

**FREE-RANGE VILLAGE CHICKEN NUTRITIONAL
STATUS AND USE OF LOCAL AGRO-
BYPRODUCTS BASED FEED SUPPLEMENT
IN SMALL HOLDERS' FARMS IN SABAH**



UMS

NIK NUR RASYIDAH BINTI NIK HASSAN

**FACULTY OF SUSTAINABLE AGRICULTURE
UNIVERSITI MALAYSIA SABAH
2017**

**FREE-RANGE VILLAGE CHICKEN NUTRITIONAL
STATUS AND USE OF LOCAL AGRO-
BYPRODUCTS BASED FEED SUPPLEMENT
IN SMALL HOLDERS' FARMS IN SABAH**

NIK NUR RASYIDAH BINTI NIK HASSAN



UMS
UNIVERSITI MALAYSIA SABAH

**THESIS SUBMITTED IN PARTIAL FULFILLMENT
FOR THE DEGREE OF MASTER OF
AGRICULTURE SCIENCE**

**FACULTY OF SUSTAINABLE AGRICULTURE
UNIVERSITI MALAYSIA SABAH
2017**

UNIVERSITI MALAYSIA SABAH

BORANG PENGESAHAN TESIS

JUDUL : _____

IJAZAH : _____

SAYA : _____ SESI PENGAJIAN : _____

(HURUF BESAR)

Mengaku membenarkan tesis *(LPSM/Sarjana/Doktor Falsafah) ini disimpan di Perpustakaan Universiti Malaysia Sabah dengan syarat-syarat kegunaan seperti berikut:-

1. Tesis adalah hak milik Universiti Malaysia Sabah.
2. Perpustakaan Universiti Malaysia Sabah dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (/)

SULIT (Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di AKTA RAHSIA RASMI 1972)

TERHAD (Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

TIDAK TERHAD

Disahkan oleh:

(TANDATANGAN PENULIS)

(TANDATANGAN PUSTAKAWAN)

Alamat Tetap: _____

(NAMA PENYELIA)

TARIKH: _____

TARIKH: _____

Catatan:

*Potong yang tidak berkenaan.

*Jika tesis ini SULIT dan TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali sebab dan tempoh tesis ini perlu dikelaskan sebagai SULIT dan TERHAD.

*Tesis dimaksudkan sebagai tesis bagi Ijazah Doktor Falsafah dan Sarjana Secara Penyelidikan atau disertai bagi pengajian secara kerja kursus dan Laporan Projek Sarjana Muda (LPSM).

DECLARATION

I hereby declare that the material in this thesis is my own except for quotations, equations, summaries and references, which have been fully acknowledged.

March 2017

.....

Nik Nur Rasyidah Binti Nik Hassan

MR1411002T



UMS
UNIVERSITI MALAYSIA SABAH

CERTIFICATION

NAME : **NIK NUR RASYIDAH BINTI NIK HASSAN**

MATRIC NUMBER : **MR1411002T**

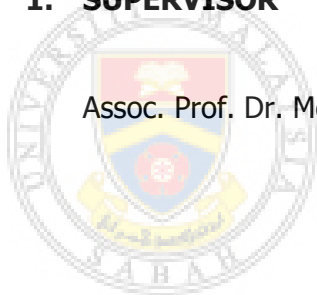
TITLE : **FREE-RANGE VILLAGE CHICKEN NUTRITIONAL STATUS AND USE OF LOCAL AGRO BYPRODUCTS BASED FEED SUPPLEMENT IN SMALL HOLDERS' FARMS IN SABAH**

DEGREE : **MASTER OF AGRICULTURE SCIENCE (LIVESTOCK PRODUCTION)**

VIVA DATE : **10 OCTOBER 2016**

DECLARE BY;

1. SUPERVISOR



Assoc. Prof. Dr. Md. Shahidur Rahman

Signature

UMS
UNIVERSITI MALAYSIA SABAH.....

2. CO-SUPERVISOR

Assoc. Prof. Dr. Azwan Bin Awang

.....

ACKNOWLEDGEMENT

Alhamdulillah, I thank Allah the Most Gracious for His help and blessings. I had been able to finish my master in research and writing up of the thesis. I would not be where I am now without His love and kindness. I would like to express my appreciation to all who have been very helpful and supportive throughout my master study.

