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**THE NATURE AND DETERMINATION OF
METABOLIZABLE ENERGY**

A THESIS PRESENTED FOR THE PARTIAL FULFILMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF AGRICULTURAL SCIENCE IN ANIMAL SCIENCE
AT
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ABSTRACT

Part 1 of this thesis involves a review along quantitative lines of investigations concerning metabolizable energy (ME) in poultry nutrition. A model for the mechanism of nitrogen (N) excretion is presented and examined in an experimental section comprising Part 2.

In Part 1, Chapter 1 is an exposition of the distribution and utilization of feed energy and raises the subject of additivity and questions of standardization of ME assay procedure. Chapter 2 consists of 2 sections. Section 1 provides a literature review of the bioassay determination of apparent metabolizable energy (AME). It covers an analysis of the nature of AME and explains basic concepts, provides mathematical definitions and perspectives and N corrected AME values (AME_n) are discussed. Further it describes methods of determination and provides an examination of the factors involved in AME variation. Section 2 deals with the nature of true metabolizable energy (TME) in which definitions and derivations of TME are provided, the relationship between TME and AME given, deviations from linearity of the energy excreted (EO) on energy input (EI) regression investigated and N corrected TME values (TME_n) discussed. Additionally, methods and evidence bearing on the central premise to TME are presented and other areas that have gained attention reviewed.

In Part 2, the subject of Chapter 3 is a linear experimental model developed by King (1984) to explain deviations in linearity of the relationship between N excreted (NO) and N intake (NI) as it may apply to adult cockerels and the nature of the correction of TME values to zero N balance (ZNB). Chapter 4 deals with 2 experiments, LN 202 and LN 204. The primary objective of Experiment LN 202 was to examine and investigate the regression relationship, EO on EI obtained for adult cockerels, and to assess the effect on it of correcting EO to ZNB. Experiment LN 204 was set up to study the impact of diet and assay procedure on TME of meat and bone meal (M & B) and to examine the effect on these values of correcting to ZNB. The effect of assay procedure on TME and TME_n of a whole diet was also explored.

In Experiment LN 202 2 slopes were obtained for the regression relationship, EO on EI, and on correcting EO to ZNB 1 slope satisfactorily represented the relationship. This was consistent with expectations arising from the model. The model suggests that this slope contains a bias element that causes TME values to deviate from unbiased TME.

In Experiment LN 204 the TME values of M & B as determined by dietary inclusion and by direct supply were compared and assessed in terms of the model. Correction of the TMEs to ZNB resulted in a single value. TME assessment of a whole diet by 2 different assays resulted in similar values when the values, according to the model, estimated the same quantity and different values when the quantities measured were, as predicted by the model, different. Correction to ZNB caused like values to deviate and unlike values to come closer together.

Chapter 5 provides an overview of the model and the experimental findings and outlines the conclusions that have been drawn from this work.

TABLE OF CONTENTS

	<u>page</u>
ACKNOWLEDGEMENTS	i
ABSTRACT	ii
TABLE OF CONTENTS	iv
LIST OF FIGURES	viii
LIST OF TABLES	ix
LIST OF ABBREVIATIONS	xi
PART 1	
CHAPTER 1 INTRODUCTION	1
1.1 Faecal Energy	8
1.2 Digestible Energy	8
1.3 Urinary Energy	8
1.4 Metabolizable Energy	8
1.5 Heat Increment	9
1.6 Net Energy	10
1.7 Maintenance Energy	10
1.7.1 Basal Metabolism	10
1.7.2 Energy of Voluntary Activity	12
1.7.3 Heat to Keep Body Warm	12
1.7.4 Heat to Keep Body Cold	12
1.8 Production Energy	13
CHAPTER 2 METABOLIZABLE ENERGY	14
SECTION 1 APPARENT METABOLIZABLE ENERGY	15
2.1 The Nature of Apparent Metabolizable Energy	17
2.1.1 Point Perspective	17
2.1.2 Linear Perspective	20
2.1.3 Nitrogen Corrected Apparent Metabolizable Energy (AME _n) ..	25
2.2 Chemical Determination of AME	30
2.3 Methods of Determination of Apparent Metabolizable Energy	32
2.3.1 Conventional Methods	35
2.3.1 (a) The Assay of Hill <i>et al.</i> (1960) and Potter <i>et al.</i> (1960)	35
2.3.1 (b) The Assay of Sibbald and Slinger (1963a)	38
2.3.1 (c) Assay Variations	40

