UNIVERSITI PUTRA MALAYSIA

UTILIZATION OF ORGANIC AND INORGANIC CALCIUM AND DEHYDRATED FOOD WASTE IN IMPROVING EGG PRODUCTION AND EGG QUALITY OF VILLAGE CHICKEN LAYERS

ALIYU AHMED YUSUF

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By

ALIYU AHMED YUSUF

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

March 2016

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DEDICATION

In memory of my late father and my beloved mother. The words could have been silent without you. Had it not been your fulfillment on the duty that Al-mighty ALLAH permit you, I could not have had this opportunity in life.

To my beloved brothers and sisters, for their excellent encouragement, caring, help to my immediate family and understanding my absence.

To my precious wife, Habiba I. M. Yusuf, for your love and encouragement in achieving this objective. Above all thank you very much for your patience and understanding my absence.

I thank my precious boys Al-amin, Ibrahim, and Abdullah for having not been troublesome in my absence to their mother that could have disturbed my studies.

To my friends and well-wishers, with much regards to Abubakar sadeeq magaji for his immeasurable help, caring, encouragement and enduring my absence.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the Degree of Master of Science

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March 2016

Chairman : Prof. Dahlan Ismail, PhD
Faculty : Agriculture

The study was conducted to investigate the performance of different organic and inorganic dietary calcium from halal sources in Malaysian village chicken layers diet and utilization of dehydrated food waste (DFW) as an economical alternative feed supplement in Malaysian village chicken layers for better egg production and quality. One hundred and twenty (120) Malaysian Village chickens (Arabian strain) at the age of 50 weeks old were randomly assigned to four dietary feed treatments with different calcium and energy sources. Commercial layers feed was used as control diet (T_1). Formulated layer feed ingredients + DFW + Bone meal as a source of dietary calcium (T_2). Formulated layer feed ingredients + DFW + Eggshell powder as a source of dietary calcium (T_3). Formulated layer feed ingredients + DFW + Limestone as a source of dietary calcium (T_4). Each treatment was replicated 3 times with 10 birds per replicate. Restaurant food leftover (mainly rice) was locally sourced from 15 different halal restaurant within Universiti Putra Malaysia (UPM) and processed to dehydrated food waste (DFW) and used as energy sources in T_2, T_3, and T_4. Raw tibia bovine bone from Malaysian Brakmas breed of cattle was source from meat processing plant of the Department of Animal Science, UPM and processed to bone meal as source of organic dicalcium phosphate (DCP) ($Ca + PO_4$) in T_2. Eggshell waste was source from hatcheries of poultry research unit of Ladang two, UPM and processed to eggshell powder for organic source of $CaCO_3$ (calcium carbonate) in T_3. Limestone powder was purchased from animal feeds supplier (Animal feed vendor) and used as inorganic mineral source of calcium carbonate ($CaCO_3$). The feeding period lasted for 7 weeks in which feed were measured every day and the leftover also measured the following morning (24 hours) for daily feed intake. Clean and fresh water was given *ad libitum* every morning. The effects of different dietary calcium sources and DFW on production and egg quality traits (feed intake, body weight gain, egg production, feed conversion ratio, egg weight, egg height, egg width, egg volume, eggshell weight, eggshell thickness, eggshell percentages, albumen weight, albumen height, albumen percentage, yolk weight, yolk percentage, yolk colour, egg grade and haugh units) were evaluated. All data obtained in 3^{rd}, 5^{th}, and 7^{th} weeks on egg quality traits were subjected to one way ANOVA, except that of egg production where all data's for the 7 weeks were used.

Statistical test was performed and means comparism between performance of experimental dietary feed treatments on production and egg quality were done using Duncan multiple range test at $P< 0.05$. The results indicated that, treatments had statistical ($P<0.05$) significant effects on egg quality traits, except in feed intake, body weight gained, FCR and weekly rate of lay. The result showed that, T_2 was highly utilized for production of eggs with superior qualities on egg weight (49.71g), egg height (53.13mm), egg width (41.40mm), egg volume (47.67ml), eggshell weight (5.67g), eggshell thickness (0.34mm), albumen weight (26.70g), albumen height (3.63mm) yolk weight (16.77g), yolk percentage (33.90%), and yolk colour (4.25 points) over other dietary feed treatments. Based on the outcome of this result, it can be concluded that, organic DCP from bovine bone meal and DFW from restaurant leftover are promising poultry feedstuff for better nutrition, production of quality eggs and provision of halal feed ingredients for poultry production. Also, the result proves the hypothesis that absorption of calcium from organic source is better than absorption from inorganic sources. Therefore, organic DCP from bovine bone meal and DFW can be offered to small-scale farmers as an economical substitute to conventional feedstuff and halal poultry feed ingredients which may help to contribute effectively on production of quality eggs that will provide adequate protein to population from village chicken layers.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Master Sains

