FEED PARTICLE SIZE, WHOLE WHEAT INCLUSION AND XYLANASE SUPPLEMENTATION IN BROILER DIETS: INFLUENCE ON THE PERFORMANCE, DIGESTA CHARACTERISTICS AND DIGESTIVE TRACT DEVELOPMENT

A thesis presented in partial fulfillment of the requirements for the degree of

Doctor of Philosophy in

Poultry Nutrition

at Massey University, Palmerston North,
New Zealand

Ahmed M. Amerah

2008

ABSTRACT

The first three experiments of this thesis examined the effects of particle size reduction of grains in relation to feed form (mash vs. pellet), grain type (wheat vs. maize) and xylanase supplementation on broiler performance, energy utilisation, digestive tract development and digesta parameters. The fourth experiment examined the interaction between wheat hardness and xylanase supplementation. The effects of insoluble fibre source and whole wheat inclusion were studied in the fifth experiment.

In the first experiment (Chapter 4), pelleting reduced nitrogen-corrected apparent metabolisable energy (AMEn), but broiler performance was superior in birds fed pelleted wheat-based diets compared to those fed mash diets. Feed form had a greater effect on various measured parameters than did particle size. Pelleting evened out differences in particle size distribution between treatments and, as a result, wheat particle size had no effect on the performance of broilers fed pelleted diets. In contrast, the second experiment (Chapter 5) showed that differences in particle size distribution persisted between diets after pelleting and, as a result, coarse grinding of wheat or maize improved broiler performance compared to those fed diets based on fine particles. These results may be related, in part, to changes in size distribution following pelleting.

In mash diets, inconsistency in performance reponses were found. In the first experiment (Chapter 4), coarse grinding of wheat improved weight gain and feed per gain compared to medium grinding. In the third experiment (Chapter 6), however, grinding particle size had no influence on broiler performance. The observed discrepancy suggests involvement of other factors such as wheat cultivar and grain hardness.

Data reported in Chapter 6 showed that xylanase supplementation improved feed per gain of birds fed the coarse particle size diet, but had no effect on those fed the medium particle size diet. In Chapter 7, there was a significant interaction between wheat hardness and xylanase supplementation due to the improved feed per gain and AMEn of birds maintained on hard wheat-based diet, while there was no effect of xylanase on soft wheat-based diet. These findings suggest that the efficiency of exogenous enzymes is influenced by both particle size and wheat hardness.

Data reported in Chapter 7 showed that inclusion of soft or hard whole wheat pre-pelleting produced different particle size distributions in the pelleted diets. This

suggested that hardness of the grain must be considered when choosing whole wheat for inclusion in broiler diets.

Data on the effect of feed particle size on its subsequent distribution in poultry digesta are scanty. Results reported in Chapters 4 and 5 showed that there was no effect of feed particle size within feed form on duodenal digesta particle size. On the other hand, particle size of duodenal digesta was influenced by feed form (mash vs. pellet). Wheat hardness was also found to influence the particle size of proximal (duodenum and jejunum) intestinal digesta (Chapter 7). These results indicated that the gizzard does not uniformly reduce the size of all particles. However, the gizzard appears highly efficient in grinding large particles, although some large particles escape the grinding.

The final experiment demonstrated that the effects of insoluble fibre on digestive tract development and broiler performance differed depending on the fibre source. Wood shavings, a source of coarse insoluble fibre, increased relative gizzard size and improved corrected feed per gain and ileal starch digestibility. In contrast, cellulose, a source of fine insoluble fibre, had no influence on these parameters.

In conclusion, dietary manipulations, which stimulated gizzard development, positively influenced broiler performance and starch digestibility. The findings of this thesis suggest that energy savings during feed processing could be achieved by coarse grinding of grains with no adverse effect on broiler performance and that cereals used in broiler diets can be ground more coarsely than the current practice. Wheat hardness appears to be an important criterion to consider when choosing a cultivar for whole wheat inclusion in broiler diets. Another major finding was that the effectiveness of exogenous xylanase in wheat-based diets could be improved by considering factors such as particle size and wheat hardness.

Didicated to Nrmeen (my wife)

Acknowledgments

First of all, I would like to express my profound gratitude and sincerest thanks to my chief supervisor, Professor Ravi Ravindran, for his guidance, encouragement, advices and providing expert knowledge in poultry nutrition. Without his guidance, patience, understanding and encouragement, I would not have had this achievement. Warmest thanks and appreciation is also extended to my co-supervisor Associate Professor Roger Lentle, for his valuable comments, encouragement and advice. I would like also to thank my co-supervisor, Dr. David Thomas, for his support, guidance and advice with histological measurements. Very special appreciation to Mr Donald Thomas for his technical support, assistance, suggestions and advice; Dr Patrick Morel for his advice on statistical matters.

