



**UNIVERSITI PUTRA MALAYSIA**

**THE INFLUENCE OF DIETARY ENERGY, PROTEIN AND COPPER  
LEVELS ON THE SULPHUR AMINO ACID REQUIREMENTS  
OF BROILER CHICKENS**

**SOMCHAI SUWANPRADIT**

**FPV 1994 3**

**THE INFLUENCE OF DIETARY ENERGY, PROTEIN AND COPPER LEVELS  
ON THE SULPHUR AMINO ACID REQUIREMENTS  
OF BROILER CHICKENS**

**By**

**SOMCHAI SUWANPRADIT**

**Dissertation Submitted in Fulfilment of the Requirements for  
The Degree of Doctor of Philosophy in the Faculty  
of Veterinary Medicine and Animal Science  
Universiti Pertanian Malaysia**

**October 1994**



## ACKNOWLEDGEMENTS

I wish to express my appreciation and sincere gratitude to my chairman, Associate Professor Dr. Kassim bin Hamid for his invaluable guidance and advice throughout the course of study and in the thesis preparation.

I also would like to express my appreciation and sincere gratitude to many individuals and organizations who had help in numerous ways towards my accomplishment, namely:

Professor Dato' Dr. Syed Jalaludin bin Syed Salim, Vice Chancellor of Universiti Pertanian Malaysia (UPM), for his immeasurable kindness and assistance for the study at UPM.

Associate Professor Dr. Boonlom Cheewa-issarakul, Deputy Dean, Faculty of Agriculture, Chiang Mai University, Thailand, for her helpful comments, suggestions and assistance.

Associate Professor Ramlah Abd. Hamid, and Dr. Abd. Razak Alimon, Department of Animal Sciences, Faculty of Veterinary Medicine and Animal Science, UPM, for providing the laboratory facilities, helpful comments and suggestions.

Department of Animal Sciences, Faculty of Veterinary Medicine and Animal Science, Universiti Pertanian Malaysia, for providing the research facilities.



The Southeast Asian Regional Centre for Graduate Study and Research in Agriculture (SEARCA) for providing scholarship to study at UPM.

Faculty of Agriculture, Rajamangala Institute of Technology, Ministry of Education, Thailand, for the permission to take the study leave.

Finally, my family, friends and students in Thailand for their encouragement, moral support and love.



## TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS.....	ii
LIST OF TABLES.....	vii
LIST OF FIGURES.....	viii
LIST OF ABBREVIATIONS.....	xvii
ABSTRACT.....	xviii
ABSTRAK.....	xxi
 CHAPTER	
I    INTRODUCTION.....	1
II   LITERATURE REVIEW.....	3
Dietary Factors Affecting Intake.....	3
Energy Concentration.....	3
Protein Concentration.....	4
Amino Acid Deficiency and Imbalance.....	5
Sulphur Amino Acid Requirement.....	8
Dietary Energy Concentration and Amino Acid Requirement.....	10
Dietary Protein Concentration and Amino Acid Requirement.....	11
Dietary Copper Concentration and Sulphur Amino Acid Requirement.....	15
Nutrition and Fat Deposition in Broilers.....	18
Energy and Protein Levels (Energy Protein Ratio, E:P Ratio).....	19
Specific Amino Acid.....	22



	Dietary Fat.....	23
	Feeding Regime.....	24
	Effect of Dietary Protein Level and Amino Acid Supplementation on Yield and Composition of Meat Portions.....	25
	Sulphur Amino Acids Influence on the Fat Content of Broiler Carcasses.....	27
	Sulphur Amino Acid Excess and Toxicity.....	31
III	SULPHUR AMINO ACID REQUIREMENTS OF BROILER CHICKENS AS INFLUENCED BY DIETARY ENERGY LEVELS..	34
	Materials and Methods.....	34
	Starter Period (0–3 wk).....	34
	Grower Period (4–6 wk).....	41
	Results.....	46
	Starter Period.....	46
	Grower Period.....	62
	Discussion.....	79
IV	SULPHUR AMINO ACID REQUIREMENTS OF BROILER CHICKENS AS INFLUENCED BY DIETARY PROTEIN LEVELS.....	89
	Materials and Methods.....	89
	Starter Period (0–3 wk).....	89
	Grower Period (4–6 wk).....	95
	Results.....	99
	Starter Period.....	99
	Grower Period.....	115
	Discussion.....	130



