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Nutritive Value and In Vivo Digestibility of Rhinoceros Beetle (*Oryctes rhinoceros l.*) Larva Meal in Laying Quails (*Coturnix coturnix japonica*)

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Abstract

Insects have long been observed and studied as an alternative nutrient resource for poultry feed production. Insects offer adequate essential nutrients as a feed source. Beetles are the most common insect species utilized mostly in their larval stages. This study was conducted to determine the nutritive and in vivo digestibility of Rhinoceros Beetle Larva Meal (RBLM) in laying quails. For the nutritive study, live Rhinoceros Beetle larvae were collected in decaying trunks of coconut and other palm families. A kilogram of these larvae were processed into RBLM, weighed, freeze-dried and submitted for chemical analysis. Results revealed that RBLM has a rate of recovery of 33%, dry matter content of 37.70%, 1.42% ash, 20.70% crude protein, 6.50% crude fat, 7.71% crude fiber, 200 mg/Kg calcium,250 mg/Kg phosphorus, and 51.10 mg/Kg iron content. In the digestibility study, a total of fifteen five-month-old quails were given 16 grams of RBLM/hd/day for five days. Feces were collected daily and freeze-dried for chemical analysis. Results showed that dry matter, crude fat, crude fiber, and calcium contents of RBLM have high digestibilities in laying quails with 69.10%, 78.97%, 73.02%, and 59.11%, respectively. Also, ash, crude protein, phosphorus and iron composition of RBLM have satisfactory digestibilities of 45.59%, 35.69%, 31.06%, and 36.88%, respectively. Therefore, RBLM has high nutritive composition and these nutrients are highly digestible in laying quails. Thus, RBLM can be an alternative nutrient resource for laying quails.

Keywords: *quail, Coconut Rhinoceros Beetle Larva, proximate analysis, nutrient composition*

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1.0 Introduction

The goal to improve poultry and livestock sector sustainability to feed the mounting global population needs drastic measures such as on finding sustainable feed sources (FAO, 2014). The aforementioned sectors utilize 70% of total land use intended for agriculture. Demand for production, such as for meat, is expected to increase by 75% in 2050 than it was in 2005 (van Huis *et al.*, 2015).

Meat and eggs are the primary sources of protein and mineral nutrients of the populace in developing countries (FAO, 2008). Poultry is the foremost source of these nutrients, with domestic chickens as the primary species. However, the chicken industry is compelled to meet the growing demand of meat and eggs. Other poultry species have to be considered to ease pressure on chicken production.

A poultry species that needs consideration is quail. Quails can be raised either for meat and eggs. These quails reach maturity in much less time than chickens. Laying quails produce eggs that are much bigger in relation to bodyweight compared to other poultry species. However, as in other poultry species, feed is a limiting aspect of quail production.

Feed accounts for roughly 70% of poultry production costs. The feed should contain adequate amounts of micro and macronutrients for maintenance and production in quails. Feed sources mostly come from plants. Yet, plant sources are inferior in terms of the quality of nutrients compared to animal products and by-products.Thus, this study attempts to discover sustainable feed sources that are of animal origin.

Insects have been tapped as an alternative nutrient source for humans and in animal production (FAO, 2009b). Insects provide satisfactory amounts of essential nutrients as food or feed source (Rumpold and Schluter, 2013). Beetles (Coleoptera) are the most common insect species consumed worldwide (Jongema, 2012). These coleopterans are either consumed in theiradult or larval stages (Cerritos, 2009).

A species of beetle commonly found in coconut-producing areas is the Rhinoceros Beetle (*Oryctes rhinoceros L.*). Adults of this species are destructive because they eat leaves and burrow into crowns of palms stunting plant development. Its larvae feed on organic matter mainly in decomposing trunks of coconut trees and other palm families. These larvae convert low-nutrient coconut fibers into nutrient-rich biomass (Doloriel, 2018). This study attempts to assess the nutritive value of Rhinoceros Beetle Larva Meal (RBLM) and its digestibility in laying quails.