I am very thankful and grateful for all the guidance and assistance from my supervisor, Associate Professor Dr. Md. Shahidur Rahman for his comment and suggestion throughout my research. Without his kind guidance, I would not be able to finish my master degree research successfully. I am also thankful to all the lecturers in the Faculty of Sustainable Agriculture for all of their comments and suggestion to improve my research. Especially to my co-supervisor Associate Professor Dr. Azwan Awang and also Dr. Abdul Rahim Awang and Prof. M.A.M. Yahia Khandoker. I also would like to thank all the laboratory staff and farm staff who had helped me throughout my research especially Mdm. Anika, Mdm. Nurul, Mr. Panjiman and Mr. Razali Puta.

I would also would like to express my gratitude to all my family members and friends for their supports and prayers. Special thanks to my parents (Mr. Nik Hassan Nik Jaafar and Mdm. Nik Noriyah Bt Nik Mat) who encouraged me to pursue my master degree and for all their prayers and moral supports. I also thankful my sisters and brother (Nik Ruqiyah, Nik Likhman and Nik Mashitah) for all their moral supports and prayers. I am also very thankful and grateful to my fiancee (Ahmad Bahily Azmi) and his family for all the moral supports, prayers and understanding throughout my research study. I am also indebted to my friends (Alfiza, Charlene, Siti Warda, Siti Kalsom, Surinah, Vella Fung, Lydianie Wesley, Mdm. Linda, Nafy, Olivia, Kimberly and Susilawati) for helping me throughout my research and for their prayers and moral supports. Not to forget Mdm Anika Family, Mr. Dominic Ganie, Mr. Eddy and Mr. Muji Ampau for helping in the sampling. Millions of thanks also to all the farmers who helped me in the field testing of the feed experiment especially to Mr. Japar Ekie, Mdm. Lungina binti Sikul, Mdm. Masra Bte Mansor and Mr. Herianto Muhammad for their time and help throughout my research.

Nik Nur Rasyidah Binti Nik Hassan

March 2017

ABSTRACT

Keeping free-range village chicken (FRVC) with supplementations are common practices for most of the rural families in Sabah. However, the main limitation of the current practice is supplementing the FRVC overlooking their actual nutritional demand. The availability of the nutrients to the FRVC from scavenging sources is also unknown. In addition, until today, there is no standard ready-made supplementary feed in the market for FRVC in Sabah that can meet up the exact nutritional requirement of the FRVC, cost effectively. Therefore, a series of experiment were conducted in Sabah to; i) investigate the common feeding practices and nutrition related challenges in the FRVC, ii) know the nutritional status in the scavenging feed, iii) develop and test the capability of supplementary feed, and iv) establish protocol of introducing supplementary feed for FRVC. Initially, a survey on common feeding practices and nutritional related challenges were conducted on 153 respondents through interview. Results showed that 89.5% of the farmers practices supplementary feeding using commercial feed or broken maize which was available at local market. Next, a study on the nutritional availability and nutrition related challenges to the FRVC were performed on 120 FRVC from three different agro-ecological locations and age groups. The concentration of dry matter, crude protein, ash, crude fibre, ether extract, nitrogen free extract, metabolizable energy, phosphorus and calcium were 58.2%, 12.6%, 38.0%, 5.78%, 7.69%, 36.04%, 2180 kcal kg⁻¹ DM, 0.009% and 0.200% in the crop gizzard contents (CGC) of the FRVC irrespective of the age and locations, respectively. There were significant variations in the age groups and locations of the FRVC (p<0.05). The nutrient requirements of these FRVC were computed and compared with the availability. Results showed that the major nutrients were insufficient in quantity to all FRVC and also imbalanced along with 100% parasitic burdens. To fulfil the deficiency of the nutrients particularly balancing the ME deficiency, two separate feed formulations for the young and adult FRVC have been introduced under this study. The ME contents in the young and adult feeds were 3150 Kcal and 3000 kcal kg⁻¹ DM which would incur a cost of RM 1.45 and RM 1.41, respectively. The recommended supplementary amounts were 38.9, 54.3 and 30.44 g kg⁻¹ body weight for young FRVC per day for the Sandakan, Kota Belud and Kundasang areas, whereas for adult FRVC per day, the amounts recommended were 33.4, 48.5 and 36.7 g kg⁻¹ respectively in the same locations. The feed was formulated comprising of 5% local fish meal, 24.9% palm kernel cake (PKC), 10% copra meal, 20% local maize, 14.5% broken rice and 25% rice bran for the young feed and for the adult feed were 5%, 25.2%, 10%, 20%, 10.4%, and 25% respectively. Some common additives were also added. Supplementary feeding trial confirmed that the new feed have comparable body weight gain of the FRVC with that of the commercial broiler feed. Finally, it was concluded that this research introduced basic information on the nutritional status of the FRVC in Sabah for the first time. It also introduced two low-cost supplementary feed formulations for the young and adult FRVC in Sabah incorporating six local ingredients. This research also established a general procedure of introducing supplementary feed suitable for the FRVC applicable in other parts of Malaysia and others country.

