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Review article

Feed intake response of broilers: Impact of feed processing

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ABSTRACT

Feed intake (FI) is the primary factor driving the growth rate of broilers. Amongst a broad spectrum of the factors affecting the FI, less attention has been paid to the impact of feed processing variables, such as particle size, feed form and whole grain feeding on the FI of the bird. Current poultry feed production involves various processing practices (or at least particle size reduction in the case of mash feed). To achieve the genetic potential of modern broilers that are more than ever susceptible to FI stressors, it is vital to recognise, minimise or even eliminate feed processing-related factors inducing FI suppression. Feed intake in broilers can be affected by feed particle size and, the effects vary with age of birds and the grain type being fed. Fine grinding of wheat should be avoided in broiler mash diets because of beak pasting caused by wheat gluten and possible increase in digesta viscosity with subsequent depressions in FI. The FI response of broilers fed mash diets varying in particle size cannot be extrapolated to pelleted or crumbled diets, because the differences in particle size are evened out during the pelleting process. Macrostructural characteristics of pellets such as proportion of intact pellets, durability, hardness, length and diameter have the ability to influence feed consumption and should also be considered. A wide diversity in experimental methodology used in broiler studies with whole grain feeding complicates drawing definite conclusions of the impact of this feeding strategy on FI. However, to prevent the suppression of FI and achieve the beneficial effects of whole grain feeding on feed efficiency, age of birds, proportion of whole grain in the diet and an adaptation period should be considered before any transition to this feeding strategy.

1. Introduction

The selection for rapid growth has resulted in appetite indirectly becoming an important criterion in the selection of modern broiler strains (Applegate, 2012). Besides ensuring an adequate and balanced nutrient intake, feed intake (FI) has been suggested as the single-most important factor determining the growth rate of broilers (Ferket and Gernat, 2006). Higher FI increases weight gain and consequently reduces the proportion of energy used for bird's maintenance in relation to gain (Svihus et al., 2004a). Therefore, to maximise the genetic potential and take advantage of the appetite of modern broilers, it is essential to minimise the factors that induce FI suppression. Numerous factors affect FI, and hence nutrient intake, of the chickens including dietary (feed form, nutrient density and anti-nutritional factors), management (stocking density, temperature, lighting, stress and water supply) and bird (genotype, sex, age and capacity of digestive tract) factors (Sklan, 2001; Brickett et al., 2007; Latshaw and Moritz, 2009; Applegate, 2012; Abdollahi et al., 2013c).

Abbreviations: BW, body weight; ESBM, expeller-extracted soybean meal; FI, feed intake; GG, ground grain; GMD, geometric mean diameter; GSD, geometric standard deviation; NSP, non-starch polysaccharides; SBM, soybean meal; SSBM, solvent-extracted soybean meal; WW, whole wheat

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Feed processing is a common practice in poultry feed production worldwide with the recent focus being on increasing the value of feeds prior to ingestion. However, less attention has been paid to the impact of feed processing on FI of the bird. Rather than focusing on the broad spectrum of the factors affecting FI, the current review examines the evolving understanding of the impact of select aspects of feed processing such as particle size, feed form and whole grain feeding on FI.

2. Effect of feed particle size on feed intake

During the manufacturing process, the majority of feed ingredients, particularly cereal grains, are ground prior to mixing into a diet. Grinding reduces particle size and modifies the physical characteristics of ingredients to increase the surface area, improve blending ability and homogeneity of the mixed feed, decrease segregation and mixing problems, and facilitate pelleting (Behnke, 1996; Koch, 1996). In the last two decades, the importance of particle size in poultry nutrition is being increasingly recognised because of the benefits associated with a better developed and more functional gizzard. Most studies examining the effect of feed particle size focus their discussion on growth performance and feed conversion, and only peripherally on FI. In fact, FI data have not been reported in many studies (Reece et al., 1985, 1986a; Douglas et al., 1990; Hamilton and Proudfoot, 1995; Kasim and Edwards, 2000; Kilburn and Edwards, 2001, 2004; Charbeneau and Roberson, 2004; Jacobs et al., 2010). Moreover, published data on the effects of particle size on the FI of broilers have been somewhat inconsistent. This discrepancy is due mainly to feed physical form (mash vs. pellets) as the major confounding factor. The pelleting process, widely used in the manufacture of broiler feeds, has been shown to considerably reduce the feed particle size and equalise differences in particle size distribution (Engberg et al., 2002; Svihus et al., 2004a; Péron et al., 2005; Amerah et al., 2007b; Abdollahi et al., 2011; Hafeez et al., 2015). This has resulted in the impact of particle size being more pronounced in mash feeds than in pelleted or crumbled feeds (Reece et al., 1985, 1986a; Svihus et al., 2004a; Péron et al., 2005; Amerah et al., 2007b; Zang et al., 2009). Another possible explanation for this inconsistency might be the difficulty in accurately differentiating the actual FI by bird from feed disappearance that also includes feed wastage. Whilst authors are not aware of any research studying the effect of particle size on feed wastage in broilers, Serrano et al. (2013) reported that, compared to crumble and mash diets, feeding pelleted diets might have different impact on feed spillage depending on age of bird and, size and hardness of pellets.

