Animal Feed Science and Technology 168 (2011) 88–99

Contents lists available at ScienceDirect

Animal Feed Science and Technology

journal homepage: www.elsevier.com/locate/anifeedsci

Influence of feed form and conditioning temperature on performance, apparent metabolisable energy and ileal digestibility of starch and nitrogen in broiler starters fed wheat-based diet

M.R. Abdollahi, V. Ravindran*, T.J. Wester, G. Ravindran, D.V. Thomas

Institute of Food, Nutrition and Human Health, Massey University, Private Bag 11 222, Palmerston North 4442, New Zealand

ARTICLE INFO

Article history:
Received 9 October 2010
Received in revised form 11 March 2011
Accepted 18 March 2011

Keywords:
Feed form
Conditioning temperature
Broilers
Nutrient utilisation
Pellet quality

ABSTRACT

The influence of feed form and conditioning temperature on performance, apparent metabolisable energy (AME) and ileal digestibility of starch and nitrogen in broilers fed wheat-based starter diet were examined in this study. Two feed forms (mash and pellet) and four conditioning temperatures: 20 °C (dry-conditioning), 60, 75 and 90 °C (steam-conditioning) were evaluated in a 2 × 4 factorial arrangement of treatments. In mash diets, weight gain of birds fed the diet conditioned at 60 °C was higher (P<0.05) than those fed diets conditioned at 75 and 90 °C and similar (P>0.05) to those fed diet conditioned at 20 °C. In pelleted diets, while steam-conditioning increased (P<0.05) the weight gain compared to dry-conditioning, birds fed diets conditioned at 60, 75 and 90 °C had similar (P>0.05) weight gains. Pelleting increased (P<0.001) the feed intake. Birds fed diets conditioned at 20 °C had lower (P<0.01) feed intake than those fed diets conditioned at 60 and 90 °C and similar (P>0.05) to those fed diets conditioned at 75 °C. In mash diets, birds fed the diet conditioned at 90 °C had higher (P<0.05) feed per unit gain than those fed diets conditioned at 20 and 60 °C, but similar (P>0.05) to those fed the diet conditioned at 75 °C. In pelleted diets, while steam-conditioning decreased (P<0.05) the feed per unit gain, birds fed steam-conditioned diets (at 60, 75 and 90 °C) had similar (P>0.05) feed per unit gain. Pellet durability and hardness increased (P<0.001) with increasing conditioning temperatures. Pelleting reduced (P<0.001) the coefficient of ileal apparent digestibility (CIAD) of nitrogen of the diets. Coefficient of ileal apparent nitrogen digestibility of the diets conditioned at 60 and 75 °C was similar and higher (P<0.01) than those conditioned at 20 and 90 °C. In mash diets, the CIAD of starch in the diet conditioned at 60 °C was higher (P<0.05) than diet conditioned at 90 °C, but similar to those conditioned at 20 and 75 °C. In pelleted diets, those conditioned at 60 and 90 °C had higher (P<0.05) CIAD of starch than the diet conditioned at 20 °C, but similar to the diet conditioned at 75 °C. Higher (P<0.001) apparent metabolisable energy values were determined for mash diets. The AME content of diets conditioned at 60 °C was similar to those conditioned at 75 °C and higher (P<0.05) than diets conditioned at 20 and 90 °C. In both feed forms, the diet conditioned at 90 °C had the highest (P<0.05) gelatinised starch content. In mash diets, while the diets conditioned at 20, 60 and 75 °C had similar resistant starch content, the diet conditioned at 90 °C had the highest (P<0.05) resistant starch content. In pelleted diets, the diets conditioned at 20 and

Abbreviations: PDI, pellet durability index; AME, apparent metabolisable energy; CIAD, coefficient of ileal apparent digestibility; N, nitrogen; DM, dry matter; GE, gross energy; GS, gelatinised starch; RS, resistant starch; Ti, titanium.

* Corresponding author. Tel.: +64 6 350 5528; fax: +64 6 350 5684.
E-mail address: V.Ravindran@massey.ac.nz (V. Ravindran).

doi:10.1016/j.anifeedsci.2011.03.014

90 °C had higher (P<0.05) resistant starch content than the diet conditioned at 60 °C, but similar to the diet conditioned at 75 °C. Overall, the current results suggest that while in mash diets steam-conditioning at 60 °C improved weight gain and feed intake, increasing conditioning temperatures *per se* had negative effects on nutrient utilisation and, weight gain and feed per unit gain of broiler starters. But the deterioration in performance parameters caused by conditioning at higher temperatures was restored when steam-conditioned mash diets were pelleted.