ABSTRAK

Pengenalan kepada Makanan Berasaskan Bahan Sampingan Agro untuk Ayam Kampung Ternakan Lepas Bebas

Memelihara Ayam Kampung ternakan lepas bebas (FRVC) dengan memberi makanan tambahan merupakan amalan yang biasa bagi penduduk luar bandar di Sabah. Walaubagaimanapun, amalan ini hanya terhad kepada memberi makanan tambahan sahaja tanpa mengambil kira keperluan nutrisi sebenar. Nutrien yang ada pada sumber makanan yang dicari oleh FRVC tidak diketahui. Tambahan lagi, sehingga hari ini, masih belum terdapat makanan tambahan pasaran di Sabah yang disediakan khusus buat FRVC yang boleh memenuhi keperluan nutrisi yang tepat dan pada harga yang berpatutan. Oleh itu, beberapa siri kajian telah dijalankan untuk i) mengenalpasti amalan yang biasa dalam memberi makanan dan juga cabaran berkaitan nutrisi yang dihadapi oleh FRVC di Sabah, ii) mengetahui status nutrisi FRVC di Sabah, iii) menghasilkan dan menguji makanan tambahan yang kompeten terhadap FRVC di Sabah, iv) menetapkan satu protokol dalam memperkenalkan makanan tambahan yang kompeten bagi FRVC. Satu tinjauan terhadap amalan yang biasa dalam memberi makanan dan cabaran berkaitan nutrisi pada mulanya telah dijalankan terhadap 153 responden melalui temubual. Hasil daripada kajian ini telah mendapati 89.5% daripada penternak FRVC mengamalkan pemberian makanan tambahan menggunakan sama ada makanan komersial atau jagung hancur yang terdapat di pasaran tempatan. Kajian terhadap nutrisi yang diperolehi dan cabaran berkaitan nutrisi daripada sumber makanan yang diperolehi oleh ayam telah dijalankan terhadap 120 ekor ayam FRVC di tiga lokasi agro-ekolgi dan kumpulan umur yang berbeza. Kepekatan kandungan bahan kering (DM), protein kasar (CP), abu (ash), serat kasar (CF), ekstrak eter (EE), ekstrak nitrogen bebas (NFE), tenaga metabolisme (ME), fosforus (P) dan kalsium (Ca) masing-masing adalah 58.2%, 12.6%, 38.0%, 5.78%, 7.69%, 36.04%, 2180kcal/kg DM, 0.009% dan 0.200% dalam kandungan tembolok dan hempedal FRVC. Terdapat interaksi signifikan yang berbeza pada kumpulan umur dan lokasi FRVC ($p < 0.05$). Hasil kajian menunjukkan majoriti kuantiti nutrisi tidak mencukupi dan tidak seimbang berserta bebanan parasit 100%. Bagi memenuhi kekurangan nutrisi, terutamanya untuk mengimbangi kekurangan ME, dua formulasi makanan bagi ayam muda dan dewasa telah diperkenalkan dalam kajian ini. Kandungan ME pada ayam muda dan tua masing-masing adalah 3150 dan 3000kcal/kg pada pengiraan harga RM1.45 dan RM1.41 untuk 1kg makanan. Cadangan jumlah makanan tambahan untuk ayam muda bagi kawasan Sandakan (SDK), Kota Belud (KB) dan Kundasang (KDG) masing-masing adalah 38.9, 54.3 and 30.44 g/kg. Makanan diformulasikan dengan menggunakan formulasi makanan UFFDA yang merangkumi 5% tepung ikan tempatan, 24.9% hampas isirong sawit, 10% tepung hampas kelapa, 20% jagung tempatan, 14.5% beras hancur and 25% dedak padi untuk ayam muda dan kadar 5%, 25.2%, 10%, 20%, 10.4%, and 25% masing-masing untuk ayam dewasa serta beberapa bahan tambahan. Ujian makanan tambahan membuktikan penambahan berat badan FRVC setanding dengan penambahan berat badan ayam pedaging tanpa ada sebarang kekurangan. Kesimpulannya, kajian ini buat pertama kalinya telah memperkenalkan maklumat asas bagi status nutrisi FRVC di Sabah. Dua formulasi makanan tambahan kos rendah untuk FRVC muda dan dewasa turut diperkenalkan dengan menggunakan enam bahan-bahan tempatan di Sabah. Selain itu, kajian ini juga membangunkan prosedur am dalam memperkenalkan makanan tambahan yang kompeten yang boleh diaplikasikan bagi FRVC di tempat-tempat lain di Malaysia dan negara luar.