2.3.2	Rapid Method	41
2.3.2 (a)	The Assay of Farrell (1978b)	41
2.3.2 (b)	The Assay of Sibbald (1975)	41
2.4	Factors Affecting $AME_{(n)}$ Values	42
2.4.1	Nitrogen Retention	42
2.4.2	Quantitative Evaluation of Excreta Elimination	43
2.4.3	Level of Food Intake	43
2.4.4	Substitution Effects	46
2.4.5	Effect of Basal Diets	46
2.4.6	Effect of Nutrient Imbalances and Deficiencies	47
2.4.7	Species	47
2.4.8	Strains	48
2.4.9	Age	48
2.4.10	Environmental Temperatures	49
2.4.11	Stocking Density and Colony Size	49
2.4.12	Method of Calculation	50
2.4.13	Pelleting Effects	50
2.4.14	Laboratory Handling	50
2.4.15	Fats	51
SECTION 2	TRUE METABOLIZABLE ENERGY	52
2.5	The Nature of True Metabolizable Energy	53
2.5.1	Definitions and Derivations	53
2.5.2	The Relationship between TME and AME	59
2.5.3	Deviation from Linearity	60
2.5.4	Nitrogen Corrected True Metabolizable Energy (TME_n)	62
2.6	The True Metabolizable Energy Bioassay	66
2.6.1	The Assay of Sibbald (1976a)	66
2.6.2	Assay Variations	70
2.7	Evidence Related to the Central Premise of TME	72
2.8	Additivity and Reproducibility	74

PART 2

CHAPTER 3	A THEORETICAL STUDY OF THE RELATIONSHIP BETWEEN NITROGEN EXCRETION AND TRUE METABOLIZABLE ENERGY	75
3.1	A Model of Nitrogen Balance and Its Relationship to TME	77
3.1.1	Analysis of the Excreta Energy Slope of TME	77
3.1.2	A Model of Nitrogen Balance	80
3.1.3	Correction of TME for UmE and for UmE + UeE	86
3.1.4	Correction of TME to Zero Nitrogen Balance	89
CHAPTER 4	EXPERIMENTAL	93
4.1	Experiment 1 -- LN 202	98
4.1.1	Objectives	98
4.1.2	Materials, Methods and Treatments	98
4.1.3	Results	103
4.1.4	Discussion	118
4.2	Experiment 2 -- LN 204	121
4.2.1	Objectives	121
4.2.2	Materials, Methods and Treatments	121
4.2.3	Results	125
4.2.4	Discussion	133
CHAPTER 5	SUMMARY AND CONCLUSIONS	136
BIBLIOGRAPHY	141

APPENDIX	165
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Table

A1	Experiment LN 202: Individual bird body weights at the assay start and at 24 hour intervals	165
A2	Experiment LN 202: Individual bird food intake for days of the assay	166
A3	Experiment LN 202: Nitrogen of excreta per bird day (g) and nitrogen of excreta per kg ^{0.67} BW per bird day (mg)	167
A4	Experiment LN 202: Air dry excreta output per bird per day	168
A5	Constraints used in Experiment LN 202 diet	169
A6	Ingredient, calculated and determined nutrient composition of Experiment LN 202 diet	170
A7	Ingredient composition of Experiment LN 204 diets	171
A8	Calculated and determined nutrient composition of Experiment LN 204 diets	172
A9	Ingredient and calculated nutrient composition of the "low density" maintenance diet used before and between experiments	173
A10	Analysis of variance tables for estimating proportional contribution of components of the total variance of nitrogen excreted in mg per kg BW per day	174
A11	Sums of squares of regression determinations associated with data of Table 4.8	176