V	SULPHUR AMINO ACID REQUIREMENTS OF BROILER CHICKENS AS INFLUENCED BY DIETARY COPPER LEVELS	138
	Materials and Methods.....	138
	Starter Period (0–3 wk).....	138
	Grower Period (4–6 wk).....	142
	Results.....	147
	Starter Period.....	147
	Grower Period.....	160
	Discussion.....	174
VI	GENERAL DISCUSSION.....	181
VII	CONCLUSION.....	189
	BIBLIOGRAPHY.....	191
	APPENDIX.....	205
	A    Additional Figures.....	206
	BIOGRAPHICAL VITA.....	240



## LIST OF TABLES

Table	Page
1 Composition of Starter Basal Diets for Experiment I.....	36
2 Protein and Amino Acid Compositions of Starter Basal Diets of Experiment I.....	38
3 Composition of Grower Basal Diets for Experiment I.....	43
4 Protein and Amino Acid Compositions of Grower Basal Diets of Experiment I.....	44
5 Effect of Dietary ME and TSAA Levels on Performance of Starter Broilers (0-3 wk).....	47
6 Effect of Dietary ME and TSAA Combinations on Performance of Starter Broilers (0-3 wk).....	49
7 Effect of Dietary ME and TSAA Levels on CP, ME and TSAA intake of Starter Broilers (0-3 wk).....	51
8 Effect of Dietary ME and TSAA Combinations on CP, ME and TSAA Intake of Starter Broilers (0-3 wk).....	53
9 Effect of Dietary ME and TSAA levels on Breast Portion of Starter Broilers (0-3 wk).....	54
10 Effect of Dietary ME and TSAA Combinations on Breast Portion of Starter Broilers (0-3 wk).....	55
11 Effect of Dietary ME and TSAA Levels on Drumstick Portion of Starter Broilers (0-3 wk).....	56
12 Effect of Dietary and TSAA Combinations on Drumstick Portion of Starter Broilers (0-3 wk).....	57
13 Effect of Dietary ME and TSAA Levels On Thigh Portion of Starter Broilers (0-3 wk).....	59
14 Effect of Dietary ME and TSAA Combinations on Thigh Portion of Starter Broilers (0-3 wk).....	60





Table	Page
15 Effect of Dietary ME and TSAA Levels on Skin Compositions of Starter Broilers (0-3 wk).....	61
16 Effect of Dietary ME and TSAA Combinations on Compositions Skin of Starter Broilers (0-3 wk).....	63
17 Effect of Dietary ME and TSAA Levels on Performance of Grower Broilers (4-6 wk).....	64
18 Effect of Dietary ME and TSAA Combinations on Performance of Grower Broilers (4-6 wk).....	66
19 Effect of Dietary ME and TSAA Levels on CP, ME and TSAA intake of Grower Broilers (4-6 wk).....	67
20 Effect of Dietary ME and TSAA Combinations on CP,ME and TSAA Intake of Grower Broilers (4-6 wk).....	68
21 Effect of Dietary ME and TSAA Levels on Body Composition of Grower Broilers (4-6 wk).....	69
22 Effect of Dietary ME and TSAA Combinations on Body Composition of Grower Broilers (4-6 wk).....	71
23 Effect of Dietary ME and TSAA Levels on Breast Portion of Grower Broilers (4-6 wk).....	72
24 Effect of Dietary ME and TSAA Combinations on Breast Portion of Grower Broilers (4-6 wk).....	74
25 Effect of Dietary ME and TSAA Levels on Drumstick Portion of Grower Broilers (4-6 wk).....	75
26 Effect of Dietary ME and TSAA Combinations on Drumstick Portion of Grower Broilers (4-6 wk).....	77
27 Effect of Dietary ME and TSAA Levels on Thigh Portion of Grower Broilers (4-6 wk).....	78
28 Effect of Dietary ME and TSAA Combinations on Thigh Portion of Grower Broilers (4-6 wk).....	80
29 Composition of Starter Basal Diets for Experiment II.....	92



