

# AND ENERGY LOSS THROUGH VOLATILE FATTY ACIDS IN BROILER CHICKENS

Ву

Ann Magambo Tukei

A thesis submitted in partial fulfilment of the requirements for the degree of Master in Science in Agriculture

March, 1998

Division of Animal Science University of New England Armidale, New South Wales, 2351 Australia

### **DECLARATION**

I certify that this thesis hasn't already been submitted in substance for any degree and is not being currently submitted for any other degree.

I certify that to the best of my knowledge, any help received in preparing this thesis and all sources used have been duly acknowledged.

-----

Ann Magambo Tukei

### **ACKNOWLEDGMENTS**

I am greatly indebted to my supervisors, Dr. Mingan Choct and Associate professor C. J. Thwaites, for their interest, understanding, guidance, encouragement and discussion throughout my candidature at the University of New England.

I am thankful to Mr. F. Ball, E. Thompson, K. Day, M. Hyland, Andi and Alex for the expert technical assistance provided.

Special gratitude is due to Dr. M. Choct and E. Thompson for their great assistance with the statistical analysis of the data presented in this study.

Thanks are also due to the Australian Agency for International Development (AusAID) and the Ministry of Education and Sports that gave me the fellowship award and opportunity to study in Australia. The Division of Animal Science, Faculty of the Sciences, the University of New England is also acknowledged for providing the facilities and a pleasant working atmosphere.

Special appreciation is also extended to colleagues and friends in Australia and Uganda for moral support, love and encouragement especially during the difficult moments after losing my dear husband.

Lastly, I wish to dedicate this thesis to my late husband, George Tukei, my children: Ivan Ocan, Kennie Alamai, Yvonne Alupc and Kevin Obonyo.

### ABBREVIATIONS

AME apparent metabolisable energy

AME<sub>n</sub> nitrogen corrected metabolisable energy

AIA acid insoluble ash

CC degrees celcius

CP crude protein

d day (s)

DE digestible energy
DM dry matter
EE effective energy

EEL endogenous energy loss
ER energy retention (energy gain)

et al. and others

FCR feed conversion ratio

FH fasting heat

F<sub>m</sub>E metabolic faecal energy

g gram(s)

g relative centrifugal force

GE gross energy

g/bird/d grams per bird per day

g/g gram per gram g/kg gram per kilogram

h hour (s)
h/d hours per day
HP heat production
HI heat increment

ie that is kg kilograms

kg b wt/d kilogram body weight per day

kJ kilojoules

kJ/d kilojoules per day kJ/g kilojoules per gram kJ/L kilojoules per litre

L litre (s) M molar

ME metabolisable energy

min minute(s)
MJ megajoules

MJ/kg/d megajoules per kilogram per day
MJ/kg DM megajoules per kilogram dry matter
MJ/kg feed megajoules per kilogram feed

mM/L millimoles per litre

mL millilitre (s)

mPa.s millipascale per second M.Wt molecular weight

NE<sub>m</sub> net energy for maintenance NE<sub>p</sub> net energy for production NR nitrogen retention

NRC national research council NSP(s) non-starch polysaccharide(s)

P<0.05 statistically significant at 5 per cent P<0.01 statistically significant at 1 per cent statistically significant at 0.1 per cent

PE productive energy

pers. comm. Personal communication RQ respiratory quotient

s seconds s<sup>-1</sup> per second

SCA standing committee on agriculture

SE standard error

TME true metabolisable energy

TME<sub>n</sub> nitrogen corrected true metabolisable energy

UE urinary energy

U<sub>e</sub>E endogenous urinary energy

VFA(s) volatile fatty acid(s)

W<sup>0.75</sup> metabolic body weight (kg)

### **ABSTRACT**

The apparent metabolisable energy assay is the default system of energy estimation in the poultry industry. However, the system is not capable of accounting for the utilisation of ME within the birds. The system is limited because it does not account for losses of chemical energy in the solid, liquid and gaseous excreta or as heat. Such energy losses may become significant if the composition of the diet changes substantially. This was the basis for the current study. Two experiments were conducted to examine (1) whether the amount of energy lost via heat increment and as volatile fatty acids in the excreta is influenced by the types of cereal grain, for example, maize and barley, and (2) whether (a) consumption of diets with elevated levels of soluble NSPs would increase energy loss as heat increment and volatile fatty acids in the excreta, and (b) enzymatic supplementation would enhance depolymerisation of the NSPs in vivo, and thus alleviate these losses.