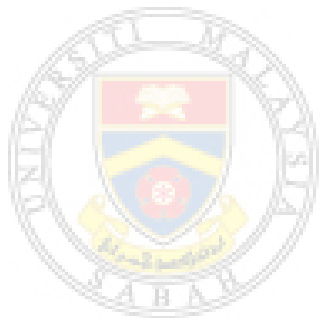
TABLE OF CONTENT

	Page
TITLE	i
DECLARATION	ii
ACKNOWLEDGEMENT	iv
ABSTRACT	v
<i>ABSTRAK</i>	vi
LIST OF CONTENTS	vii
LIST OF TABLES	xi
LIST OF FIGURES	xiv
LIST OF ABBREVIATIONS	xvi
LIST OF UNIT	xvii
LIST OF SYMBOLS	xviii
LIST OF APPENDIXS	xix
CHAPTER 1: GENERAL INTRODUCTION	1
1.1 Background of the Study	1
1.2 Problem Statement	4
1.3 Objective of the Study	5

1.4	Justification of the Study	6
CHAPTER 2: LITERATURE REVIEW		
2.1	Free-Range Village Chicken	8
2.2	The Ancestors of Free-Range Village Chicken	10
2.3	Advantage And Disadvantages of Free-Range Village Chicken	10
2.4	The Production System of Free-Range Village Chicken	12
2.5	Comparison Between Free-Range and Commercial Chicken	15
2.6	Feeds And Nutrition of Free-Range Village Chicken	17
2.6.1	Feed Resources	17
2.6.2	The Scavenging Feed Resources Base	17
2.6.3	How Do Chicken Digest Feed?	18
2.6.4	Farmers Common Practice In Feeding Free-Range Village Chicken	18
2.6.5	Feed And Nutrients Requirement of Free-Range Village Chicken	19
2.6.6	Agro-byproducts Available in Malaysia for Feeding Chicken	23
2.7	Common Challenges To Free-Range Chicken	25
2.7.1	Malnutrition	25

2.7.2	Factors Interfering With Nutrient Utilization	26
2.8	Research Gap	31
CHAPTER 3:	NUTRITION AND NUTRITION RELATED CHALLENGES IN FREE-RANGE VILLAGE CHICKEN OF SABAH.	32
3.1	Introduction	32
3.2	Studies	34
3.2.1	Survey On The Feeding And Management Practices Of Free-Range Village Chicken (FRVC) In UMS- Sandakan Neighbouring Area Of Sabah	34
3.2.2	A Study On The Nutritional Status Of Free-Range Village Chicken At Different Agro-Ecological Zones Of Sabah	46
3.2.3	Estimation Of Requirement, Availability And Deficiency Of The Major Nutrient	53
3.2.4	Study On The Parasitic Loads In Free-Range Village Chicken Of UMS- Sandakan Neighbouring Area Of Sabah	60
CHAPTER 4:	FORMULATION, DEVELOPMENT AND TESTING OF THE SUPPLEMENTARY FEED FOR FREE-RANGE VILLAGE CHICKEN IN SABAH	69
4.1	Introduction	71
4.2	Studies	76
4.2.1	Study On Formulation And Manufacturing Of The Supplementary Feed For Free-Range Village Chicken In Sabah	72