LIST OF FIGURES

<u>Figure</u>	<u>Page</u>
1.1 The partition of gross energy of food (Vohra, 1972)	2
2.1 Relationship between apparent metabolizable energy value and food intake (Guillaume and Summers, 1970)	44
2.2 Theoretical relationships among apparent (AME) and true (TME) metabolizable energy and their nitrogen-corrected equivalents (AME_n , TME_n) for various intake levels of a single feedingstuff (Wolynetz and Sibbald, 1984)	45
3.1 Slope components of energy excretion (King, 1984)	78
3.2 Relationships between nitrogen input, nitrogen excreted and zero nitrogen balance (King, 1984)	81
4.1 Components of excreta energy	94
4.2 The relationship between endogenous excreta energy and levels of energy fed on TME	95
4.3 The effect on TME of correcting to zero nitrogen balance	97
4.4 Treatment 24 hour nitrogen excreted per $kg^{0.67}$ BW associated with each day's feeding schedule	107
4.5 The relationship between nitrogen input and nitrogen excreted	109
4.6 Relationship between nitrogen input and nitrogen balance (upper line) and between TME input and energy retention (lower line)	110
4.7 Regression relationships for energy excreted on energy input, nitrogen balance x 36.51 kJ on energy input and energy excreted corrected for nitrogen balance x 36.51 kJ on energy input	114

LIST OF TABLES

<u>Table</u>	<u>Page</u>
1.1 Calculated and determined TME values of whole diets (Edmundson <u>et al.</u> , 1978; Edmundson, 1979 and Edmundson, 1981)	5
4.1 The body weight allocations to treatment for Experiment LN 202	100
4.2 Timetable of assay procedures for Experiment LN 202	101
4.3 Treatment mean body weights by days	104
4.4 Treatment mean food intakes by days	104
4.5 Treatment mean dietary nitrogen intake (g/b/d)	105
4.6 Treatment mean excreta nitrogen (g/b/d)	105
4.7 Gross energy of air dry excreta based on samples weighted for days (kJ/b/d)	106
4.8 Summary of regression determinations and TME/TME_n estimations	113
4.9 The slopes obtained by regressions of energy excreted on energy input (uncorrected), energy equivalent nitrogen balance on energy input and energy excreted corrected for energy equivalent nitrogen balance on energy input (corrected) for various combination of treatments	117
4.10 Timetable of assay procedures for Experiment LN 204	123
4.11 Analyzed nitrogen and gross energy of treatment diets of LN 202 and LN 204	126

4.12	Meat and bone meal -- by basal -- regression relationships ...	127
4.13	Meat and bone meal -- force feeding -- regression relationships	128
4.14	LN 202 diet -- force feeding -- regression relationships	129
4.15	Food intake, energy, nitrogen and nitrogen balance data means over final 3 days of Treatments F, D and E meat and bone meal.....	130
4.16	Energy, nitrogen and energy equivalent nitrogen balance data of Treatments A, B and C meat and bone meal.....	131
4.17	Energy, nitrogen and energy equivalent nitrogen balance data of Treatments A, B and C LN 202 diet	132
4.18	TME measurements of meat and bone meal and diet LN 202	134

LIST OF ABBREVIATIONS

a_N	The intercept on Y of the slope for N excretion on N input.
ADE	Apparent digestible energy.
AME	Apparent metabolizable energy.
a_{Nm}	Nitrogen excretion constant arising from day to day wasting of N from the body. It is the result of normal maintenance activity. It is body weight related and independent of the food fed.
a_{Np}	Nitrogen excreted resulting from tissue protein catabolism that takes place for the purpose of supplying energy needs and takes place during starvation.
AME_b	AME obtained by bioassay.
AME_c	The conceptual measure of AME.
AME_n	Nitrogen corrected AME (commonly to zero N balance).
$AME_{(n)}$	Refers to AME or AME_n .
b	The slope for the subscript by which it is defined.
b_{Nr}	The N excreted per unit of N input over subsequent values of N input.
b_{Nna}	The proportion of N input that is not metabolized and is eliminated directly.
BE	Bioavailable energy.
BM	Basal metabolism.
BW	Body weight.
BMR	The standard or basal metabolic rate.
C.L.	Confidence limits.
Cr_2O_3	Chromic oxide.
DE	Digestible energy.
E	Energy.
EE	Refer to text for specific meaning: (i) Excreta energy. (ii) Endogenous energy.
EE_n	Energy excreted (by control birds) corrected for energy equivalent zero N balance.
EI	Energy input.
EO	Energy excreted.
EO_n	Energy excreted (by fed birds) corrected for energy equivalent zero N balance.