Four groups, each consisting of two birds, were randomly selected from two different batches of 21-day old mixed sex, Cobb strain, broiler birds. For each experiment two birds were placed in each of the 4 closed-circuit respiratory chambers at  $25 \pm 2^{\circ}$ C for a 4-day period during which HI and VFAs in the faeces were determined. Diets were maize and barley-based in Experiment 1 and wheat-based (including 4% of a 78.5% soluble NSP product) with or without commercial xylanase. Two replicates of two birds were used for each diet in each experiment.

In experiment 1, maize or barley-based diets did not influence (P>0.05) the amount of energy lost via heat increment, but energy lost as volatile fatty acids in the excreta was significantly (P<0.01) higher with the birds fed the barley-based diet than with those fed the maize-based diet. The net energy value of maize was markedly (P<0.01) higher than that of barley.

Experiment 2 showed that inclusion of isolated soluble NSPs in a broiler diet significantly increased energy loss via heat increment (P<0.01) and tended to increase energy loss as volatile fatty acids in the excreta (105.4kJ vs. 34.3kJ). Depolymerisation

of the NSPs *in vivo* using an exogenous enzyme (xylanase) markedly (P<0.01) decreased heat increment on the basis of MJ/kg body weight per day, but the variations in HI on the basis of MJ/kg feed were not significant (P>0.05). The xylanase markedly reduced duodenal (P<0.05) jejunal (P<0.01) and ileal (P<0.01) viscosities.

The current studies, although on a small scale, indicated that birds lost energy via heat increment and volatile fatty acids in the excreta, and this energy loss was influenced by dietary non-starch polysaccharides. The loss of volatile fatty acids in birds fed high NSP diets varied enormously and the use of appropriate enzymes appeared to alleviate the loss as well as decrease the between-bird variability.

# LIST OF TABLES

TABLE 2.1	MICROBIOLOGICAL STATUS OF GROWER FEED IN DIFFERENT
	FORMS
TABLE 2.2	APPARENT (AME) AND TRUE (TME) METABOLISABLE ENERGY
	VALUES OF FEEDSTUFFS AT LOW FEED INTAKES27
TABLE 2.3	COMPARISON OF TME $_{\rm N}$ VALUES DERIVED AFTER 48 H AND 72 H
	EXCRETA COLLECTION 30
TABLE 4.1	DIET COMPOSITION51
TABLE 4.2	THE EFFECT OF MAIZE OR BARLEY DIETS ON BIRD PERFORMANCE 52
TABLE 4.3	THE EFFECT OF MAIZE OR BARLEY DIETS ON ENERGY UTILISATION 52
TABLE 4.4	THE EFFECT OF DIETS BASED ON MAIZE OR BARLEY ON LOSS OF
	ENERGY AS VFAS IN THE EXCRETA53
TABLE 5.1	DIET COMPOSITION58
TABLE 5.2	THE EFFECT OF SOLUBLE NSPS AND XYLANASE
	SUPPLEMENTATION ON BIRD PERFORMANCE59
TABLE 5.3	THE EFFECT OF SOLUBLE NSPS AND XYLANASE
	SUPPLEMENTATION ON ENERGY UTILISATION60
TABLE 5.4	THE EFFECT OF WHEAT + NSPS (-ENZYME) OR WHEAT + NSPS
	(+ENZYME) ON GUT VISCOSITY OF THE BROILER CHICKENS61
TABLE 5.5	THE EFFECT OF WHEAT + NSPS (-ENZYME) OR WHEAT + NSPS
	(+ENZYME) ON VOLATILE FATTY ACID (VFA) ENERGY IN THE
	EXCRETA OF BROILER CHICKENS6