1. Introduction

It is generally accepted that pelleting of feeds enhances the economics of production by improving the growth and feed efficiency responses in broilers (Behnke and Beyer, 2002). Because the cost of feed is a substantial portion of producing meat, even small improvements in feed efficiency can increase economic returns (Behnke and Beyer, 2002). There is no consensus, however, regarding the factors contributing to the observed improvements, though chemical and physical changes occurring during pelleting appear to be largely responsible (Saunders, 1975). While the improved performance is due in part to increased nutrient digestibility, it has been shown that when the pelleted diet is re-ground to the consistency of mash and re-fed the growth response due to pelleting is eliminated (Hussar and Robblee, 1962). Bolton (1960) reported that pelleting improved the weight gain and feed efficiency, but the digestibility of nutrients was not affected. Hussar and Robblee (1962) reported that re-ground pellets did not affect early bird (7–14 days) performance. However, as the birds matured (28–49 days), those fed whole pellets had better weight gain and feed efficiency compared with those fed re-ground pellets. Generally, weight gain and feed efficiency of birds fed re-ground pellets were superior to those fed mash. Jones et al. (1995) demonstrated that physical form is responsible for the enhanced performance of pellet feeds. These studies have shown that, even though small significant responses were obtained by feeding re-ground pellets, a much greater response was obtained by feeding whole pellets. Therefore, a large portion of the growth response obtained by pelleted feeds is apparently accounted for by increased density (Jensen et al., 1962).

Some studies (Hull et al., 1968; Hussar and Robblee, 1962) have investigated the importance of intact pellets *per se* and chemical changes during pelleting by comparing intact pellets with re-ground pellets. To our knowledge, no studies have simultaneously examined the effects of feed form and conditioning temperature on the performance and nutrient utilisation of broilers. Considering the fact that probable chemical changes in pellets caused by pellet die can be carried over even after grinding the pellets, one of the objectives of this study was to differentiate the effects of conditioning from pelleting.

The performance of broiler starters fed pellet diets conditioned at different temperatures may reflect a balance between nutrient availability and pellet quality (Abdollahi et al., 2010). 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 enough to overcome the negative effects of high conditioning temperatures on nutrient availability, then the bird performance will be largely restored due to the fact that the improvement in productive energy achieved from feeding high quality pellets can offset the lowered nutrient availability (Moritz et al., 2001, 2003); otherwise, bird performance will deteriorate. The fact that these factors can overcome the effect of each other is relevant in determining the broiler performance. It can therefore be hypothesised that birds fed diets steam-conditioned at similar temperatures but differing in feed form (mash *vs*. pellet) may show different patterns of growth response. To test this hypothesis, the present experiment was designed to compare the interaction between feed form (mash or pellet) and conditioning temperature on the performance, apparent metabolisable energy (AME) and, coefficient of ileal apparent digestibility (CIAD) of starch and nitrogen (N) in broiler starters.

2. Materials and methods

2.1. Diets

The experimental design was a 2 × 4 factorial arrangement of treatments, which included two feed forms and four conditioning temperatures. Whole wheat was ground in a hammer mill (Bisley's Farm Machinery, Auckland, New Zealand) to pass through a screen size of 7.0 mm for coarse grade. A wheat-based diet was formulated to meet the Ross 308 strain recommendations for major nutrients for broiler starters (Ross, 2007) (Table 1). The formulated diet was divided into eight equal batches. The first four batches were conditioned at four different temperatures: 20 °C (dry-conditioning), 60, 75 and 90 °C (steam-conditioning) by adjusting the steam flow rate. All diets were collected at the outlet of the conditioner (before entering the pellet press). Representative mash samples were collected for the determination of particle size distribution and feed hardness. The second four batches were similarly conditioned at the four temperatures and pelleted using a pellet mill (Richard Size Limited Engineers, Orbit 15, Kingston-upon-Hull, UK) capable of manufacturing 180 kg of feed/h and equipped with a die ring (3-mm holes and 35-mm thickness). Representative pellet samples were collected and particle size distribution, feed hardness, pellet durability and pellet hardness were determined. Another set of mash and pellet samples was collected for the determination of gelatinised starch (GS) and resistant starch (RS). Conditioning time of the mash was