SEX AND THE SINGLE CHICKEN

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Summary

This paper discusses results from some recent studies that point to the existence of fundamental differences between males and females in metabolism of energy. It is apparent that gender can influence the digestive capacity of chickens through endogenous energy losses, gut structure and function, and metabolic activity of gut microflora. This raises the question "Is there sexual dimorphism in other physiological and biochemical systems also?" There are important scientific and commercial implications should such differences exist. Firstly, future research should include an examination of any gender-related influences. Secondly, the commercial implications are that males and females may have different nutrient requirements, and may respond differently to feed additives such as prebiotics, probiotics and feed enzymes. Hence, single-sex feeding and management programs may be desirable for optimisation of growth, carcass yield and carcass composition within each sex.

I. INTRODUCTION

The effect of the gender of the individual chicken on its functional capacity to digest and absorb nutrients has received little attention by researchers until recently. Hughes (2001) noted that much of our current knowledge of nutrient utilisation and nutrient requirements of broiler chickens was gained by study of males only. Experiments designed around chickens of the same sex may have some advantages, however, it is possible that only half of the true story will be revealed, or less, if underlying interactions involving sex go undetected.

This paper examines some recently published results which indicate that gender can influence the digestive capacity of chickens in several different ways involving endogenous energy losses, gut structure and function, and metabolic activity of gut microflora.

II. SEX INFLUENCES ENERGY METABOLISM

Hughes *et al*. (2000) observed that apparent metabolisable energy (AME) of a wheat-based diet was significantly affected (P<0.05) by an interaction between cleanliness of the rearing environment and sex of chickens. Males had lower AME than females (15.15 vs 15.32 MJ/kg DM) when reared in a dirty environment but there was no difference between males and females (mean value 15.29 MJ/kg DM) reared in a clean environment.

Hughes *et al*. (2001) reported that chickens of two different breeds showed variable responses in energy metabolism when given a diet containing a high concentration of soluble non-starch polysaccharide (NSP), with males more affected than females. The breed effect (14.4 vs 14.2 MJ/kg dry matter) was not significant, whereas females were superior to males (14.6 vs 14.0 MJ/kg dry matter). The plot of individual data points shown in Figure 1 points to a higher degree of variability in males than in females, irrespective of breed, with a relatively large proportion of males showing a poor capacity for uptake of energy.

Wu *et al*. (2002) noted that AME values in males tended to decrease when dietary P was increased, whereas no effect was observed in females. They also reported that apparent ileal

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nitrogen digestibility increased in males given a P deficient diet but decreased in females.

III. SEX AND ENDOGENOUS ENERGY LOSSES

Johnson (1987) and King (1998) pointed out that endogenous energy loss (EEL) could be a large source of error in measurements of AME and TME in assays involving the allocation of fixed amounts of test diet. The size of the EEL error relative to AME becomes minor in fully-fed birds.

An estimate of EEL can be obtained from the value α in the linear relationship:-
$$EE = \alpha + \beta \times GEI$$
where α = energy voided at fasting, and β = rate of increase in energy excreted as gross energy intake increases (King, 1998). The data of Hughes *et al.* (2001) shown in (Figure 1) were plotted in this manner (Figure 2).
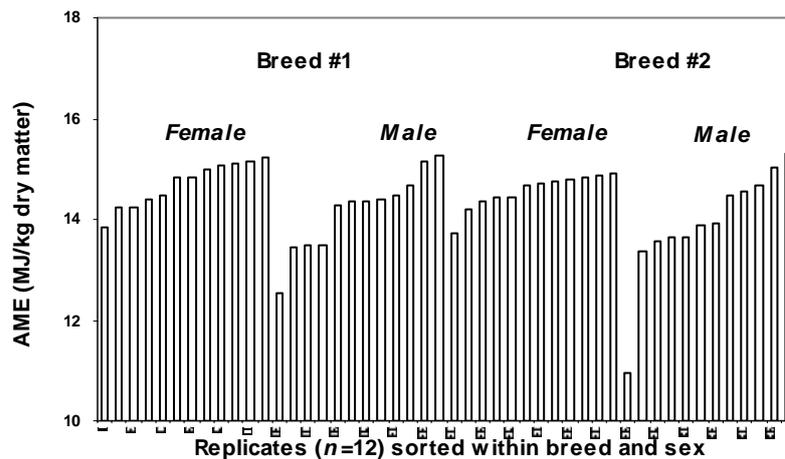