4.2.2	Testing Of The Performance Of The Newly Introduced Supplementary Feed For The Growing Free-Range Village Chicken In Ums-Sandakan Neighbouring Area Of Sabah	78
CHAPTER 5:	GENERAL DISCUSSION	84
CHAPTER 6:	CONCLUSION	88
CHAPTER 7:	RECOMMENDATION	90
REFERENCES		92
APPENDIX		110



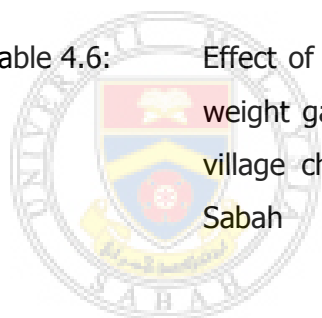
UMS
UNIVERSITI MALAYSIA SABAH

LIST OF TABLE

	Page
Table 2.1: Nutritive value of 100g free-range village chicken meat	12
Table 2.2: The comparison of production system of village chicken	14
Table 2.3: The comparison between village and commercial chicken	16
Table 2.4: Functions of various nutrients in chicken feed	21
Table 2.5: Optimum levels of inclusion in poultry rations of some ingredients	24
Table 3.1: Background of the free-range village chicken (FRVC) farmers in UMS-Sandakan neighbouring area of Sabah	37
Table 3.2: Number, types and breeds of free-range village chickens (FRVC) kept by the farmers in UMS-Sandakan neighbouring area of Sabah	39
Table 3.3: Importance of keeping free-range village chickens (FRVC) by the farmers in UMS-Sandakan neighbouring area of Sabah	40
Table 3.4: Feeds, feeding and housing for the free-range village chickens (FRVC) in UMS-Sandakan neighbouring area of Sabah	41
Table 3.5: Amount and cost of feeding supplementary feed to the free-range village chickens (FRVC) in UMS-Sandakan neighbouring area of Sabah	42
Table 3.6: Challenges and problems faced by free-range village chickens (FRVC) farmer in UMS-Sandakan neighbouring area of Sabah	43

Table3.7:	Perception of the farmers on feeding and rearing of free-range village chickens (FRVC) in UMS-Sandakan neighbouring area of Sabah	44
Table 3.8:	Impact of flock size of the free-range village chicken (FRVC) on production and management related parameters of the FRVC at UMS-Sandakan Neighbouring area in Sabah	45
Table 3.9:	Feed ingredients found in the crop and gizzard contents (CGC) of the free-range village chicken (FRVC) in Sabah	50
Table 3.10:	Nutrients content in the CGC of 120 FRVC collected from 3 different agro-ecological locations of Sabah	51
Table 3.12:	Quantitative availability of the daily scavenged feed (DM) and nutrients in free-range chicken (FRVC) of 3 agro-ecological locations Sabah	57
Table 3.13:	Nutrients requirement (g kg^{-1} body weight) of the FRVC used in Study 3.2.2	59
Table 3.14:	Amount of nutrients deficiencies in the free-range village chicken (FRVC) used in Study 3.2.2	59
Table 3.15:	Influences of the age, sex and their interactions on the total count of ecto- and endo-parasite in 40 free-range village chickens (FRVC) in UMS-Sandakan neighbouring areas of Sabah	63
Table 3.16:	Species wise prevalence and intensity of parasites and their association with the age and sex of 40 free-range village chickens (FRVC) in UMS-Sandakan neighbouring areas of Sabah	63

