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BRIEF COMMUNICATION: Influence of conditioning temperature on pellet quality and the performance and nutrient utilisation of broilers fed maize- and sorghum-based diets

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INTRODUCTION

Improved performance of broilers offered pelleted diets is thought to be due to improved nutritional value, decreased feed wastage, lowered energy expenditure during ingestion and decreased ingredient segregation (Behnke, 1994). The influence of pelleting, however, depends on the conditioning temperature used. While moderate thermal treatment of broiler diets improve the nutritional value, high conditioning temperatures can destroy vitamins and heat-labile amino acids, reduce the availability of starch by the formation of resistant starch and lower the availability of lysine through the Maillard reaction (Silversides & Bedford, 1999). Published data on the influence of conditioning temperature on the performance and nutrient utilisation of broilers are limited. The objectives of the present experiment were to compare the interaction between two grain-based diets and conditioning temperature on the performance and nutrient utilisation of broiler starters and on the quality of pellets.

MATERIALS AND METHODS

The experimental design was a 2 x 3 factorial arrangement of treatments, involving maize and sorghum based diets and three conditioning temperatures (60, 75 and 90ºC). The two diets were formulated to meet the Ross 308 strain recommendations for major nutrients for broiler starters (Table 1). The diets were formulated to be isocaloric and isonitrogenous. Each formulated diet was divided into three equal batches and conditioned at either 60ºC, 75ºC or 90ºC. Conditioning time of the mash was 30 seconds. The conditioning temperature was measured at the outlet of the conditioner. The diets were pelleted using a pellet mill (Richard Size Limited Engineers, Orbit 15, Kingston-upon-Hull, UK) equipped with a die ring (3 mm holes and 35 mm thickness). Each of the six dietary treatments was offered *ad libitum* to six replicate cages with eight one day-old male broilers per cage. The body weight and feed intake were recorded at weekly intervals throughout the 21-day trial. From Day 17 to 20, feed intake and excreta output were measured quantitatively per cage for the determination of apparent metabolisable energy (AME). On Day 21 the ileal digesta were collected for determination of apparent ileal digestibility of nitrogen and starch. Pellet hardness was tested using a Stable Micro Systems Texture Analyser (TA-XT Plus, Godalming, Surrey, UK). Pellet durability index (PDI) was determined in a Holmen Pellet Tester (New Holmen Pellet Tester, TekPro Ltd., Norfolk, UK). The data were analysed as a two-way factorial arrangement of treatments using the general linear models procedure of SAS (2004). Differences were considered to be significant at $P < 0.05$. Significant differences between means were separated by the least significant difference test.

TABLE 1: Composition and calculated analysis of the basal diets

Description	Maize-based diet	Sorghum-based diet
Feed component		
Maize (g/kg)	618	-
Sorghum (g/kg)	-	613
Soybean meal-48% (g/kg)	279	262
Meat and bone meal (g/kg)	80	80
Soybean oil (g/kg)	8.7	27.8
Limestone (g/kg)	2.3	2.6
Salt (g/kg)	1.6	1.5
Sodium bicarbonate (g/kg)	0.9	0.3
Lysine HCl (g/kg)	2.3	3.3
DL-methionine (g/kg)	2.0	2.5
L-threonine (g/kg)	0.1	0.3
Trace mineral- vitamin premix[1](g/kg)	3.0	3.0
Titanium oxide (g/kg)	3.0	3.0
Analysis		
Metabolisable energy (MJ/kg)	12.6	12.6
Crude protein (g/kg)	230	230
Lysine (g/kg)	13.8	13.8
Methionine (g/kg)	5.5	5.6
Methionine + cystine (g/kg)	9.2	9.2
Threonine (g/kg)	8.5	8.5
Calcium (g/kg)	10.0	10.0
Available phosphorus (g/kg)	5.2	5.3

[1]Supplied per kg of diet: Antioxidant, 100 mg; Biotin, 0.2 mg; Calcium pantothenate, 12.8 mg; Cholecalciferol, 60 µg; Cyanocobalamin, 0.017 mg; Folic acid, 5.2 mg; Menadione, 4 mg; Niacin, 35 mg; Pyridoxine, 10 mg; Trans-retinol, 3.33 mg; Riboflavin, 12 mg; Thiamine, 3.0 mg; dl-α-tocopheryl acetate, 60 mg; Choline chloride, 638 mg; Co, 0.3 mg; Cu, 3.0 mg; Fe, 25 mg; I, 1 mg; Mn, 125 mg; Mo, 0.5 mg; Se, 200 µg; Zn, 60 mg.

TABLE 2: Influence of diet type and conditioning temperature on performance and nutrient utilisation of broiler starters. Pellet hardness values are mean of 15 replicates; Other parameters values are the mean of six replicates; N = Nitrogen; SEM = Standard error of mean.