Figure 1. Variability in apparent metabolisable energy (AME) of a wheat diet given to male and female chickens of two commercial breeds. Each bar in the figure represents the result for a single chicken.
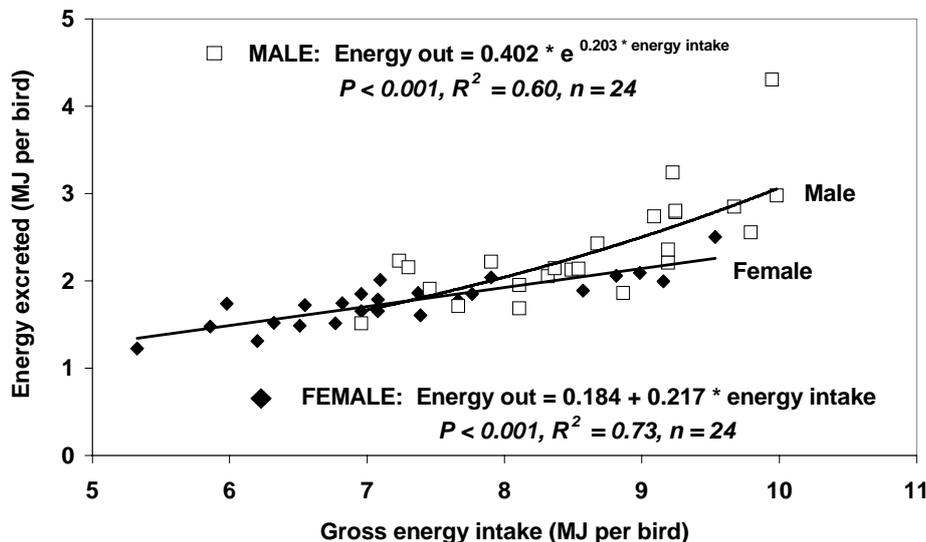

Figure 2. Relationship between energy excreted and gross energy intake for male and female

Analysis of covariance was used to determine whether the linear coefficients of regression for EE on GEI differed between the two breeds and between males and females. Breed was unimportant (P>0.05) but there was a significant difference (P<0.05) due to sex. It was also evident from observation of the plot of data points for males (Figure 2) that the

relationship was not linear. Various curvilinear functions were fitted to the data from male chickens. The best fit (as determined by R^2 value) indicated an exponential increase in excreted energy with increase in gross energy intake. Put simply, this points to fundamental differences between males and females in their digestive physiology. This conclusion is supported by recent data published by Yaghobfar (2001) who demonstrated differences in EEL according to sex and type of chicken. The estimates for energy voided at fasting were 46 KJ/bird/day for females, and 101 KJ/bird/day for males (Figure 1). These estimates should be verified by further testing at lower levels of energy intake to reduce errors associated with extrapolation.

IV. SEX INFLUENCES GUT STRUCTURE AND FUNCTION

Hughes (2001) estimated that up to one third (33%) of the variation in AME shown in Figure 1 was associated with physical features of the small intestinal mucosa. Ileal crypt depth was the single most important feature of the small intestinal mucosa associated with variation in AME. The breed and sex of chicken significantly affected villus heights of the mucosa in the jejunum and ileum, respectively. Re-modelling of the villus/crypt axis, presumably in response to dietary NSP in the wheat, differed in male chickens depending on breed, but there were no differences observed in female chickens.

Iji *et al*. (2001) observed a greater *in situ* expression of α-glucosidase in jejunal mucosa in female chickens compared with males, irrespective of whether the diet contained a commercial enzyme product with xylanase, glucanase and pectinase activities.