Table	Page
30 Protein and Amino Acid Compositions of Starter Basal Diets (16 and 18% CP) of Experiment II.....	93
31 Protein and Amino Acid Compositions of Starter Basal Diets (20 and 23% CP) of Experiment II.....	94
32 Composition of Grower Basal Diets for Experiment II.....	97
33 Protein and Amino Acid Compositions of Grower Basal Diets of Experiment II.....	98
34 Effect of Dietary Protein and TSAA levels on Performance of Starter Broilers (0-3 wk).....	100
35 Effect of Dietary Protein and TSAA Combinations on Performance of Starter Broilers (0-3 wk).....	102
36 Effect of Dietary Protein and TSAA Levels on CP, ME and TSAA Intake of Starter Broilers (0-3 wk).....	104
37 Effect of Dietary Protein and TSAA Combinations on CP, ME and TSAA Intake of Starter Broilers (0-3 wk).	105
38 Effect of Dietary Protein and TSAA Levels on Breast Portion of Starter Broilers (0-3 wk).....	106
39 Effect of Dietary Protein and TSAA Combinations on Breast portion of Starter Broilers (0-3 wk).....	108
40 Effect of Dietary Protein and TSAA Levels on Drumstick Portion of Starter Broilers (0-3 wk).....	109
41 Effect of Dietary Protein and TSAA Combinations on Drumstick Portion of Starter Broilers (0-3 wk).....	111
42 Effect of Dietary Protein and TSAA Levels on Thigh Portion of Starter Broilers (0-3 wk).....	112
43 Effect of Dietary Protein and TSAA Combinations on Thigh Portion of Starter Broilers (0-3 wk).....	113
44 Effect of Dietary Protein and TSAA Levels on Skin Compositions of Starter Broilers (0-3 wk).....	114



Table	Page
45 Effect of Dietary Protein and TSAA Combinations on Skin Compositions of Starter Broilers (0–3 wk).....	116
46 Effect of Dietary Protein and TSAA Levels on Performance of Grower Broilers (4–6 wk).....	117
47 Effect of Dietary Protein and TSAA Combinations on Performance of Grower Broilers (4–6 wk).....	118
48 Effect of Dietary Protein and TSAA Levels on CP, ME and TSAA Intake of Grower Broilers (4–6 wk).....	119
49 Effect of Dietary Protein and TSAA Combinations on CP, ME and TSAA Intake of Grower Broilers (4–6 wk)..	120
50 Effect of Dietary Protein and TSAA Levels on Body Composition of Grower Broilers (4–6 wk).....	121
51 Effect of Dietary Protein and TSAA Combinations on Body Composition of Grower Broilers (4–6 wk).....	123
52 Effect of Dietary Protein and TSAA Levels on Breast Portion of Grower Broilers (4–6 wk).....	124
53 Effect of Dietary Protein and TSAA Combinations on Breast Portion of Grower Broilers (4–6 wk).....	126
54 Effect of Dietary Protein and TSAA Levels on Drumstick Portion of Grower Broilers (4–6 wk).....	127
55 Effect of Dietary Protein and TSAA Combinations on Drumstick Portion of Grower Broilers (4–6 wk).....	129
56 Effect of Dietary Protein and TSAA Levels on Thigh Portion of Grower Broilers (4–6 wk).....	129
57 Effect of Dietary Protein and TSAA Combinations on Thigh Portion of Grower Broilers (4–6 wk).....	131
58 Composition of Starter basal Diet for Experiment III.....	140
59 Protein and Amino Acid Compositions of Starter Basal Diets of Experiment III.....	141



Table	Page
60	Composition of Grower Basal Diet for Experiment III..... 144
61	Protein and Amino Acid Compositions of Grower Basal Diet of Experiment III..... 145
62	Effect of Dietary TSAA and Copper Levels on Performance of Starter Broilers (0-3 wk)..... 148
63	Effect of Dietary TSAA and Copper Combinations on Performance of Starter Broilers (0-3 wk)..... 149
64	Effect of Dietary TSAA and Copper levels on Breast Portion of Starter Broilers (0-3 wk)..... 152
65	Effect of Dietary TSAA and Copper Combinations on Breast portion of Starter Broilers (0-3 wk)..... 153
66	Effect of Dietary TSAA and Copper Levels on Drumstick Portion of Starter Broilers (0-3 wk)..... 154
67	Effect of Dietary TSAA and Copper Combinations on Drumstick Portion of Starter Broilers (0-3 wk)..... 156
68	Effect of Dietary TSAA and Copper Levels on Thigh Portion of Starter Broilers (0-3 wk)..... 157
69	Effect of Dietary TSAA and Copper Combinations on Thigh Portion of Starter Broilers (0-3 wk)..... 158
70	Effect of Dietary TSAA and Copper Levels on Skin Compositions of Starter Broilers (0-3 wk)..... 159
71	Effect of Dietary TSAA and Copper Combinations on Skin Compositions of Starter Broilers (0-3 wk)..... 161
72	Effect of Dietary TSAA and Copper Levels on Performance of Grower Broilers (4-6 wk)..... 162
73	Effect of Dietary TSAA and Copper Combinations on Performance of Grower Broilers (4-6 wk)..... 164
74	Effect of Dietary TSAA and Copper Levels on Body Composition of Grower Broilers (4-6 wk)..... 165