PENGGUNAAN KALSIUM ORGANIK DAN BUKAN ORGANIK SERTA SISA MAKANAN DEHIDRAT DALAM MENINGKATKAN PENGELUARAN TELUR DAN KUALITI TELUR DI PETEMPATAN AYAM PENELUR

Oleh

ALIYU AHMED YUSUF

Mac 2016

Pengerusi : Profesor Dahlan Ismail Phd
Fakulti : Pertanian

Kajian ini dijalankan untuk mengkaji prestasi kalsium diet organik dan bukan organik yang berbeza daripada sumber halal bagi diet di petempatan ayam penelur dan penggunaan sisa makanan dehidrat (DFW) sebagai suplemen makanan alternatif yang ekonomikal di petempatan ayam penelur di Malaysia bagi pengeluaran ayam telur yang lebih baik dan berkualiti. Sebanyak seratus dua puluh (120) ayam penelur di petempatan Malaysia (baka Arab) berusia 50 minggu telah dipilih secara rawak bagi empat rawatan makanan diet dengan sumber kalsium dan tenaga yang berbeza. Makanan ayam penelur komersial telah digunakan sebagai diet kawalan (T_1). Bahan makanan ayam penelur yang diformulasi + DFW + Hidangan tulang sebagai sumber kalsium diet (T_2). Bahan makanan ayam penelur yang diformulasi +DFW + Serbuk kulit telur sebagai sumber kalsium diet (T_3). Bahan makanan ayam penelur yang diformulasi + DFW + Batu kapur sebagai sumber kalsium diet (T_4). Setiap rawatan diulang sebanyak tiga kali dengan sepuluh unggas bagi setiap pusingan. Sisa makanan restoran (terutamanya nasi) telah diperoleh dari sumber tempatan dari 15 restoran halal yang berbeza dalam lingkungan Universiti Putra Malaysia dan diproses menjadi sisa makanan dehidrat (DFW) dan digunakan sebagai sumber tenaga bagi T_2, T_3, dan T_4. Tulang bovin tibia mentah dari baka kacukan lembu Brakmas Malaysia merupakan sumber dari kilang pemprosesan daging, Jabatan Sains Haiwan, UPM dan diproses menjadi hidangan tulang sebagai sumber dichasium fosfat organik (DCP) (Ca + PO_4) dalam T_2. Sisa kulit telur merupakan sumber dari unit penyelidikan penetasan poltri, Ladang Dua, UPM dan diproses menjadi serbuk kulit telur bagi sumber organik bagi CaCO3 (kalsium karbonat) dalam T_3. Serbuk batu kapur diperoleh daripada pembekal makanan haiwan (vendor makanan haiwan) dan digunakan sebagai sumber mineral bukan organik kalsium karbonat ($CaCO_3$). Tempoh beri makan berakhir selama 7 minggu dan makanan disukat setiap hari, manakala lebihan makanan juga disukat pada pagi berikutnya (24 jam) bagi setiap pengambilan makanan. Air Segar dan bersih diberikan secara *ad libitume* setiap pagi. Kesan sumber kalsium diet yang berbeza dan DFW ke atas pengeluaran dan ciri kualiti telur (pengambilan makanan, penambahan berat badan, pengeluran telur, nisbah penukaran makanan, berat telur, ketinggian telur, kelebaran telur, isi padu