E_{NB}	Energy equivalent of N balance.
EO_s	Energy excreted over subsequent values of food intake.
Ea_{Nm}	The intercept of the energy of N excreted arising from normal maintenance activity.
Ea_{Np}	The intercept of the energy of N excreted arising from tissue protein breakdown during starvation.
FE	Faecal energy.
Fi	Weight of food residues.
FeE	The energy of microflora and microbial debris voided as faeces.
FeN	The N content of microflora and microbial debris voided as faeces.
FfE	The energy of food residues passaged through the gut.
FfN	The N content of food residues passaged through the gut.
FiE	The energy of food residues.
F_{ir}	Weight of excreta of food residues remaining which are eliminated via the gut or the urine.
FmE	Energy of products of the gut specified as cells of the gut wall, bile mucous and unabsorbed digestible juices and gas.
FmN	The N content of the gut specified as cells of the gut wall, bile mucous and unabsorbed digestible juices and gas.
FMR	Fasting metabolic rate.
FuE	The energy of materials absorbed across the intestine and excreted directly in the urine without undergoing metabolic change.
FuN	The N content of materials absorbed across the intestine and excreted directly in the urine without undergoing metabolic change.
F_{ign}	Weight of N containing products of the food not absorbed and passaged via the gut.
F_{iun}	Weight of N products that are absorbed across the gut wall and excreted directly in the urine without undergoing metabolic change.
F_{ir}^E	Energy of excreta of food residues remaining which are eliminated via the gut or the urine.
F_{ign}^E	Energy of N containing products of the food not absorbed and passaged via the gut.

$F_{iun}E$	Energy of N products that are absorbed across the gut wall and excreted directly in the urine without undergoing metabolic change.
$F_{m+e}E$	$F_mE + F_eE$.
GE	Gross energy.
GE_a	The sum of energy not lost as energy of N excretion products in the urine resulting from metabolism of food absorbed, GE_r , and that eliminated by the process U_iE .
GE_r	Energy not lost as energy of N excretion products in the urine resulting from metabolism of food absorbed.
HI	Heat increment.
HP	The total heat production of an animal consuming food in a thermally neutral environment.
HBC	Heat to keep body cold.
HBW	Heat to keep body warm.
LCT	Lower critical temperature.
ME	Metabolizable energy.
M & B	Meat and bone meal.
N	Nitrogen.
NB	Nitrogen balance.
NI	Nitrogen input.
NO	Nitrogen excreted.
NE_m	Maintenance energy.
NE_p	Production energy.
NE_w	Energy of work.
NO_i	Nitrogen excreted over initial values of N fed or input.
NO_s	Nitrogen excreted over subsequent values of N fed or input.
NI_{ge}	Nitrogen input per unit of food over gross energy input per unit of food.
NE_{m+p}	Net energy for body maintenance and for production purposes.
PRC	Poultry Research Centre.
r^2	Correlation.
S	Standard deviation.
S.E.	Standard error of the mean.
TME	True metabolizable energy.
TME_b	Biassed TME values.

TME _h	TME obtained over high food intake levels (equivalent to TME _s).
TME _L	TME at level of energy intake stated, e.g. TME _{L3} = TME at level 3.
TME _l	TME obtained over low food intake levels (equivalent to TME _{in}).
TME _n	TME corrected to zero N balance.
TME _o	Biassed TME values.
TME _s	TME for subsequent values of food intake or as obtained from the subsequent slope (equivalent to TME _h).
TME _u	Unbiassed TME values.
TME _{in}	TME for initial values of food intake or as obtained from the initial slope (equivalent to TME _l).
TME _{Ni}	TME corrected for N over initial values of food intake.
TME _{Ns}	TME corrected for N over subsequent values of food intake.
TME _{ZNB}	TME corrected to zero N balance.
TME _{N_{UmE}}	TME corrected for energy of N arising from UmE.
TME _{N_{UmE+UeE}}	TME corrected for energy of N arising from both UmE and UeE.
UE	Urinary energy.
UCT	Upper critical temperature.
UeE	Energy equivalent of N by-products in the urine resulting from the day to day wasting of N due to maintenance activity.
UeN	The N content of by-products in the urine resulting from the day to day wasting of N due to maintenance activity.
UiE	The energy of N excretion products in the urine resulting from metabolic breakdown of absorbed food.
UmE	Energy equivalent of N by-products in the urine resulting from tissue catabolism and evident under starvation conditions.
UmN	The N content of by-products in the urine resulting from tissue catabolism and evident under starvation conditions.
VAE	Energy of voluntary activity or activity increment.
ZNB	Zero N balance.
ZNR	Zero N retention.
Δ	Change in.