ŧ

## LIST OF FIGURES

FIGURE 1.1	THE PARTITION OF DIETARY ENERGY IN POULTRY.
FIGURE 2.1	THE RELATIONSHIP BETWEEN ENERGY METABOLISABILITY
	(AME/G ENERGY) OF CEREALS AND THEIR NSP COMPOSITION
	(PENTOSANS + □ - GLUCANS: % OF WEIGHT), (R=-0.97, P<0.001)1
FIGURE 2.2	RELATIONSHIP BETWEEN THE CONTENT OF NON-STARCH
	POLYSACCHARIDES AND THE AME OF WHEAT IN DIETS OF
	BROILER CHICKENS
FIGURE 3.1	THE RESPIRATION CHAMBER AND ANCILLARY EQUIPMENT4

# TABLE OF CONTENTS

DECLARATI	ON		.ii				
ACKNOWLEDGMENTSiii							
ABBREVIAT	IONS.		iv				
ABSTRACT			vi				
LIST OF TAB	BLES	v	iii				
LIST OF FIG	URES.		ix				
CHAPTER 1	GENI	ERAL INTRODUCTION	. 1				
CHAPTER 2	LITE	RATURE REVIEW	. 7				
	2.1	Introduction	.7				
	2.2	ME values of feedstuffs	. 8				
	2.3	In vivo techniques for the assessment of the me values of feedstuffs	19				
		2.3.1 Conventional methods.	20				
		2.3.2 Rapid methods.	23				
		2.3.3 A critique of ME	31				
	2.4	Determination of productive energy (PE)	32				
	2.5	Determination of effective energy (EE)	33				
	2.6	Determination of net energy (NE)	33				
	2.7	Conclusion	34				
CHAPTER 3	MAT	ERIALS AND METHODS.	37				
	3.1	Ethical considerations	37				
	3.2	Experimental birds	37				
	3.3	Feed formulation and mixing	38				
	3.4	Respiration chambers	38				
	3.5	Principle of operation	39				
	3.6	Analytical methods and related procedures	41				
		3.6.1 GE determination	41				
		3.6.2 AME determination	41				
		3.6.3 DM content of feeds (%)	42				
		3.6.4 DM content of excreta (%)	42				
		3.6.5 Oxygen consumption.	42				
		3.6.6 Carbon dioxide recoveries	42				
		3.6.7 Heat production (HP)	44				
		3.6.8 Net energy (NE)	45				
		3.6.9 Basal metabolism	45				

		3.6.11 Determination of VFA concentration by use of the internal	
		standard method	45
		3.6.12 Calculation of energy loss as VFAs in the excreta	47
	3.7	Statistical analysis	48
CHAPTER 4	- EXP	ERIMENT 1	
	THE	EFFECT OF FEEDING MAIZE OR BARLEY ON HEAT	
	PRO	DUCTION DURING METABOLISM AND LOSS OF ENERGY AS	
	VOL	ATILE FATTY ACIDS IN THE EXCRETA OF BROILER BIRDS	49
	4.1	Introduction	49
	4.2	Materials and methods	50
		4.2.1 Experimental length	50
		4.2.3 Experimental diets and design	50
	4.3	Results	51
	4.4	Discussion	53
CHAPTER 5	- EXP	ERIMENT 2	56
		EFFECT OF NON STARCH POLYSACCHARIDES AND	
		ANASE SUPPLEMENTATION ON THE NET ENERGY VALUE ROILER DIETS	56
	5.1	Introduction	
	5.2	Materials and methods	
		5.2.1 Experimental length	57
		5.2.2 Experimental diets and design	58
	5.3	Results	59
	5.4	Discussion	61
CHAPTER 6	GEN	ERAL DISCUSSION AND CONCLUSIONS	64
REFERENCE	S		66