telur, berat kulit telur, ketebalan kulit telur, peratusan kulit telur, berat albumen, ketinggian albumen, peratusan albumen, berat kuning telur, peratusan kuning telur, warna kuning telur, gred telur, dan unit haugh) telah diukur. Semua data yang diperoleh dalam minggu ketiga, kelima dan ketujuh ke atas ciri kualiti telur telah diolah mengikut ANOVA sehala, kecuali bagi pengeluaran telur, iaitu semua data untuk 7 minggu telah digunakan. Ujian statistik telah dijalankan dan min perbandingan antara prestasi rawatan makanan diet eksperimental ke atas pengeluaran dan kualiti telur menggunakan ujian julat berganda Duncan pada $P< 0.05$. Hasil kajian menunjukkan bahawa rawatan mempunyai kesan statistik yang signifikan ke atas ciri kualiti telur, kecuali dalam pengambilan makanan, penambahan berat badan , FCR dan kadar bertelur mingguan. Dapatan juga menunjukkan bahawa T_2 merupakan campuran paling tinggi digunakan bagi pengeluaran telur dengan kualiti yang superior ke atas berat telur (49.71g),ketinggian telur (53.13mm),kelebaran telur (41.40mm),isi padu telur (47.67ml),berat kulit telur(5.67g),ketebalan kulit telur(0.34mm),berat albumen (26.70g),ketinggian albumen (3.63mm),berat kuning telur (16.77g),peratusan kuning telur(33.90%) dan warna kuning telur(4.25 mata) berbanding dengan rawatan makanan diet yang lain. Berdasarkan dapatan kajian ini, dapatlah dibuat kesimpulan bahawa DCP organik dari hidangan tulang bovin dan DFW dari sisa lebihan makanan restoran merupakan bahan makanan ternakan yang berpotensi bagi nutrisi yang lebih baik, pengeluaran kualiti telur, dan bekalan bahan makanan halal bagi pengeluaran poltri. Di samping itu, dapatan kajian ini juga membuktikan hipotesis bahawa penyerapan kalsium dari bahan sumber organik adalah lebih baik daripada sumber bukan organik. Oleh sebab itu, DCP organik dari hidangan tulang bovin dan DFW harus ditawarkan kepada penternak skala kecil sebagai gantian yang ekonomikal berbanding dengan bahan makanan ternakan konvensional dan bahan makanan poltri halal yang dapat menyumbang secara efektif ke atas pengeluaran telur yang berkualiti yang akan memberikan protein secukupnya untuk populasi dari petempatan ayam penelur.

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I certify that a Thesis Examination Committee has met on 15 March 2016 to conduct the final examination of Aliyu Ahmed Yusuf on his thesis entitled "Utilization of Organic and Inorganic Calcium and Dehydrated Food Waste in Improving Egg Production and Egg Quality of Village Chicken Layers" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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Declaration by graduate student

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Name of Member of Supervisory Committee: Dr. Tee Tuan Poy

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AD	After dead
AMP	Adenosine monophosphate
Av. P	Average phosphorus
ASA	American Soybeans Association
ANOVA	Analysis of variance
BC	Before Christ
BMB	Bone mineral density
BMP	Bone morphogenic protein
BWG	Body weight gained
Ca	Calcium
Ca^{2+}	Calcium ions
Ca/P	Calcium to phosphorus ration
CaBp	Calcium binding protein
$CaCO_3$	Calcium carbonate
$CaPO_3$	Calcium phosphate
$Ca_2\,PO_3$	Dicalcium phosphate
$Ca_3(PO_4)_2$	Tricalcium phosphate
$Ca_{10}(PO4)_6(OH)_2$	Hydroxyapatite
cm	Centimeter
CP	Crude protein
CF	Crude fiber
CV	Coefficient of variation
CT	Calcitonin
DCP	Dicalcium phosphate
DFW	Dehydrated food waste
DM	Dry matter
ESG	Egg specific gravity
EGT	Eggshell thickness
ESW	Eggshell weight
FAO	Food and Agricultural organization

g	Grams
GH	Growth hormone
GLM	General linear model
GE	Gross energy
hrs.	Hours
Kcal	Kilocalories
kg	Kilogram
mRNA	Messenger RNA
ME	Metabolisable energy
$Mg_3 (PO_4)_2$	Tri-magnesium phosphate
MSU	Mississippi state university
NaCl	Sodium chloride
NPP	Nonphytate phosphorus
NRC	National research council
P	Phosphorus
pH	Hydrogen ions concentration
PTH	Parathyroid hormone
RNA	Ribonucleic acid
RJF	Red jungle fowl
SAS	Statistical analysis system
STD. DEV	Standard deviation
TCP	Tricalcium phosphate
$1,25(OH)_2D_3$	Dihydroxycholecalciferol
UPM	Universiti Putra Malaysia