Table	Page
75 Effect of Dietary TSAA and Copper Combinations on Body Composition of Grower Broilers (4–6 wk).....	166
76 Effect of Dietary TSAA and Copper Levels on Breast Portion of Grower Broilers (4–6 wk).....	167
77 Effect of Dietary TSAA and Copper Combinations on Breast Portion of Grower Broilers (4–6 wk).....	169
78 Effect of Dietary TSAA and Copper Levels on Drumstick Portion of Grower Broilers (4–6 wk).....	170
79 Effect of Dietary TSAA and Copper Combinations on Drumstick Portion of Grower Broilers (4–6 wk).....	172
80 Effect of Dietary TSAA and Copper Levels on Thigh Portion of Grower Broilers (4–6 wk).....	173
81 Effect of Dietary TSAA and Copper Combinations on Thigh Portion of Grower Broilers (4–6 wk).....	174



## LIST OF FIGURES

Figure		Page
1	ME x TSAA Interaction for Feed Intake of Starter Broilers.....	50
2	ME x TSAA Interaction for Thigh Meat Protein of Grower Broilers.....	81
3	CP x TSAA Interaction for Feed:Gain Ratio of Starter Broilers.....	103
4	TSAA x Cu Interaction for Feed Intake of Starter Broilers.....	150
5	The Relationship Between TSAA Levels and Body Weight Gain for Various Dietary ME Levels of Starter Broilers.....	207
6	The Relationship Between TSAA Levels and Feed:Gain Ratio for Various Dietary ME Levels of Starter Broilers.....	208
7	The Relationship Between TSAA Levels and Abdominal Fat Content for Various Dietary ME Levels of Starter Broilers.....	209
8	The Relationship Between TSAA Intake and Body Weight Gain for Various Dietary ME Levels of Starter Broilers.....	210
9	The Relationship Between TSAA Intake and Feed:Gain Ratio for Various Dietary ME Levels of Starter Broilers.....	211
10	The Relationship Between TSAA Intake and Abdominal Fat Content for Various Dietary ME Levels of Starter Broilers.....	212
11	The Relationship Between TSAA Levels and Body Weight Gain for Various Dietary ME Levels of Grower Broilers.....	213
12	The Relationship Between TSAA Levels and Feed:Gain Ratio for Various Dietary ME Levels of Grower Broilers.....	214



Figure	Page
13 The Relationship Between TSAA Levels and Abdominal Fat Content for Various Dietary ME Levels of Grower Broilers.....	215
14 The Relationship Between TSAA Levels and Carcass Composition for Various Dietary ME Levels of Grower Broilers.....	216
15 The Relationship Between TSAA Intake and Body Weight Gain for Various Dietary ME Levels of Grower Broilers.....	217
16 The Relationship Between TSAA Intake and Feed:Gain Ratio for various Dietary ME Levels of Grower Broilers.....	218
17 The Relationship Between TSAA Intake and Abdominal Fat Content for Various Dietary ME Levels of Grower Broilers.....	219
18 The Relationship Between TSAA Intake and Carcass Fat Content for Various Dietary ME Levels of Grower Broilers.....	220
19 The Relationship Between TSAA Levels and Body Weight Gain for Various Dietary CP Levels of Starter Broilers.....	221
20 The Relationship Between TSAA Levels and Feed:Gain Ratio for Various Dietary CP Levels of Starter Broilers.....	222
21 The Relationship Between TSAA Levels and Abdominal Fat Content for Various Dietary CP Levels of Starter Broilers.....	223
22 The Relationship Between TSAA Intake and Body Weight Gain for Various Dietary CP Levels of Starter Broilers.....	224
23 The Relationship Between TSAA Intake and Feed:Gain Ratio for Various Dietary CP Levels of Starter Broilers.....	225



