Dried bakery product	-	7.00
Soybean oil	4.18	3.45
Animal fat	4.00	4.00
Diasol[2]	1.00	1.00
Calcium carbonate	0.73	0.69
Calcium phosphate	0.38	0.37
Sodium bicarbonate	0.20	0.20
Sodium chloride	0.25	0.15
DL-methionine	0.35	0.36
L-lysine	0.36	0.38
L-threonine	0.06	0.06
Choline chloride	0.07	0.07
Vitamin premix[3]	0.03	0.03
Mineral premix[4]	0.10	0.10
Xylanase[5]	0.03	0.03
Phytase[6]	0.01	0.01
Calculated composition[7]		
ME (kcal per kg)	3,050	3,050
Crude protein	21.15	21.15
Fat	9.31	9.05
Analyzed composition (% DM)		
Dry matter	90.89	90.83
CP (N×6.25)	24.68	24.36
Methionine	0.43	0.42
Cystine	0.35	0.39
Lysine	1.11	1.07
Tryptophan	0.35	0.32
Threonine+Arginine	1.79	1.66
Isoleucine	0.73	0.65
Histidine	0.41	0.37
Valine	0.83	0.68
Leucine	1.30	1.18
Phenylalanine	0.85	0.52
Glycine	0.75	0.69
Serine	0.89	0.83
Glutamic acid	3.88	3.69
Aspartic acid	1.99	1.57
Alanine	0.75	0.66
Proline	1.07	1.00
Tyrosine	0.53	0.48

[1] HF = High fat; DBP = Dried bakery product.

[2] Acid-insoluble ash digestibility marker (Diasol®, Adiveter. Barcelona, Spain).

[3] Supplied per kilogram of diet: vitamin A (retinyl acetate), 9,000 IU; vitamin D3, 3,000 IU; vitamin E (DL-α-tocopheryl acetate), 48 mg; vitamin K, 3 mg; thiamin, 1.8 mg; riboflavin, 6 mg; pyridoxine, 3 mg; vitamin B_{12}, 0.012 mg; niacin, 42 mg; folic acid, 1.2 mg; biotin, 0.24 mg; pantothenic acid, 12 mg.

[4] Supplied per kilogram of diet: manganese, 100 mg; zinc, 80 mg; iron, 30 mg; copper, 15 mg; iodine, 2 mg; selenium, 0.3 mg; cobalt, 0.2 mg.

[5] Natugrain Prod. N° JEB8296569/1-54, BASF Group, Ludwigshafen, Germany.

[6] Natuphos Prod. N° JEA8085632/1-29, BASF Group, Ludwigshafen, Germany.

[7] According to De Blas et al. (2003).

addition ($p<0.001$). As regards durability prior to post-pelleting fat addition, the percentages ranged from 89.3 to 94.0% for 0H and 7L, respectively, but with no clear trend. There was no significant effect of fat addition before post-pelleting on either pellet hardness or durability, although the two lowest durability values were found in diets with high levels of fat added in the mixer (around 90%). Past research has shown that increasing fat above 2% in a corn-soybean diet before pelleting decreases pellet quality with respect to durability (Richardson and Day, 1976). Briggs et al. (1999) found a pellet durability close to 60% when the oil content in the pellet die was increased from 2.9 to 7.5%. In addition, fats added to the mash pre-pelleting influence hardness since it act as a lubricant between particles, resulting in lower pelleting pressure.

With or without DBP inclusion, higher post-pelleting hardness and durability were measured in diets to which a lower level of fat had been added in the mixer ($p<0.001$), and which, consequently, had a greater fat coating. Bakery product (DBP) did not affect final pellet hardness or durability. However, pellet hardness was influenced by post-pelleting fat addition ($p<0.001$) but with no significant differences between the dietary treatments without DBP. Post-pelleting fat addition reduced pellet hardness in treatments 7H and 7M ($p<0.05$).

Hardness data from the Kahl tester showed considerable variation, in agreement with the data given for a series of five experiments on pellet quality (Thomas and van der Poel, 1996). The average coefficient of variation (CV) was close to 34%, which increased when hardness was lower. Thomas and van der Poel (1996) indicated that the CV data is frequently reduced by excluding the highest and lowest values, although this may be highly questionable from a scientific point of view. In any case, hardness results were consistent in both procedures, whether or not extreme values were excluded.

Post-pelleting fat application improved durability in all the treatments ($p<0.05$) except for 7H, in which this effect was not significant. This effect could be partly explained by a lower amount of dust produced. The final effect of the coating also depended on the initial durability of the feed (prior to pelleting). Van Rooyen (2003) increased the pellet durability of the final product from 63 to 86% by lowering the fat in the mixer from 3.5 to 0.5% and therefore adding the fat by means of a post-pelleting fat coater.