CHAPTER 1

INTRODUCTION

1.1 Background

Rapid increase in human population all over the world and awareness on religious obligation from Muslims across the globe, creates tremendous challenges on demand of animal products (meat and eggs) for the supply of adequate protein as well as halal food products for quality nutrition and halal food security (FAO, 2006; Vloreen, *et al.*,2012). Global shortages in animal products for the supply of animal protein have long been started since early 40s when animal products were in limited supply due to the effect of World War II (FAO, 2010). Since then, researchers in the field of animal production as well as nutritionist were making effort to bridge the gap with the alternative sources that will contribute solely in supply of adequate animal products to meet up with the protein requirements of the population worldwide (Bartussek, 1999). This led to rapid evolution in livestock production with more emphasis in poultry production (FAO, 2006). Presently, the world poultry products economy, have gone far in global livestock production with the aims of meeting the demand and supply of the produce to the growing population worldwide (Sulistiyanto, *et al*., 1999). Poultry stands to be one of the major source of protein to the entire population across the globe (Zaman, *et al.,* 2004), and in these days, eggs from poultry are considered to be perfect or standard source of protein worldwide (Annie and Francine, 1997).

However, in an effort to increase the productivity of poultry products for the demand and supply of protein, including halal products, researcher's attentions are now attracted to specialty markets for village chicken breeds for their stress tolerance, disease resistant and easy management, but the major problem in village chicken rearing, is the issue of low productivity, associated with poor available nutrition as a consequence of lack of adequate supplementary feed (Islam and Jabbar, 2003). Therefore, in order to allow local village chickens to contribute effectively to the improvement of food security as well as provision of halal food products, it becomes necessary to increase their productivity by reducing the use of conventional feed ingredients for their high cost and affordability in poultry feeds formulation (Sonaiya and Swan, 2004).

Meanwhile, animal nutritionist and feed formulators from poultry feed industries are working hard to come up with means by which they can reduce or wipe out dependency on those expensive conventional poultry feed ingredients with more emphasis on energy and minerals feed ingredients sources which has for long been taken for granted. In this direction, researchers began to understand that utilization of cheap and locally available non-conventional feed resources, such as restaurant food waste or left over from restaurant (Hossein and Dahlan, 2015) and animal products and by-products that are not directly utilized as human food appears to be the most practical and economic approach in substituting conventional feed ingredients for

both energy and minerals sources in poultry feed formulation (Reddy, 2005). According to Westendorf, (2000) restaurant food waste or leftover food is an available, nutritional and cost effective resource which could be used as a possible economical alternative source to supplement nutrient intake for animals.

Official publications and bulletins from USDA-APHIS confirmed that using restaurant food waste as energy feeds ingredient source in poultry feeds formulation has great nutritional and economic potentialities that assist farmers in increasing their production at lower cost. In an earlier study Kim, (1995) reported that dried leftover food waste could be used as a supplemental feed or energy feed ingredient for poultry. Bao, *et al.,* (2007) stated that dried food waste has the nutritional values of approximately 20 - 28% crude protein (CP), 2 - 4% crude fiber (CF), 6 - 12% crude ash and 10 - 14% crude fat (EE): Hoshii and Yoshida, (1981) and Lipstein, (1985) also suggested that dried leftover food has such nutritive values that could be used as feed ingredient for the production of broiler and laying hens. The dried leftover food could save production costs of commercial feed by substituting up to 25% when used (Sehgal and Simmi, 1993).