Table 4.1:	Type of ingredients, cost and nutrient composition	73
Table 4.2:	Formulation and ingredients concentrations of the supplementary diet for 1 kg BW of young and adult FRVC	76
Table 4.3	Cost and nutrient concentration of the supplementary diet for 1kg feed (DM basis) of young and adult FRVC	76
Table 4.4:	Recommended amount of supplementation and nutrient concentrations for 1 kg BW of young FRVC in 3 different locations of Sabah	77
Table 4.5:	Recommended amount of supplementation and nutrient concentrations for 1 kg BW of adult FRVC in 3 different locations of Sabah	78
Table 4.6:	Effect of different types of supplementation on the body weight gain (BWG) and mortality rate of the free-range village chicken in UMS-Sandakan neighbouring area of Sabah	80

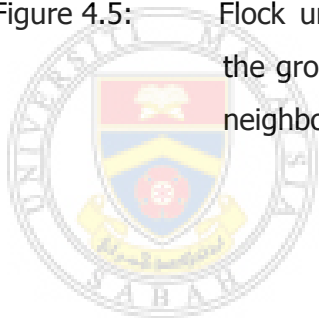


UMS
UNIVERSITI MALAYSIA SABAH

LIST OF FIGURE

	Page
Figure 2.1: Common village male (left) and female (right) chickens in Malaysia	9
Figure 3.1: Map of the study area	47
Figure 3.2: Representative photo of the packing crop and gizzard samples in zipper bag before storing into refrigerator	48
Figure 3.3: The regression of the amount of crop and gizzard content (CGC) on daily total feed intake free-range village chicken (FRVC); (a) young FRVC <1 kg BW, (b) adult frvc >1 kg BW	56
Figure 3.4: Endo-parasite and ecto-parasite collected from internal and external parts of the free-range village chickens in UMS-Sandakan neighbouring areas of Sabah	64
Figure 3.5: Distribution of the species of parasites (as % of total chickens examined) in the free-range village chicken (FRVC) collected from UMS-Sandakan neighboring area of Sabah (n = 40)	64
Figure 3.6: Relationship between total parasitic loads and body weights of the young (a) and adult (b) free-range village chicken (FRVC) irrespective of their sex (n = 20 in each case)	66
Figure 3.7: Relationship between total parasitic loads and body weights of the male (a) and female (b) free-range village chicken irrespective of their age (n = 20 in each case)	67

- Figure 4.1: Representative photo of mixing the ingredients using locally made mini mixer machine 74
- Figure 4.2: Pelleting the formulated feed using locally made pellet machine 74
- Figure 4.3: Sample of the developed palleted feed(left) and sample of commercial grower feed(right) 74
- Figure 4.4: Pattern of the responses of different supplementary feed to the body weight gain (%) in the growing free-range village chicken in UMS-Sandakan neighbouring area of Sabah 80
- Figure 4.5: Flock uniformity on different supplementation groups in the growing free-range village chicken of UMS-Sandakan neighbouring area of Sabah 81



UMS
UNIVERSITI MALAYSIA SABAH

LIST OF ABBREVIATIONS

ANOVA	-	Analysis of Variance
FAO	-	Food and Agriculture Organization of the United Nations
USDA	-	United State Department of Agriculture
SPSS	-	Statistical Package for Social Science
UFFDA	-	User Friendly Feed Formulation Done Again
JPM	-	Jabatan Pertanian Malaysia
IDS	-	Institute for Development Studies
ECD	-	Environmental and Conservation Workgroup Sabah Structure Plan 2020
DOVSAI	-	Department of Veterinary Services and Animal Industry
JPHPT	-	Jabatan Perkhimatan Haiwan Dan Perusahaan Ternakan Sabah
CDC	-	Centre for Disease Control and Prevention
CAST	-	Council for Agricultural Science and Technology
AOAC	-	Association of Official Analytical Chemists
MADF	-	Ministry of Agriculture Development and Food Industry, Sabah
MPOB	-	Malaysian Palm Oil Board
MOL and FD	-	Ministry of Livestock and Fisheries Development
NRC	-	National Research Council