Treatment	Conditioning temperature (°C)	Total liveweight gain (g/bird)	Total feed intake (g/bird)	Feed per unit gain (g/g)	Pellet hardness (N)	Pellet durability index (%)	Ileal N digestibility (%)	Ileal starch digestibility (%)	Apparent metabolisable energy (MJ/kg DM)
Maize diet	60	1,074	1,294	1.21	17.3	46.3^{c}	81.1^{a}	97.4^{a}	14.80^{bc}
	75	1,026	1,269	1.24	20.1	68.7^{b}	78.5^{b}	97.6^{a}	14.98^{a}
	90	1,046	1,275	1.23	30.4	85.5^{a}	80.9^{a}	98.1^{a}	14.86^{ab}
Sorghum diet	60	962	1,231	1.29	7.9	31.4^{e}	77.6^{b}	93.7^{b}	14.78^{bc}
	75	930	1,199	1.29	12.5	36.0^{d}	77.0^{bc}	92.7^{b}	14.71^{cd}
	90	961	1,255	1.31	23.0	83.2^{e}	75.3^{c}	91.4^{c}	14.59^{d}
Pooled SEM		12	14	0.01	1.0	0.8	0.7	0.4	0.05
Main effect									
Diet type									
Maize		$1,049^{a}$	$1,279^{a}$	1.23^{b}	22.5^{a}	66.8	80.2	97.7	14.88
Sorghum		951^{b}	$1,228^{b}$	1.30^{a}	14.6^{b}	49.3	76.6	92.6	14.69
Conditioning temperature									
60		$1,018^{a}$	1,263	1.25	12.6^{c}	39.5	79.4	95.5	14.79
75		978^{b}	1,234	1.26	16.3^{b}	52.3	77.7	95.1	14.85
90		$1,003^{a}$	1,265	1.27	26.5^{a}	84.5	78.1	94.7	14.73
P value									
Diet type		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Conditioning temperature		0.008	0.070	0.326	<0.001	<0.001	0.082	0.200	0.057
Interaction		0.536	0.172	0.314	0.550	<0.001	0.032	0.007	0.022

^{a,b,c,d,e} Means in a column not sharing a common superscript are significantly different (P <0.05).

RESULTS

The birds offered the maize-based diets had higher (P <0.001) weight gain than those offered sorghum-based diets (Table 2). There was a significant effect of conditioning temperature on weight gain, with birds offered diets conditioned at 60ºC having a higher (P <0.01) gain than those offered diets conditioned at 75ºC. There was no significant difference in live weight gain between birds offered diets conditioned at 60 ºC and 90ºC.

Birds offered maize-based diets consumed significantly more (P <0.001) feed than those offered sorghum-based diets. Birds offered diets conditioned at 60ºC and 90ºC tended (P = 0.07) to have a higher feed intake than those offered diets conditioned at 75ºC.

Birds offered maize-based diets had a lower (P <0.001) feed intake per kg of weight gain compared to those offered sorghum-based diets. No significant effect of conditioning temperature or interaction was observed for feed intake per kg of weight gain.

Maize-based diets produced harder (P <0.001) pellets than sorghum-based diets. Pellet hardness increased (P <0.001) with increasing conditioning temperatures. In particular, marked increases were observed when the conditioning temperature was increased from 75ºC to 90ºC.

A significant (P <0.001) diet type by conditioning temperature interaction was observed for PDI. Increasing conditioning temperatures caused gradual improvements in PDI in maize-based diets, while the improvement was marked in sorghum-based diet conditioned at 90ºC.

Increasing the conditioning temperature to 90ºC decreased ileal nitrogen digestibility in sorghum-based diets, but the digestibility of the maize-based diets conditioned at 60ºC and 90ºC was similar and higher than the diet conditioned at 75ºC, resulting in a significant (P <0.05) diet type by conditioning temperature interaction.

Starch digestibility was unaffected by conditioning temperature in maize-based diets, but reduced with increasing conditioning temperatures in sorghum-based diets, resulting in a diet type by conditioning temperature interaction (P <0.01).

A significant interaction between diet type and conditioning temperature was observed for the AME. Increasing conditioning temperatures decreased AME values in sorghum-based diets, but the AME value of maize-based diet conditioned at 75ºC was higher than of conditioned at 60ºC and similar to the diet conditioned at 90ºC.

DISCUSSION

Increasing conditioning temperatures from 60ºC to 75ºC in both basal diets reduced weight gain, but conditioning at 90ºC restored weight gain. A tendency was observed for birds offered diets conditioned at 60ºC and 90ºC to have higher feed intake than those offered diets conditioned at 75ºC. These results are difficult to explain, but it appeared that weight gain and feed intake of broilers offered diets conditioned at different temperatures may be a balance between nutrient availability and pellet quality. Whilst conditioning at 75ºC improved the hardness by 29% and the durability by 32 % of the pellets compared to conditioning at 60ºC, this improvement did not appear to be sufficient to overcome the potential negative effects of higher conditioning temperature on nutrient availability. However, improvements in pellet hardness of 110 % and durability of 114 % due to conditioning at 90ºC compared to 60ºC seemed to overcome the negative effects of higher conditioning temperature on nutrient availability and restored the weight gain and feed intake. It has been reported in many studies (Jensen, 2000; Cutlip *et al.*, 2008) that high pellet quality along with low levels of fines enhanced the growth rate of birds.

Poorer ileal nitrogen digestibility of the sorghum-based diet conditioned at 90ºC may be explained by the formation of enzyme-resistant disulphide-bonded oligomeric proteins that occurs to a greater extent in sorghum than in maize (Duodu *et al.*, 2002). The observed reduction in AME content of sorghum-based diets with increasing conditioning temperature may be due to probable formation of enzyme-resistant starch. In maize-based diets, the apparent ileal starch digestibility was unaffected by higher conditioning temperatures. However, ileal nitrogen digestibility of the diets conditioned at 60ºC and 90ºC was higher than those conditioned at 75ºC. These results may indicate that the performance of broilers offered maize-based diets was influenced more by the nitrogen digestibility than the starch digestibility.

Overall, the present data suggest that the early growth rate of broilers between one and 21 days of age offered diets conditioned at different temperatures may be the effect of a combination of nutrient availability and pellet quality. While nutrient availability is adversely affected at higher conditioning temperatures, pellet quality improves. If the improvements in pellet quality gained by applying higher conditioning temperatures are sufficient to overcome the negative effects of high conditioning temperatures on nutrient availability, the bird performance will be mostly restored; otherwise, bird performance will be negatively affected.

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