Despite the fact that dehydrated or dried food waste plays a vital role in supply of energy and other nutrients in poultry feeds, it also contributed in minerals supplements significantly in poultry nutrition. This is made largely by adding qualitative nutritional values to the feed and plays an important role in animal especially birds under laying condition (Dieck, *et al.,* 2003), for production of quality eggs (Ito, *et al*., 2006). With the advance in poultry feed production nowadays, different research findings indicated that organic form of mineral sources has the potentials of improving poultry production due to their organic complexity in nature, effectiveness and bioavailability than inorganic form. Organic form of minerals are associated with protein/peptide/amino acids higher than inorganic minerals (Swiatkiewicz, *et al.,* 2014). They tend to be more than twice as bioavailability than inorganic minerals and do not interact with antagonist unlike inorganic sources (Sims and Garrett, 2010). Their greater bioavailability enhances their value to livestock nutritionists and producers (Abdallah, *et al*., 2009). They are also more easily absorbed and are effectively utilized in compared to inorganic forms, because of their role in many function (Richards, *et al.*, 2010). In addition, they plays a significant roles in wide varieties of biological functions within the animal body (Elaroussi, *et al*., 1994).

However, it was discover from different research findings that performance and effect of organic minerals particularly organic calcium in laying birds, tend to be more effective in enhancement of eggshell quality traits than inorganic form (Siske, *et al*., 2000 and Maciel, *et al.,* 2010), and eggshell quality is the most important and considerable issue in production of poultry as high defective eggshell lead to increase in market loss in poultry industries worldwide (Lavelin, *et al.,* 2000). The main concern of farmers in relation to egg quality is the eggshell strength. The problems of eggshell quality in laying birds can only be overcome with the used of organic form of calcium in layers feed (Roland, 1988; Ito, *et al.,* 2006). The requirement of calcium to enhance shell quality is highly needed in poultry diet than any other

minerals (Klasing, 1998). This is because higher than 70% of the mineral content in the animal's body were constituted by calcium (Singh and Panda, 1996) and it plays a vital role on egg production, maintenance of animal body and strongness of bone integrity (Elaroussi, *et al*., 1994; Cynthia, 2013). It is necessary to supply qualitative organic calcium to chicken layers in order to overcome the problems of eggshell quality for the production of adequate superior eggs that will supply sufficient protein to population worldwide (William, *et al.,* 2006; Richard, 2007).

It therefore becomes imperative to note that, recommended dietary organic calcium sources from qualitative source is preferably needed to preserve the internal egg quality, and also the biological, chemical, physical and the functional characteristics of egg proteins that occur after lay (Leeson and Summers, 2005). Moreover, different dietary sources of calcium such as oyster shell, limestone, eggshell, DCP, De-fluorinated phosphate, mono calcium phosphate and raw rock phosphate have since been used in the diets of layers to enhance egg production and quality, but yet satisfactory sources are still in view (Safaa, *et al.,* 2008; Saunders-Blades, *et al.,* 2009;). Therefore, for better production of eggs and quality output, researchers have to intensify search to come up with satisfied dietary calcium sources that are readily available at affordable prices for improve production and meeting the needed supply of protein to population worldwide (Sultana, 2007).

1.2 Statement of the problem

The major problems that lead to inadequate supply of protein from poultry products to population worldwide, was the issue of poor level of feeding due to serious shortage of feedstuffs in poultry nutrition. These problems facilitated the up shooting cost of conventional feedstuff which creates a major gap between the demand and supply of poultry produce for protein requirement in the world. In order to manage this problem, it is essential to come up with the available unconventional feed sources for qualitative poultry nutrition. This can simply be achieved by building adequate feed sources from available alternative sources that are cheap and affordable to the farmers. And one method to harness this resources is to exploit the use of non-conventional feed resources like dehydrated food waste and animal products and by-products in poultry feed production for better production of eggs that will provide adequate protein to population (Ben Salem, *et al.,* 2002).

In addition, the problem of poor shell quality in relation to dietary calcium sources in poultry production and layers in particular, still stand to be a major and sensitive issue in poultry industry. Currently, it was observed that heavy economic loss in poultry industry worldwide occurs due to the problem associated with poor eggshell quality which led to approximately 12 – 13% eggs lost from producer to consumer (Pavlovski, *et al.,* 2012). In view of these problems, it is of great importance to established what would be the most ideal source of dietary calcium in diets of laying hens, coupled with clear understanding of the role or the effect that this dietary calcium sources play, in boosting egg production and quality on village chicken layers (Keshavarz, 1988; Roush, *et al*., 1986).