The lower durability of a pellet leads to a higher amount of fines in the feed, resulting in a lower FI, a higher FCR and a lower BW (McKinney and Teeter, 2004; Quentin et al., 2004). It is important to measure pellet hardness because broiler performance could be impaired by extremely hard pellets (Nir et al., 1994). Our experiment showed that the use of a post-pelleting spray application of

Table 2. Effect of level of fat added in the mixer and inclusion of dried bakery product on pellet quality[1]

Treatment[2]	DBP (%)	Fat in mixer (%)	Hardness (kg)			Durability (%)		
			Before PP fat addition	After PP fat addition	s.l.[4]	Before PP fat addition	After PP fat addition	s.l.
0H	0	4.80	2.00^{b}	1.98^{bc}	NS	89.33^{d}	94.16^{d}	*
0M	0	3.80	1.77^{b}	2.08^{bc}	NS	91.70^{bc}	96.34^{b}	*
0L	0	2.80	1.91^{b}	2.39^{ab}	NS	91.54^{c}	97.34^{a}	*
7H	7	4.80	2.07^{b}	1.62^{c}	**	90.90^{c}	94.09^{d}	NS
7M	7	3.80	3.04^{a}	2.03^{bc}	*	92.90^{ab}	95.86^{c}	**
7L	7	2.80	2.75^{a}	2.95^{a}	NS	93.98^{a}	97.42^{a}	*
SEM[3]			0.08	0.08		0.15	0.04	
Effects[4]								
Fat addition (A)			NS	***		NS	***	
DBP addition (B)			***	NS		NS	NS	
A×B			***	***		**	***	

a-d Mean values within a column having different superscripts are significantly different by least significant difference test (p<0.05).

[1] PP = Post-pelleting; DBP = Dried bakery product.

[2] Means represent 10 pellets for hardness (single pellet measurement, ten replicates) and a sample of 500 g for durability (percentage of pellets returned, two replicates).

[3] SEM = Standard error of the mean.

[4] s.l.: significance level. NS: non significant (p>0.05); * p<0.05 ; ** p<0.01; *** p<0.001.

fat provides good pellet quality in spite of using high fat inclusion rates.

Performance

The effect of fat level added in the mixer and DBP inclusion on BW, ADFI and FCR is shown in Table 3. Initial BW did not differ between groups. Neither were there significant differences between dietary treatments as regards BW at day 42 or ADFI. The average growth was around 100 g/d with a feed to gain ratio of 1.72. The overall response was similar in all treatments, and no sanitary problems were noticed.

Broiler performance was not affected by either effect, fat or DBP, despite the above-mentioned differences in pellet quality. In addition, the level of DBP used in this experiment (7%) was slightly higher than the maximum level recommended (5%) by De Blas et al. (2003) for broiler finisher diets in the Spanish market.

In early studies, Damron et al. (1965) and Day and Dilworth (1968) reported that DBP could be included in broiler diets without impairing performance at rates of 10 and 15%, respectively. However, Potter et al. (1971) demonstrated a significant decrease in feed intake when turkeys were fed a diet containing 10% DBP.

In more recent studies that have evaluated the use of high levels of DBP in broilers (Saleh et al., 1996; Al-Tulaihan et al., 2004) diets supplemented with DBP (25 and 30%, respectively) had no negative effect on growth performance compared to control diets. In contrast, Kouhkan et al. (2003) reported a lower BW at 49 d when 20% of DBP was added to the diet. These differences found in the literature could be related to the DBP composition. As mentioned previously, DBP is a mixture of waste products, and the relative amount of different recycled products may vary depending on the origin. Waldroup et al. (1982) indicated that DBP samples should be constantly monitored

Table 3. Effect of level of fat added in the mixer and inclusion of dried bakery product on performance[1]

Treatment[2]	DBP (%)	Fat in mixer (%)	BW (g)		ADFI (g/d)	FCR (g/g)
			21 d	42 d	21-42 d	21-42
0H	0	4.80	804	2,913	169	1.67
0M	0	3.80	807	2,877	168	1.69
0L	0	2.80	803	2,870	174	1.77
7H	7	4.80	806	2,934	176	1.73
7M	7	3.80	801	2,855	168	1.71
7L	7	2.80	801	2,905	175	1.75
SEM[3]			4	18	3	0.02
Effects[4]						
Fat addition (A)			NS	NS	NS	NS
DBP addition (B)			NS	NS	NS	NS
A×B			NS	NS	NS	NS

[1] ADFI = Average daily feed intake; FCR = Feed conversion ratio; DBP = Dry bakery product.

[2] Means represent 3 cages. [3] SEM = Standard error of the mean. [4] NS = Non significant (p>0.05).

