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**INVESTIGATION OF ENERGY PARTITIONING IN
MODERN BROILER CHICKENS**

A thesis presented in partial fulfilment of the requirements for the

Degree of

Doctor of Philosophy in

Poultry Nutrition

at Massey University, Palmerston North,

New Zealand

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2014

ABSTRACT

Studies were conducted to estimate the energetic efficiencies for fat deposition from different energy sources (carbohydrate, protein, soybean oil and tallow) and to determine the maximum protein deposition (P_{dmax}) and minimum body lipid to protein ratio ($minL/P$) of the modern broiler chickens. Energetic efficiencies for fat deposition were assessed by feeding birds extra energy from different energy sources when protein was limiting in the diet. Comparison of birds slaughtered before and after the dietary treatments were applied allowed the determination of the energy retained as fat or protein. In the first experiment (Chapter 3), the energetic efficiencies of fat deposition from vegetable oil and starch were estimated to be 0.82 and 0.69, respectively. In the second experiment (Chapter 4), the energetic efficiencies of fat deposition were estimated to be 0.93 from soybean oil and 0.90 from tallow, but there was no significant difference between soybean oil and tallow. In the third experiment (Chapter 5), the efficiency of energy deposition as fat from non-essential amino acid intake was calculated to be 0.63.

In the fourth experiment (Chapter 6), the P_{dmax} and $minL/P$ were determined by feeding diets not limited for protein with varying energy levels. The maximum daily protein deposition was predicted at 22 g/day. According to broken-line model, the rate of protein deposition increased when the apparent metabolisable energy intake above maintenance requirement ($AMEI_p$) increased up to the break point of 1.2 MJ/day. Further increases of $AMEI_p$ did not lead to an increase in protein deposition rate whereas the fat deposition rate sharply increased. The body weight and energy intake affect the L/P ratio. Across all treatment groups, the minimum value of L/P ratio was observed at 0.31 for birds fed 1 MJ/day of $AMEI_p$ at 4 kg live body weight.

From the knowledge of net energy requirements and considering the efficiency of metabolisable energy for fat and protein deposition from all experiments, a simple mechanistic growth model was developed for modern broilers (Chapter 7). The model simulates the daily growth of broilers and it was able to predicting the broiler performance and carcass composition under a variety of nutritional conditions. Moreover, the model was evaluated with a range of experimental data (Chapter 8) and prediction values were in close agreement with observed values. The relative prediction errors were 3.8% and 7.3%, for prediction of slaughter live body weight for dependent and independent dataset, respectively.

In conclusion, the efficiencies of energy utilisation for fat deposition varied depending on energy sources with the highest values for soybean oil and tallow followed by starch and the lowest for protein. Modern broilers have an upper limit for protein deposition (22 g/day). The body weight and energy intake affect the L/P ratio and the minimal L/P ratio was observed at 0.31. The mechanistic growth model based on energy partitioning concepts can be a tool to predict the carcass composition and broiler performance and can deal adequately with the complexity of nutritional factors.

The finding of this thesis is that the broiler performance can be improved by formulating the diet to maximise the protein deposition with minimum fat deposition. The maximum protein deposition can be achieved when the birds consumed 1.2 MJ/day of AME_{ip} or 2.5 MJ/day of AME intake, further energy intake will be deposited as lipid.

Acknowledgements

Foremost, I would like to express my sincere gratitude to my Chief Supervisor Professor Patrick Morel for all I have learned from him and for his continuous help and support in all stages of this thesis. I thank him for his patience, knowledge and mentoring me through my experiments and writing of this thesis.

Besides my Chief supervisor, I am heartily thankful to my co-supervisor Dr Nicola Schreurs for her supervision insightful comments as well as her painstaking effort in proof reading the drafts. Indeed, without her guidance, I would not be able to write this thesis.

I would like to express my deepest gratitude to my co-supervisor Professor Ravi Ravindran, for his support, understanding and assistance to carry out the research work, and for providing expert knowledge in poultry nutrition.

I would like to thank my co-supervisor, Dr Rana Ravindran, for her support, encouragement and advice enabled me to reach the final goal.

This thesis would not have been possible without the support and encouragement of many people. I am deeply grateful to Donald Thomas for his generous support, suggestions and for helping me through the writing of this thesis. I would also like to thank the Massey University Poultry Research technical staff, particularly Colin Naftel and Edward James, for their assistance through my research work. I also appreciate the staff of the Nutrition Lab, and Food Chemistry Lab for their assistance. My thanks go to my office mates, Ruvini Mutucumarana and Naveed Anwar for helping me through my study.