Figure	Page
24 The Relationship Between TSAA Intake and Abdominal Fat Content for Various Dietary CP Levels of Starter Broilers.....	226
25 The Relationship Between TSAA Levels and Body Weight Gain for Various Dietary CP Levels of Grower Broilers.....	227
26 The Relationship Between TSAA Levels and Feed:Gain Ratio for Various Dietary CP Levels of Grower Broilers.....	228
27 The Relationship Between TSAA Levels and Abdominal Fat Content for Various Dietary CP Levels of Grower Broilers.....	229
28 The Relationship Between TSAA Levels and Carcass Fat Content for Various Dietary CP Levels of Grower Broilers.....	230
29 The Relationship Between TSAA Intake and Body Weight Gain for Various Dietary CP levels of Grower Broilers.....	231
30 The Relationship Between TSAA Intake and Feed:Gain Ratio for Various Dietary CP Levels of Grower Broilers.....	232
31 The Relationship Between TSAA Intake and Abdominal Fat Content for Various Dietary CP Levels of Grower Broilers.....	233
32 The Relationship Between TSAA Intake and Carcass Fat Content for Various Dietary CP Levels of Grower Broilers.....	234
33 The Relationship Between Cu Levels and Body Weight Gain for Various Dietary TSAA Levels of Starter Broilers.....	235
34 The Relationship Between Cu Levels and Feed:Gain Ratio for Various Dietary TSAA Levels of Starter Broilers.....	236





Figure	Page
35 The Relationship Between Cu Levels and Feed Intake for Various Dietary TSAA Levels of Starter Broilers.....	237
36 The Relationship Between Cu Levels and Body Weight Gain for Various Dietary TSAA Levels of Grower Broilers.....	238
37 The Relationship Between Cu Levels and Feed:gain Ratio for Various Dietary TSAA Levels of Grower Broilers.....	239
38 The Relationship Between Cu Levels and Feed Intake for Various Dietary TSAA Levels of Grower Broilers.....	240



## LIST OF ABBREVIATIONS

ME	- Metabolisable Energy	SAS	- Statistical Analysis System
PE	- Productive Energy	ppm	- Parts Per Million
P:E	- Protein:Energy	h	- Hour(s)
E:P	- Energy:Protein Ratio	d	- Day
CP	- Crude Protein	wk	- Week(s)
DM	- Dry Matter	g	- Gramme(s)
BW	- Body Weight	mg	- Milligramme(s)
ADG	- Average Daily Gain	kg	- Kilogramme(s)
FCR	- Feed Conversion Ratio	kcal	- Kilocalorie(s)
EAA	- Essential Amino Acid	MJ	- Megajoule(s)
SAA	- Sulphur Amino Acid	Cu	- Copper
TSAA	- Total Sulphur Amino Acid		
NRC	- National Research Council		
AOAC	- Association Official Agricultural Chemists		



Abstract of the dissertation submitted to the Senate of  
Universiti Pertanian Malaysia in fulfilment of the requirements  
for the Degree of Doctor of Philosophy

THE INFLUENCE OF DIETARY ENERGY, PROTEIN AND COPPER LEVELS  
ON THE SULPHUR AMINO ACID REQUIREMENTS OF BROILER CHICKENS

By

SOMCHAI SUWANPRADIT

October 1994

Chairman: Assoc. Prof. Dr. Kassim Hamid

Faculty : Veterinary Medicine and Animal Science

Three experiments were conducted with male broiler chicks to determine the influence of dietary metabolisable energy (ME), crude protein (CP) and copper (Cu) levels on the total sulphur amino acid (TSAA) requirement of broilers both during the starter (0-3 wk) and the grower periods (4-6 wk) reared in the tropics. In all the experiments the parameters used to evaluate the TSAA requirements are body weight gain, feed:gain ratio and carcass composition.