LIST OF UNITS

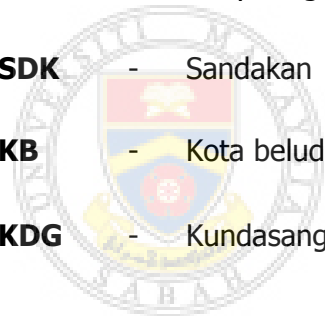
°C	- Degree Celsius
%	- Percentage
g	- Gram
mg	- Milligram
kg	- Kilogram
MT	- Metric Ton
MMT	- Million Metric Tons
si	- International unit of system
cal	- Calorie
m	- Meter
mm	- Millimeter
kcal	- Kilocalorie



UMS
UNIVERSITI MALAYSIA SABAH

LIST OF SYMBOLS

d	-	Day
Ca	-	Calcium
P	-	Phosphorus
SFR	-	Scavenged feed resources
FRVC	-	Free-range village chicken
CGC	-	Crop and gizzard content
FI	-	Feed intake
BW	-	Body weight
SDK	-	Sandakan
KB	-	Kota belud
KDG	-	Kundasang



UMS
UNIVERSITI MALAYSIA SABAH

LIST OF APPENDIX

	Page
Appendix1: Questionnaire for study 3.2.1	110
Appendix2: Table 3.11: Calculated standard requirements (g/1kg FRVC/day) of the daily feed and different nutrients for the Leghorn chicken (NRC, 1994)	123
Appendix3: Figure 3.3: Regression of body weight on the requirement of different nutrients in young and adult Leghorn. A, ME requirements for young; B, ME requirements for adult; C, CP requirements of young; D, CP requirements of adult; E, CF requirements of young; F, CF requirements of adult.	124
Appendix4: Figure 3.4: Regression of body weight on the requirement different nutrients in young and adult Leghorn. A, Ca requirements of young; B, Ca requirements of adult; C, P requirements of young; D, P requirements of adult.	125
Appendix5: List of Published Paper and Presentation (Poster/Oral)	126



CHAPTER 1

GENERAL INTRODUCTION

1.1 Background of the Study

Currently the world is harbouring estimated 96.3 million tonnes of indigenous chicken meat production (FAO, 2014¹). Malaysia is having 1367.4 thousand tonnes of indigenous chicken meat and approximately 30% of them are believed to be village chicken kept under traditional production system (FAO, 2014²; Anonymous, 2011). Low productivity and high adaptability of these chickens to local environment are the advantage of these chickens when compared with that of the high yielding farm chicken (Moreki, 2015; Aini, 1990). The meat and eggs of these chickens are of special flavour and taste (Sonaiya and Swan, 2007). Therefore, people often choose this kind of chicken as an alternative source to organic meat and eggs, and this trend is now increasing day by day (Anonymous, 2015). In recent years, consumer's interest in specialty poultry products derived from free-range or organic production systems has been steadily increasing in the United States and Europe (Fanatico, Pillai, Emmert, Gbur, Meullenet; Owens, 2007). The presence of a range of bioactive compounds in the forage, such as xanthophyll and several hypocholesterolemic and anticarcinogenic compounds, may lead to improve the meat quality of these chickens (Ponte, Mendes, Quaresma, Aguiar, Lemos, Ferreira, and Soares, 2004). In Malaysia and other tropical countries, the production of village chicken traditionally takes place in free-range system (Engku Azahan and Zainab, 1980; Barbosa, Silva², Silva¹, Coello and Savino, 2005; Milkulski, Celej, Jankowski; Teressa and Mikulski, 2011).

Free-range village chicken (FRVC) plays an important role in providing household source of income, and meat and eggs for the smallholder farmers (Conroy, 2005; Minh, 2005; Halima, 2007). It also has an important position in cultural and religious life of the society (Minh, 2005; Conroy, 2005). The ancestor of these FRVC in Malaysia is mainly the Red Jungle Fowl (*Gallus gallus*) (Noraida Ilias, no yr; Bambang

Cahyono and Natasha Azmi, 2008). The current stock of FRVC in Malaysia is no longer purebreds of *Gallus gallus* as they evolved from the indiscriminate and random crossbreed between original jungle fowl and exotic commercial breeds (Engku Azahan, 1994; Edjeng Suprijatna and Hakim Johari, 2008). Generally, the village chicken in Malaysia and elsewhere in the world are smaller in size, possesses poor genetic potentials and low productivity in terms growth and egg production (Engku Azahan, 1994; Sonaiya, Branckaert and Guèye, 1999; Tadelle, Million, Alemu and Peters, 2003; Pousga, Boly, Lindberg and Ogle, 2005).