Table 4. Effect of level of fat added in the mixer and inclusion of dried bakery product on ileal and faecal digestibility (%)[1]

Treatment[2]	DBP (%)	Fat in mixer (%)	Ileal digestibility (42 d)		Faecal digestibility (mean of 27 and 34 d)	
			DM	CP	DM	CP
0H	0	4.80	62.4	64.5	73.1	59.7
0M	0	3.80	70.1	70.0	72.9	59.5
0L	0	2.80	71.0	71.9	72.1	58.9
7H	7	4.80	69.2	71.9	70.7	58.4
7M	7	3.80	63.9	65.2	71.0	57.4
7L	7	2.80	65.2	70.2	72.1	57.8
SEM[3]			3.1	3.5	0.6	1.0
Effects[4]						
Fat addition (A)			NS	NS	NS	NS
DBP addition (B)			NS	NS	***	NS
A×B			NS	NS	NS	NS

[1] DBP = Dried bakery product. [2] Means represent 3 cages. [3] SEM = Standard error of the mean. [4] NS = Non significant (p>0.05); *** p<0.001.

by the feed industry to determine the correct nutrient value to be used in feed formulation. In addition, bakery waste from USA or Europe may include sugars and fats, while those produced in other countries have probably less energetic materials. A different composition could explain the large variation in the published data (Haddad and Ereifej, 2004). In Spain, food industry by-product recycling is relatively new and still in its phase of development, but two standard products are available in the market according to their ash content (< or >3%).

Digestibility

Data recorded for nutrient digestibility are shown in Table 4. At 42 d, no significant differences were found between diets for either ileal digestibility of DM or CP. However, measurements varied by about 10% between some diets (0H vs. 0L).

Faecal digestibility of DM in diets with DBP was lower than in those diets without DBP (p<0.001). The DBP manufacturing process involves heat treatment, which could reduce the digestibility of nutrients, such as lysine, through Maillard linkages (Dale, 1992). The compounds concerned in this reaction are carbonyl and amino compounds, including reducing-carbohydrates and free amino groups of amino acids, peptides or proteins, which are responsible for the brown color. In addition, DBP is usually rich in fat, while hot and moist conditions during pelleting could lead to changes in the chemical structure of fat and modify its nutritive value. These changes could range from simple oxidation products to the dimerization and polymerization of both fatty acids and triacylglycerides (Wiseman, 2002).

Carcass and organ weights

The effect of the moment at which fat is added or DBP included on carcass yield, cuts, abdominal fat and organ weights is shown in Table 5. The different treatments had a significant but variable response on CY and, showed comparable values to those reported by Al-Tulaihan et al. (2004). The highest percentage was achieved when the diet included DBP and 3.8% of fat was added in the mixer

Table 5. Effect of level of fat added in the mixer and inclusion of dried bakery product on carcass yield (CY) and on breast, leg, abdominal fat, liver and pancreas weights relative to BWDT (%)[1]

Treatment[2]	DBP (%)	Fat in mixer (%)	CY	Right leg	Right breast	Abdominal fat	Liver	Pancreas
0H	0	4.80	86.41[b]	10.07	10.09	2.23	2.47	0.143
0M	0	3.80	86.38[b]	10.15	9.73	2.23	2.61	0.156
0L	0	2.80	85.28[c]	10.26	9.76	2.53	2.88	0.157
7H	7	4.80	86.10[b]	10.25	10.16	2.30	2.64	0.159
7M	7	3.80	87.46[a]	10.14	10.53	2.06	2.64	0.161
7L	7	2.80	86.55[b]	10.46	10.25	2.37	2.69	0.149
SEM[3]			0.12	0.13	0.16	0.09	0.07	0.006
Effects[4]								
Fat addition (A)			**	NS	NS	NS	NS	NS
DBP addition (B)			**	NS	NS	NS	NS	NS
A×B			**	NS	NS	NS	NS	NS

[a-c] Mean values within a column having different superscripts are significantly different by least significant difference test (p<0.05).

[1] CY = Carcass yield (carcass weight as a proportion of live body weight; carcass weight measurements were done after removing the digestive tract but including head, skin, feet and feathers). BWDT = Body weight without digestive tract; DBP = Dried bakery product.

[2] Means represent 3 cages. [3] SEM = Standard error of the mean. [4] NS = Non significant (p>0.05); ** p<0.01.

(Treatment 7M: 87.46%). Broilers fed diets including DBP showed a higher CY than those fed diets without DBP (p<0.01). As regards organ weights, no diet effect was observed. It was thought that the differences found in the CY of broilers fed DBP diets could be related to amino acid concentrations, but when the amino acid profile from the feed was analyzed, no differences in concentration were found. However, the supply of synthetic lysine and methionine was slightly higher in diets including DBP (Table 1).

In conclusion, the post-pelleting liquid application of fat to wheat-soybean based diets allowed high fat levels to be used without negatively affecting pellet quality, particularly as far as pellet hardness and durability were concerned. Moreover, pellet hardness and durability were especially improved when fat was sprayed on the pellet rather than added in the mixer. These results suggest that the point in the process that the fat is added has a strong influence on durability. However, including the fat at different points in the manufacturing process did not influence performance, nutrient digestibility or organ weights in 3 to 6 wk-old male broilers. Furthermore, dried bakery product (DBP) could be used up to 7% in the broiler diet without impairing these parameters. With the constant increase in the price of cereals, the use of recycled human food or local products to supply the energy of the diet, such as DBP, will inevitably increase. This study demonstrates that DBP can be regarded as a suitable ingredient for broiler diets.

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