In the first experiment, two factorial arrangements of three ME levels (3000, 3200 and 3400 kcal/kg) x four levels of TSAA (0.73, 0.83, 0.93 and 1.03%) and the same three ME levels (3000, 3200 and 3400 kcal/kg) x four levels of TSAA (0.65, 0.72, 0.79 and 0.86%) were used for the starter and the grower



periods, respectively. The results showed significant differences ( $p < .05$ ) in body weight gain and feed:gain ratio of the broilers with increasing dietary TSAA levels both in starter and grower periods. There were no significant interaction ( $p < .05$ ) between dietary ME and TSAA levels for the performance, with the exception for feed intake of starter broilers. It indicated that for the starter period, a TSAA of 0.93% produced the best performance regardless of energy levels while for the grower period the requirement of TSAA at both 0.79 and 0.86% were suggested. The results further showed that dietary energy levels had no effect on the TSAA requirement of the broilers.

In the second experiment, two factorial arrangements of four CP levels (16, 18, 20 and 23%) x three levels of TSAA (0.83, 0.93 and 1.03%) and three CP levels (16, 18 and 20%) x three levels of TSAA (0.72, 0.79 and 0.86%) were examined for the starter and grower periods, respectively. The results showed significant influence ( $p < .05$ ) of dietary CP levels on body weight gain and feed:gain ratio in both starter and grower periods. No significant interaction between dietary CP and TSAA levels was noted for the performance of the broilers. The results suggested that the requirement of TSAA of broiler chickens during the starter period was 0.93% and during the grower period was 0.79–0.86%. However, the requirement for TSAA per unit of diet was not affected by dietary protein levels.



In the third experiment, studies were also carried out with two factorial arrangements of four Cu levels (0, 125, 250 and 375 mg/kg) x three TSAA levels (0.73, 0.83 and 0.93%) and the same levels of Cu (0, 125, 250 and 375 mg/kg) x three levels of TSAA (0.72, 0.79 and 0.86%) were used during the starter and the grower periods, respectively. The results indicated that supplementation of Cu at the level of 375 mg/kg significantly decreased ( $p < .05$ ) feed intake of the chicken in both of the two growing periods. This resulted in significant reduction ( $p < .05$ ) of the growth rate and interference with the TSAA requirement of the starter broilers. However, the results showed that in grower broilers revealed no effect of Cu at the levels used to increase the TSAA requirement of the chicken. Dietary copper had no influence on carcass, meat and skin composition of the broilers.

The results of the present studies clearly indicated that under tropical conditions the NRC (1984) recommendation for TSAA requirements of 0.93% for starter broilers is adequate but the recommended level of 0.72% for grower broilers is less than the level of 0.79–0.86% suggested from the results of this study. In addition, the TSAA requirements of broilers per unit of diet were not affected by dietary ME and CP levels. Although, dietary copper level examined had the interference for TSAA requirements of starter broilers, there were no effects on the grower broilers.



Abstrak disertasi yang dikemukakan kepada Senat Universiti Pertanian Malaysia bagi memenuhi syarat untuk mendapatkan ijazah Doktor Falsafah

PENGARUH ARAS TENAGA, PROTEIN DAN KUPRUM DIET KEATAS KEPERLUAN ASID AMINO SULFUR OLEH AYAM PEDAGING.

Oleh

SOMCHAI SUWANPRADIT

Oktober 1994

Pengerusi: Prof. Madya Dr. Kassim Hamid

Fakulti : Kedokteran Veterinar dan Sains Peternakan

Tiga eksperimen telah dijalankan ke atas anak ayam pedaging jantan bagi menentukan pengaruh aras tenaga metabolik (TM), protein kasar (PK) dan kuprum atas keperluan jumlah asid amino sulfur (JAAS) pada ayam pedaging di peringkat permulaan (0-3 minggu) dan pembesaran (4-6 minggu) dipelihara dalam kawasan tropika. Dalam semua eksperimen parameter yang digunakan untuk menilai keperluan jumlah asid amino sulfur ialah kenaikan berat badan, nisbah makanan:berat badan dan komposisi karkas.

