Soluble non–starch polysaccharides affect net utilisation of energy by chickens

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Summary

Feed constituents such as the non–starch polysaccharides (NSPs) not only affect nutrient digestion in general, but also influence gut dynamics through changing the types and numbers of the microflora and the secretory response of the gut. The use of nutrients such as starch through microbial fermentation is not energy efficient; increased endogenous secretion of water, protein, lipids and minerals can affect post–digestive and, perhaps, post–absorptive processes because the gut secretes some 20 hormones or regulatory peptides. This paper discusses the importance of evaluating feed constituents from the standpoint of ‘efficiency’ and presents some experimental data on the effect of soluble NSPs on the net energy value and losses of energy as heat and as volatile fatty acids in the excreta of broiler chickens.

Effect of NSPs on post–digestive processes

The effect of soluble NSPs on the apparent digestibility of nutrients in poultry has been studied extensively during the past ten years (Bedford et al. 1991; Choct and Annison 1992a). The negative correlation between NSPs in the diet and its nutritive value has been demonstrated in poultry (Choct and Annison 1990; Annison 1991), in pigs (King and Taverner 1975) and in dogs and cats (Earle et al. 1998). A general inhibition of the digestibility of nutrients occurs when diets with high levels of soluble NSPs are fed to chickens. Thus, Choct and Annison (1992a) demonstrated that addition of a soluble NSP isolate from wheat to a broiler diet depressed the ileal digestibilities of starch, protein and lipid by 14.6, 18.7 and 25.8%, respectively.

One constituent that has negative effect on the nutritive value of grains in poultry is the content of soluble non–starch polysaccharides (NSPs) (Burnett 1966; Antoniu et al. 1981; Annison 1991). This paper discusses how soluble NSPs affect energy utilisation beyond digestive processes in poultry.

Introduction

The measures used to assess the nutritive value of poultry diets to date are metabolisable energy and amino acid contents, which also are the bases for practical diet formulations. The use of a net energy system for energy and digestible amino acid values for diet formulations has been strongly advocated in recent years (Farrell 1996; Ravindran et al. 1998; Ravindran and Bryden 1999). The rationale is that the efficiency of energy utilisation and the digestibility of amino acids are affected by diet constituents and that it is logical to consider the amounts of nutrients ‘available’ to the animal when evaluating feed. However, gut dynamics in relation to absorption of nutrients and their regulation and energetic costs have been given little attention in nutritional research. Considering the fact that 20% of whole animal energy expenditures can be accounted for by the gut (McBride and Kelly 1990; Cant et al. 1996), it is essential to investigate the way feed constituents behave in the gut and their effect on energetic efficiency of feed utilisation.
NSPs on energy losses via heat increment and as volatile substances in excreta

The energy derived from microbial fermentation in the chicken is small in quantity and inefficient as a metabolic fuel (Bolton and Dewar 1965). NSPs can bring about significant changes to the ecology of the gut, e.g. proliferation of fermentative microbes in the small intestine which ferment digestible nutrients such as starch to VFA (Choc, unpublished data) examined the effect of NSPs on energy utilisation in broiler chickens. In the first experiment, the loss of energy as VFA in the excreta of birds fed maize and barley was compared because these ingredients represent the two extremes amongst cereals in terms of their soluble NSP levels. As shown in Table 1, there was a large difference between birds fed maize and barley in the energy loss as VFA in the excreta, apparently indicating that elevated levels of soluble NSPs affected the way nutrients were digested. To test this finding further, we determined the net energy (NE) value of an NSP–enriched diet with or without enzyme supplementation in a second experiment. As the level of NSPs increased in the diet, the energy losses as heat increased and a considerable amount of energy was lost as VFA in the excreta. Thus when the anti–nutritive properties of the NSPs were removed by use of an exogenous enzyme, the AME and NE were increased by 29.1% and 37.3%, and heat production and energy loss as VFA were decreased by 11% and 61%, respectively. The data are shown in Table 2.

The increases in AME and NE were not proportional, indicating that NSPs not only interfere with digestive processes, but also have strong negative effects on net utilisation of energy. Part of this discrepancy may be explained by the loss of energy as VFA in the excreta. The use of nutrients through microbial conversion of digestible carbohydrates, such as starch, to VFA is not efficient compared to a direct uptake of carbohydrates. The use of an exogenous enzyme, the AME and NE were increased by 29.1% and 37.3%, and heat production and energy loss as VFA were decreased by 11% and 61%, respectively. The data are shown in Table 2.

It is apparent that nutritionists should start to pay more attention to post–digestive and post–absorptive processes when evaluating nutritive quality. These include gut microbial balance, changes in gut dynamics such as secretory regulations and re–partitioning of nutrients. Muramatsu and colleagues (Muramatsu et al. 1983; 1987; 1993) clearly demonstrated that gut microflora increase energy costs by modifying the rate of energy–consuming reactions such as protein turnover within the chicken body. One such example is the gut cell turnover. According to LeBond and Walker (1956), a 100 g rat gaining 5 g/d synthesises 1 g mucosal cells daily, which represents a 20% additional tissue synthesis not manifest as weight gain. Extrapolating this to a 2 kg bird gaining 60 g daily, the bird would synthesise 12 g of mucosal tissue to maintain the integrity of its small intestine. Increased microbial load can exacerbate this loss (Abrams et al. 1963; Lesher et al. 1964) since some of its fermentation products, e.g. putrescine, have been shown to significantly enhance small intestinal and colonic mucosal growth rates (Osborne and Seidel 1989; Seidel et al. 1985). The indirect evidence of such costs is the often significant improvement in bird performance resulting from the inclusion of antibiotics in high–NSP diets (MacAuliffe
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Supplementation with 150 mg procaine penicillin per kg of a diet consisting of 82% rye and 13.4% casein, resulted in increases of 75% in weight gain, 37% in feed intake and 37% in feed efficiency. However, there were no significant improvements in the AME (11.43 vs. 11.06 MJ/kg DM) and the digestibilities of starch (95% vs. 96%) and protein (40% vs. 40%) (Choct 1991). A better bird health and a more efficient nutrient utilisation are the likely reasons for this improvement.

Manipulation of efficiency of nutrient utilisation for poultry

In the light of a situation where fewer, if any, antibiotics may be allowed in feeds during the next decade, the use of antibiotic growth promotants is not a long term option for improving the efficiency of nutrient utilisation in the livestock industry. As shown in Table 2, the inclusion of appropriate glycanases in diets containing high levels of soluble NSPs can reduce energy losses as heat and as VFAs in the excreta, thus leading to improved net energy value. The reason for this action is speculative. Perhaps reducing the viscosity of the digesta in the small intestine hastens digesta passage and nutrient digestion rate (through removal of the diffusional constraint of viscous gums), thereby providing less substrate for the fermentative organisms and less time for them to proliferate. This may in turn promote the normal and efficient digestion (enzymatically) of starch and protein in the small intestine. Use of other exogenous agents to manipulate gut dynamics and post–digestive and post–absorptive processes should be examined in a systematic manner for future feed and livestock production.

References