I am especially grateful to Drs. Mohammad Reza and Faegheh Zaefarian for their supporting and assisting me in many different ways. My thanks also go to my Indian friend Yashpal Singh for all the emotional support, camaraderie, entertainment and happiness he provided.

I would like to acknowledge Animal Nutrition Division, Institute of Veterinary, Animal and Biomedical Sciences, Massey University for the financial, academic and technical support.

My heartfelt thanks and love to my wife, Ethar, my parents, sisters and brothers. They were always supporting me and encouraging me with their best wishes.

Finally, the one above of us, the omnipresent God.

Publications

Shatnawi, K., Morel, P.C.H., Schreurs, N., Ravindran, V. and Ravindran, G. (2011) Effect of energy sources on energy partitioning in broiler chickens. Proceedings of the Massey Technical Update Conference, Vol. 13 pages 43-52. Monogastric Research Centre, Massey University, Palmerston North, New Zealand.

Shatnawi, K., Morel, P.C.H., Schreurs, N., Ravindran, V. and Ravindran, G. (2012) Effect of extra energy intake from soybean oil or tallow on broiler performance and carcass composition. Proceedings of the Massey Technical Update Conference, Vol. 14 pages 39-46. Monogastric Research Centre, Massey University, Palmerston North, New Zealand.

Shatnawi, K., Morel, P.C.H., Schreurs, N., Ravindran, V. and Ravindran, G. (2013) Effect of increased intake of non-essential amino acids on broiler performance and carcass composition. Proceedings of the Massey Technical Update Conference, Vol. 15 pages 66-74. Monogastric Research Centre, Massey University, Palmerston North, New Zealand.

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List of Abbreviations

AA	Amino acid
ADE	Apparent digestible energy
ADG	Average daily gain
AHP	Activity heat production
AME	Apparent metabolisable energy
AMEg	Apparent metabolisable energy for gain
AMEi	Apparent metabolisable energy intake
AMEIfpd	Apparent metabolisable energy intake free of energy for protein deposition
AMEIp	Apparent metabolisable energy intake for production
AMEn	Nitrogen corrected apparent metabolisable energy
ANOVA	Analysis of variance
CP	Dietary crude protein
CPi	Dietary crude protein intake
DCP	Digestible crude protein
DCPi	Digestible crude protein intake
DFCP	De-feathered carcass protein
DFCPf	De-feathered carcass protein final
DFCPi	De-feathered carcass protein initial
DFCW	De-feathered carcass weight
DFCWf	De-feathered carcass weight final
DFCWi	De-feathered carcass weight initial
DM	Dry matter
EAA	Essential amino acids
EE	Ether extract
EEP	Energy from excess protein intake
ER	Energy retention
ERF	Energy retention fat
ERP	Energy retention protein
EUBP	Energy from unbalanced protein
FA	Feed allowance
FI	Feed intake
FE	Feather energy retention
FHP	Fasting heat production
Fd pot	Potential body fat
Ff	Fat deposition from fat intake
FI	Feed intake
Fp	Fat deposition of unbalance/excess protein intake
Fs	Fat deposition from starch intake
g	Gram
GE	Gross energy
HI	Heat increment
HP	Heat production
IDBP	Ideal digestible balance protein
IDBP(AA)	Ideal digestible balance protein for each amino acid
IDBPI	Ideal digestible balance protein intake
<i>k</i>	Efficiency of metabolisable energy utilisation

k_f	Efficiency of metabolisable energy utilisation for fat deposition
k_{f_f}	Efficiency of metabolisable energy utilisation for fat deposition from digestible fat
k_{f_N}	Efficiency of metabolisable energy utilisation for fat deposition from protein
k_{f_s}	Efficiency of metabolisable energy utilisation for fat deposition from digestible starch
$k_{f_{so}}$	Efficiency of metabolisable energy utilisation for fat deposition from soybean oil
K_{f_t}	Efficiency of metabolisable energy utilisation for fat deposition from tallow fat
k_g	Efficiency of metabolisable energy utilisation for weight gain
km	Efficiency of metabolisable energy utilisation for maintenance
kp	Efficiency of metabolisable energy utilisation for protein deposition
kJ	Kilo Joule
LBW	Live body weight
LBWf	Final live body weight
LBWi	Initial live body weight
L/P ratio	Lipid to protein ratio
ME	Metabolisable energy
MEM	Metabolisable energy for maintenance requirement
minL/P	Minimum lipid/protein ratio
MJ	Mega joule
N	Nitrogen
NEAA	Non-essential amino acids
NE	Net energy
NEp	Net energy for production
NRC	National research council
Pd	Protein deposition
PDI	Pellet durability index
Pdmax	Maximum protein deposition
Pg	Protein for body weight gain
Pm	Maintenance protein requirement
TME	True metabolisable energy