Di dalam eksperimen pertama, susunan dua faktorial bagi tiga aras TM (3000, 3200 dan 3400 kcal/kg) x empat aras JAAS (0.73, 0.83, 0.93 dan 1.03%) dan tiga aras TM yang sama (3000, 3200 dan 3400 kcal/kg) x empat aras JAAS (0.65, 0.72, 0.79 dan 0.86%) telah digunakan masing-masing untuk peringkat permulaan



dan pembesaran. Keputusan menunjukkan perbezaan ketara ( $p < .05$ ) untuk kenaikan berat badan dan makanan: kadar kenaikan pada ayam pedaging bila tahap JAAS dalam diet meningkat antara peringkat permulaan dan pembesaran. Tiada interaksi ketara ( $p < .05$ ) antara aras diet TM dan JAAS terhadap prestasi, kecuali pengambilan makanan ayam pedaging pemula. Ia menunjukkan bahawa pada peringkat permulaan, 0.93% JAAS memberi kesan prestasi terbaik di semua tahap tenaga, sementara pada peringkat pembesaran pula keperluan JAAS pada tahap 0.79% dan 0.86% dicadangkan. Keputusan kajian menunjukkan bahawa pada peringkat permulaan, 0.93% JAAS memberi kesan prestasi terbaik di semua tahap tenaga sementara pada peringkat pembesaran pula keperluan JAAS pada tahap 0.79 dan 0.86% dicadangkan. Keputusan selanjutnya menunjukkan bahawa aras tenaga diet tidak mempunyai kesan keatas keperluan JAAS oleh ayam pedaging.

Di dalam eksperimen kedua, susunan dua faktorial bagi empat aras PK (16, 18, 20 dan 23%) x tiga aras JAAS (0.83, 0.93 dan 1.03%) dan tiga aras PK (16, 18 dan 20%) x tiga aras JAAS (0.72, 0.79 dan 0.86%) telah dikaji masing-masing untuk peringkat permulaan dan pembesaran. Keputusan menunjukkan pengaruh yang ketara ( $p < .05$ ) aras diet PK keatas kenaikan berat badan dan kadar makanan: kenaikan berat bagi kedua-dua tempoh permulaan dan pembesaran. Tiada interaksi yang ketara ( $p < .05$ ) di antara diet PK dan aras JAAS yang dilihat bagi prestasi ayam



pedaging. Keputusan ini mengesyorkan keperluan JAAS bagi ayam pedaging di peringkat permulaan ialah 0.93% dan bagi peringkat pembrebaran ialah 0.79% – 0.86%. Walaubagaimanapun, keperluan JAAS seunit diet tidak terjejas oleh aras diet protein.

Di dalam eksperimen ketiga, kajian dijalankan mengikut susunan dua faktorial di mana empat aras kuprum (0, 125, 250 dan 375 mg/kg) x tiga aras JAAS (0.73, 0.83, dan 0.93%) dan bagi aras kuprum yang sama (0, 125, 250 dan 375 mg/kg) x tiga aras JAAS (0.72, 0.79 dan 0.86%) masing-masing untuk peringkat permulaan dan pembrebaran. Hasil kajian menunjukkan bahawa tahap kandungan kuprum sehingga 375 mg/kg dapat mengurangkan pengambilan makanan oleh ayam di kedua-dua peringkat pemeliharaan. Ini menyebabkan penurunan yang bererti ( $P < .05$ ) di dalam kadar pertumbuhan dan juga menyebabkan gangguan terhadap keperluan JAAS bagi ayam pedaging permulaan. Di sebaliknya, keputusan terhadap ayam pedaging pembrebaran menunjukkan tidak ada kesan kuprum pada aras yang digunakan bagi meningkatkan keperluan JAAS oleh ayam. Diet Kuprum tidak mempunyai pengaruh ke atas komposisi karkas, daging dan kulit ayam pedaging.

Kesimpulannya, kajian pada masa ini dengan jelas menunjukkan bahawa cadangan NRC (1984) bagi keperluan JAAS pada kadar 0.93% bagi ayam pedaging di peringkat permulaan adalah mencukupi tetapi keperluan pada kadar 0.72% bagi peringkat pembrebaran adalah kurang dari kadar 0.79%–0.86% yang dicadang-





kan di dalam kajian ini. Sebagai tambahan, keperluan JAAS oleh ayam pedaging bagi seunit diet adalah tidak terjejas oleh aras diet TM dan PK. Walaupun aras diet Kuprum yang dikaji mempunyai gangguan keatas keperluan JAAS bagi ayam pedaging peringkat permulaan, tetapi tidak keatas ayam pedaging peringkat pembesaran.