I would also like to thank Colin Naftel and the entire staff of the Massey University Poultry Research Unit. I am thankful for the friendships we have made and that we worked together during my research.

Last and most of all, my deepest gratitude is expressed to my family, for all the support, patience, understanding and encouragement, to my wife Nrmeen Alkhiry and my children Heyam and Omar for their never-ending encouragement and love.

And to those I forgot to mention.

Publications

Studies completed during candidature, some of which are reported in this thesis have been presented in the following communications:

Refereed scientific papers

Amerah, A, M.., Lentle, R.G. and Ravindran, V. (2007) Influence of feed form on gizzard morphology and particle size spectra of duodenal digesta in broiler chickens. Journal of Poultry Science 44: 175-181.

Amerah, A, M. Ravindran, V., Lentle, R.G. and Thomas, D.G. (2007) Feed particle size: Implications on the digestion and performance of poultry. World's Poultry Science Journal 63: 439-456.

Amerah, A, M. Ravindran, V., Lentle, R.G. and Thomas, D.G. (2007) Influence of feed particle size and feed form on the performance, energy utilization, digestive tract development and digesta parameters of broiler starters. Poultry Science 86: 2615-2623.

Conference presentations

Amerah, A, M. Ravindran, V., Lentle, R.G. and Thomas, D.G. (2005) Influence of whole wheat feeding on the performance, gizzard size and carcass characteristics of broiler chickens. Proceedings of the Massey Technical Update Conference, Vol. 7. Massey University, Palmerston North. pp. 63-68.

Amerah, A, M. Ravindran, V., Lentle, R.G. and Thomas, D.G. (2005) Feeding of whole wheat for broilers: Influence on performance, gizzard size and carcass characteristics. Proceedings Nutrition Society of New Zealand. 30:164-170, Massey University, Palmerston North.

Amerah, A, M. Ravindran, V., Lentle, R.G. and Thomas, D.G. (2006) Influence of particle size and feed form on the performance and energy utilisation of broilers. Proceedings of the Massey Technical Update Conference, 8: 58-65 Massey University, Palmerston North.

Amerah, A, M. Ravindran, V., Lentle, R.G. and Thomas, D.G. (2006) Particle size and broiler performance. New Zealand Poultry Industry Conference 8:58-66, Massey University, Palmerston North.

Amerah A, M. Ravindran, V., Lentle R. G. and Thomas D. G. (2006). Effects of method of whole wheat feeding on the performance and gizzard development of broiler chickens. Poultry Science, 85 (Suppl. 1): 65. Auburn, Alabama, USA.

Amerah, A, M. Ravindran, V., Lentle, R.G. and Thomas, D.G.(2007) Performance and digestive tract characteristics of broilers as influenced by particle size and feed form. Proceedings of the Australian Poultry Science Symposium 19: 85-88.

Amerah, A, M. Ravindran, V., Lentle, R.G. and Thomas, D.G. (2007) Influence of particle size on the performance, digesta characteristics and energy utilisation of broilers fed maize and wheat based diets. Proceedings of the Australian Poultry Science Symposium 19: 89-92.

Amerah, A, M. Ravindran, V., Lentle, R.G. and Thomas, D.G. (2007) Influence of particle size and xylanase supplementation on the performance, energy utilisation digesta viscosity of broilers. Proceedings of the Massey Technical Update Conference, 9: 54-60 Massey University, Palmerston North.

Amerah, A, M. Ravindran, V., Lentle, R.G. and Thomas, D.G. (2007) Effects of fibre source and whole wheat inclusion on the performance, starch digestibility and gut parameters of broiler chickens. Asia Pacific Journal of Clinical Nutrition 16 (Suppl.): 59 (Abstract).

Table of contents

List of Tables

Chapter 2

Chapter 4

Chapter 5

Chapter 6

Chapter 7

Chapter 8

List of Figures

List of abbreviations

AME	Apparent metabolisable energy
AMEn	Nitrogen-corrected apparent metabolisable energy
ANOVA	Analysis of variance
DGGE	Denaturing gradient gel electrophoresis
DM	Dry matter
DNA	Deoxyribonucleic acid
GE	Gross energy
GLM	General linear model
GMD	Geometric mean diameter
GSD	Geometric standard deviation
h	Hours
HI	Hardness index
MJ	Mega joule
mm	millimetre
µm	Microns
N	Nitrogen
NIR	Near-infrared reflectance
NSP	Non-starch polysaccharide
PCR	Polymerase chain reaction
PDI	Pellet durability index
PSI	Particle size index
SEM	Standard error of mean
SKCS	Single-kernel characterisation system
Ti	Titanium
UV	Ultra violet
XU	Xylanase unit