Increase in Islamic knowledge and consciousness on consumers' rites by Muslim worldwide, had led to diversification of choice more on the particular type of services and products they use or consume (Shafie and Othman, 2006). Muslim are directed as an obligation to use or consume only halal foods (Al-Qaradawi, 2007). This issue therefore, creates a serious challenge in poultry production for the use and supply of certified halal poultry products to Muslim population; this is obvious because, almost all or bigger parts of the food chain supply, including food manufacturing, farming, retail chains and restaurant logistics are dominated either by non-Muslim countries or businesses (Tieman, 2015). Generally, most of the dietary calcium sources in poultry feeds especially DCP from animal bones are usually from non-halal sources, obtainable from either China or Australia. These were manufactured or produced from products of porcine, bovine, caprine and ovine bones, therefore, to guarantee the supply of halal poultry food products for adequate halal protein supply for Muslim consumption, a certified and standard halal poultry feed ingredient must be used in formulating poultry feed for poultry nutrition (Latif, *et al.,* 2014).

1.3 Aims and objectives of the study

i. To investigate the performance of different dietary calcium sources (organic and inorganic) in order to identify and recommend the most suitable and halal source of dietary calcium for better egg production and quality in village chicken layers.

ii. To process and utilize dehydrated food waste from halal source in order to supplement the conventional energy feed ingredients (corn, sorghum, millet etc.) in village chicken layers' diet for profitable production of good quality eggs and halal food security.

1.4 Justification for the study

More attention is being paid by researchers these days on progressed to access and harness the nutritive values of DFW as a better energy source feed ingredient to substitute conventional energy feedstuffs (cereal grains products) in animal feeds, with the purpose of overcoming the problem of feed shortage and high cost of feed ingredients in animal feed production with relevance to protein supply. Several research findings had indicated the importance and utilization of organic dietary calcium sources in production of quality eggs in chicken layers for adequate supply of protein, due to their complexes, bioavailability, high retention, readily absorbability and free from interaction with antagonist than inorganic source. Likewise, the production and supply of halal products to Muslim population worldwide is became a serious global economic issue to various countries across the globe. Nowadays almost all countries including non-Islamic countries across the world are competing on supply of halal products. So, it is the duty of Muslim scientist as well as researchers, to participate fully in production and supply of halal poultry products to its consumers. Therefore, is advisable to harness the potentialities of village chicken layers for production of quality eggs as well as halal product in order to simulating small scale farmer in the tropical countries like Malaysia,

Nigeria, etc. so as to contribute sorely in supply of protein as well as halal products to the growing population of Muslims and other interested groups worldwide.

1.5 Hypothesis of the study

It has been hypothesized that, dehydrated food waste is a better substitute to conventional energy source feed ingredients in layers' diets and absorption of organic calcium from organic sources were better than the absorption of calcium from inorganic sources.

1.6 Research Scope and Limitations

The research study was limited to utilization of different dietary calcium sources (organic and inorganic) with dehydrated food waste (DFW) in village chicken's layers for egg production and quality.

1.7 Contribution of the Research

The research findings highlighted the utmost effect of organic dietary calcium sources over inorganic sources as well as halal source of calcium in village chicken layers for better production of quality eggs. The research also determines specifically the developed outlooks on nutritional contents of DFW as cheap qualitative source of energy, protein and minerals in poultry feeds. It proves that, DFW was alternative source of poultry energy feed ingredients that would substitute conventional energy feed ingredient in poultry feed formulation. It provides an alternative halal sources of energy feed ingredient for poultry nutrition. It's also highlighted the importance and potentialities of village chicken layers (Arabian strain) for better egg production and quality, which will simulate small scale holder in poorest tropical countries worldwide for adequate contribution in supply eggs for protein requirements to population.

1.8 Thesis outline

The thesis is arranged as follows; Chapter one, highlighted the general introduction on importance of non-conventional animal feeds ingredients, their utilization, effects and halal sources of feed ingredients on egg production and quality. Related literatures were reviewed on DFW, minerals, calcium, sources of calcium (organic and inorganic), calcium requirements, calcium absorption, calcium metabolism and utilization in subsequent Chapter (2). Then, the used materials as well as illustration of method used in conducting the research study in Chapter 3. All data collected and analysis made were presented with full discussion of entire result in Chapter Four. Finally, summary and conclusions were made and suggestions were offered for future studies to be conducted in an area of dietary calcium and energy sources for village chicken layers in production of quality eggs, presented in Chapter 5.

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