V. SEX AND METABOLIC ACTIVITY OF GUT MICROFLORA

AME and ileal digestible energy (DE) values for a selection of samples of barley, oats, sorghum, triticale and wheat were reported by Hughes *et al*. (2001). AME values for barley and oats exceeded ileal DE by about 0.4 MJ/kg, whereas for sorghum samples, ileal DE was approximately 0.3 MJ/kg higher than AME. Furthermore, the responses differed between males and females. They concluded that microbial fermentation of undigested carbohydrate influenced these results. Hughes *et al*. (2001) reasoned that if microbial overgrowth of viscous digesta in the small intestine can be avoided by use of feed enzymes, then therapeutic use of antibiotics in the feed should have a similar effect by eliminating gut bacteria.
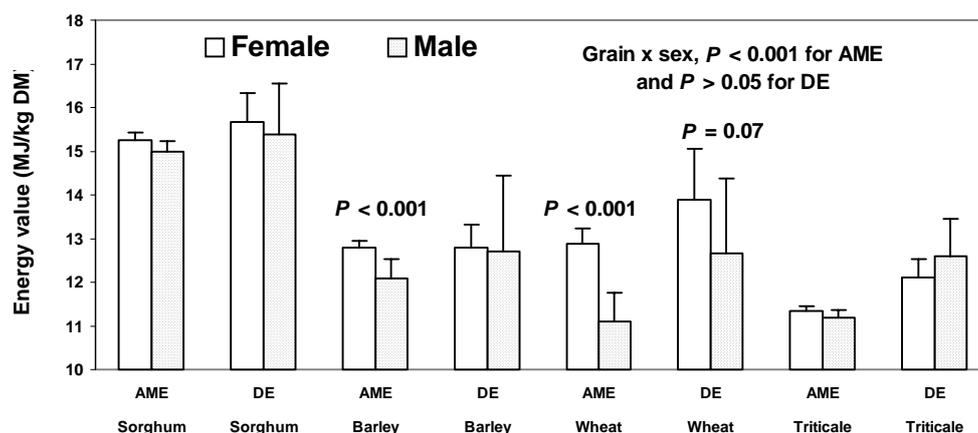

Figure 3. Effects of grain and sex of chicken on AME and ileal DE (means±SD).

Inclusion of antibiotics in the feed had no effect on AME or ileal DE values. The lack of a difference in the DE:GE ratio between males and females on sorghum, barley, wheat and triticale diets (Figure 3) implies that digestive and absorptive processes in the small intestine

were unaffected by the sex of the chicken. On the other hand, male chickens had significantly lower AME values than females when given barley and wheat diets. The differing effects of sex on DE and AME values shown in Figure 3 strongly imply that post-intestinal events associated with gut microflora were affected by the sex of the chicken. Likewise, variation in breath hydrogen concentrations (Figure 4) indicate that gender-of the host animal has a bearing on the metabolic activity of gut microflora, contrary to the expectation that antibiotics would significantly reduce the bacterial population, if not eliminate it.
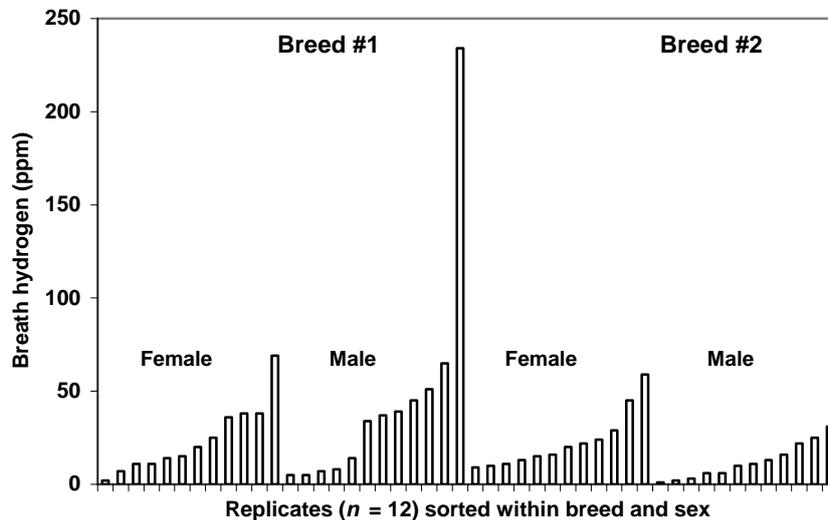

Figure 4. Hydrogen concentration in breath samples taken from chickens given a low AME wheat diet. Each bar in the figure is the result for one chicken.

VI. DISCUSSION

These observations lead to questions about processes at an organ or cellular level that result in marked changes in the numbers, species or activities of the gut microflora according to the nature of the feed consumed and the sex of the host animal. Kelly and King (2001) remarked that the molecular basis for how the gut distinguished between commensal and pathogenic bacteria was poorly understood but that there was "bi-directional communication" between epithelial cells, cells in the mucosal immune system, and gut bacteria. Similarly, Bedford and Apajalahti (2001) referred to a "two-way negotiated process" between host tissue and intestinal microflora.

VII. CONCLUSIONS

Alteration of the balance between the host and its resident microflora (by feeding different grains, enzymes, prebiotics, probiotics and other feed additives) is likely to result in outcomes that are difficult to predict, particularly when antibiotics are no longer added to feed to enhance growth. A fuller understanding of the role of the gut microflora is required.

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