There are three types of production systems of village chicken throughout the world (Guèye, 1998) and they are the free-range, backyard and semi-intensive systems. Management of chickens under free-range system is mainly done with traditional knowledge. Free-range systems allow birds to express their natural behaviours with the main feature being freedom of movement, choice of nesting site, space to escape or chase other birds during a social encounter and choice of neighbour (Armstrong and Cermak, 1989). In western countries, animal welfare activists are campaigning against intensive poultry production (Savory, 2003). However, the worldwide trend is to increase the productivity of chicken under free-range systems (Ministry of Livestock and Fisheries Development, 2003).

The FRVC have natural tendency to scavenge for their own feed (Hoffman, Styger, Muller, Brand, 2003). Their feeds mostly come from environmental materials such as worms, insects, snails, forage leaves, flowers, forage seed, sand and grits (Ologhobo, 1990; Rashid, 2003; Sonaiya, 2004; Goromela, Kwakel, Verstegen and Katule, 2007). Their owner sometimes offers them small amounts of supplements such as leftover household food or kitchen waste, garden vegetables waste, crop residues, corn and commercial feeds. Normally it is given to them, early in the morning or evening, depends on the availability (Ologhobo, 1990; Wattanachat, 2008; Sonaiya, 2004; Goromela *et al.*, 2007).

Substantial number of researches in different countries showed that the scavenging chickens have low productivity. The productivity of scavenging chicken, especially the productivity of FRVC can be improved through various ways such as improving their housing and management, health control and also improving their diet (Minh and Ogle, 2005; Ministry of Agriculture, 1980). One of the limiting factors of

improving their diet is the uncertainty with the quantity and quality of the scavenged feed (Smith, 1990; Robert and Gunaratne, 1992). To manufacture the improved supplemental feed for these chickens, information on nutrients availability from the scavenging sources and the exact amount of the supplemental need of different nutrients should be taken into consideration (Smith, 1990; Huchzermeyer, 1973; Rashid, Roy, Asaduzzaman, 2004). The availability of the nutrients in terms of quality and quantity has been reported to be varied in different geographical locations, seasons and communities (Rahman, 2003; Mutayoba, Katule, Minga, Mtambo and Olsen, 2011). Until today, there is no information on the nutritional quantity and quality of the scavenged feed available to FRVC in Sabah.

The use of unconventional feed ingredients in poultry industry is an economic strategy to ensure the maximum profit. Majority of the conventional feed stuffs for poultry are common with that of human. On the ground of frequent food crisis in the world, scientists are seriously exploring a range of agricultural by-products as the poultry feed like palm kernel cake (PKC), soybean meal, sunflower oil byproducts, slaughter house byproducts, food and beverages processing byproducts and so on, which have no use in human nutrition (Wan Zahari and Wong, 2009; National Research Council, 1994). Among the imported feed ingredients in Malaysia, the maize, wheat, full-fat soybean and soybean meal are the major for which human is also a strong competitor.

Therefore, the price and availability of these ingredients are directly related to international food market. Consequently, Malaysian poultry sector frequently become vulnerable to the shortage of feed supply and higher production cost. On the other hand, Malaysia is rich and unique in its diverse source of agro-byproducts. The PKC (2.5MMT), rice polish (0.38MMT), cassava root (0.44MMT), rubber seed (1.2MMT), copra meal (21000MT), fish meal (60000MT), oyster shell (20000MT) and poultry byproducts meal (25000MT) are the major Malaysian agro-byproducts (United States Department of Agriculture, 2012; FAO, 2011; MPOB, 2012). These are available throughout the year and usually much cheaper than the imported feed ingredients like maize, wheat and soybean. The nutritional value of these agro-byproducts has already been established and human never compete for these ingredients (NRC, 1994). The feasibility of using these agro-byproducts in poultry ration formulation has extensively been studied worldwide (Wan Zahari and Wong, 2009).