2.1. Effect of feed particle size on feed intake of broilers in mash diets

Birds are able to distinguish the differences in feed particle size by mechanoreceptors located in the beak (Gentle, 1979). The ability of young broiler chickens to distinguish even minor differences in the particle size of feed has been observed at as early as 4 d of age (Nir et al., 1990). Birds select the feed particles in accordance with the size of their beak and oral cavity; both increasing with advancing age (Moran, 1982). Moreover, birds show a pecking preference for larger feed particles (Schiffman, 1968) and the preferred particle size increases with age (Portella et al., 1988; Nir et al., 1990, 1994a,b). According to Savory (1980), particle size and nutrient concentration of the feed are the two main factors determining FI of birds. Portella et al. (1987) reported that altering feed particle size without changing diet composition affected FI in layers. Portella et al. (1988) demonstrated that feed consumption of broilers was related directly to particle size, with only a weak correlation with nutrient composition. In a feed selection study in birds, Allen and Perry (1977) reported a steady reduction over time in the proportion of large particles (> 2.0 mm) and increased proportion of fine particles (< 1.0 mm) in the remaining feed. Nir et al. (1990) reported that, regardless of the method of grinding (hammer or roller mill) of sorghum, broilers consumed feed in accordance with its coarseness and FI was inversely related to the surface area of the ground grain.

However, it should be noted that the mean size is not the only particle characteristic influencing the FI; shape, uniformity and size range of particles in the diet may also have an impact on feed consumption by the bird (Reece et al., 1986b; Douglas et al., 1990; Axe, 1995). Amerah et al. (2007a) suggested that feeding a diet with more uniform particles may have beneficial effects on growth performance through reducing the time, and possibly energy, spent for searching and choosing the desired particles. Geometric mean diameter (GMD) and geometric standard deviation (GSD) are generally used to describe the particle size and the variation in particle size, with a lower GSD representing higher uniformity. Nir et al. (1994a) reported that feeding a more uniform maize-based diet (GSD, 1.6 vs. ≥ 2.0) had no effect on FI, but improved weight gain and feed efficiency. It is noteworthy that, although the particle size of the major grain(s) in feed substantially affects the particle size distribution of feed, the uniformity of the particle size (expressed as GSD) of the complete feed is also influenced by the particle size of other feed ingredients. The more similar GMD of the cereal and other components, the more uniform (smaller GSD) the complete diet would be. It should also be noted, however, that bird's preference for coarse particles may be detrimental to growth performance, when the feed particles are less uniform. Portella et al. (1988), in a maize-wheat-soybean meal broiler diet, analysed six different particle size spectra, ranging from < 600 μm to > 2360 μm, for protein, calcium and phosphorus, and reported much higher protein, and lower calcium and phosphorus in larger particles than in fine particles. Therefore, a pecking preference for larger particles may prevent birds from receiving a balanced intake of nutrients and result in a failure to meet their nutritional requirements.

Results of studies examining the effects of particle size on the FI of broilers in mash diets have produced equivocal results (Table 1). This discrepancy is likely to be related to a complex array of confounding factors such as type and cultivar of grain, endosperm hardness, particle characteristics (size, uniformity and distribution) of feed components, type of grinding and age of the birds. Svihus et al. (2004a) ground wheat to different particle sizes by the use of either hammer mill (GMD, 600 and 930 μm) or roller mill (GMD, 670, 920 and 1700 μm) and reported no differences in FI of broilers from 11 to 30 d of age. Amerah et al. (2007b) reported that broilers fed coarse particle (7-mm screen) wheat mash diets consumed almost 13% more feed than those fed medium