2.0 Methodology

2.1 Meal Preparation

Live Rhinoceros Beetle larvae (L3) were collected from decaying trunks of coconut trees and other palm families in Tagbina, Surigao del Sur. Gathered larvae were placed in containers with decaying coconut fiber as substrates and stored and fattened for two weeks. Third instar (L3) rhino beetle larvae that were covered in body fat (yellow colored) from the containers were collected, washed with running water, rinsed, and weighed. A kilogram of these larvae was immersed in hot water to instantly kill them, gut emptied, pan-fried for eight minutes, and cut into smaller pieces. Rate of recovery was computed using the formula:

2.1.1 Rate of Recovery (%)

$$\text{Rate of Recovery (\%)} = \frac{\text{weight of rhino beetle larva meal (Kg) x 100}}{\text{fresh weight of rhino beetle larvae (Kg)}}$$

2.2 In Vivo Digestibility Trial

Fifteen five-month-old quails were used in this trial. The quails were fasted for a day and given 240 grams (16 grams of feed/hd/day) of RBLM every day for five days. The first two days were meant for the adaptation period and the three succeeding days for data collection. Feces were collected daily and placed in a resealable plastic container, weighed, and freeze-dried for chemical analysis. In vivo digestibility was determined using the formula:

2.1.2 In vivo digestibility(%)

$$\text{In vivo digestibility(\%)} = \frac{\text{(amount of feed intake)(nutrient in feed)} - \text{(amount of feces)(nutrient in feces) x 100}}{\text{(amount of feed intake)(nutrient in feed)}}$$

2.3 Chemical Analysis

The freeze-dried feces of quails were submitted to The First Analytical Services and Technical Cooperative (FAST) Laboratories in Cagayan de Oro City for proximate analysis using the AOAC Method (AOAC, 2012). Ash content of the samples was analyzed using Ignition-Gravimetric, fat using Soxhlet Extraction Method, crude protein using Kjeldahl, crude fiber using ANKOM fiber analyzer, phosphorus using Colorimetry, and calcium and iron contents using Atomic Absorption Spectrophotometry.

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3. Results and Discussion

3.1 Rate of Recovery

The rate of recovery of RBLM is 33%, wherein a kilogram of fresh larvae produced 0.33 Kg or 330 grams of RBLM.

3.2 Proximate Analysis and In Vivo Digestibility

As shown in Table 1, RBLM used in this study has a dry matter content of 37.7%, where 69.10% of this can be utilized by laying quails. It has an ash content of 1.42% and is 45.59% digestible. Rhinoceros Beetle larva efficiently converts low-nutrient substrates such as coconut fibers into nutrient-rich biomass (Doloriel, 2018). Efficient conversion of fibrous organic matter is due to the larva's presence of cellulolytic and hemicellulolytic bacteria in its gut. These bacteria have 63.6% cellulolytic, 72.7% xylanolytic, and 100% mannanolytic activities (Sari *et al.,* 2016). Cellulase and hemicellulase are hydrolytic enzymes that play an important role in lignocellulose hydrolysis.

Table 1. Proximate analysis and *in vivo* digestibility of RBLM in laying quails

PARAMETER	PROXIMATE ANALYSIS[1]	*IN VIVO* DIGESTIBILITY	REMARKS
Dry Matter, %	37.70	69.10	High[2]
Ash,%	1.42	45.59	Satisfactory[3]
Crude Protein,%	20.70	35.69	Satisfactory[2]
Crude Fat,%	6.50	78.97	High[2]
Crude Fiber,%	7.71	73.02	High[2]
Calcium,mg/Kg	200.00	59.11	High[3]
Phosphorus, mg/Kg	250.00	31.06	Satisfactory[3]
Iron, mg/Kg	51.10	36.88	Satisfactory[3]

[1]First Analytical Services and Technical Cooperative (FAST) Laboratories (2018)
[2] Faliolu *et al.* (2015)
[3]NDVSU

A cellulase is a group of enzymes that degrade cellulose, a major component of lignocellulose. Mannanase and Xylanase are the fundamental enzymes that play a role in hemicellulose hydrolysis (Lynd *et al.,* 2002 and Dashtban *et al.,* 2009). The key process of herbivorous insect feed digestion is polysaccharide hydrolysis (Shi *et al.,* 2011). These insects' ability to consume lignocellulose as its energy source is supported by microorganisms in its digestive tract that produce these hydrolytic enzymes (Suh *et al.,* 2003).

RBLM has 20.7% crude protein content and is 35.69% digestible in quails. This CP content differs from that of other researchers' findings, such as that of Xiaoming *et al.* (2010) with 23-66%, Egba *et al.* (2014) with 33.97%, Oluwu *et al.* (2012) having 48%, Doloriel (2018) with 13.70% and Omotoso (2018) with 70.76%. Differences in the nutrient composition of RBLMs could be due to the different feed sources and varied agro-climatic conditions of the same feed sources of the larvae, i.e., in Coconut Palms, Oil Palms, etc., and the methods in preparing and processing RBLM.

The population in most countries does not take advantage of consuming the high-quality protein present in insects owing to the disgust factor associated with consuming it. However, these can be alleviated by incorporating these insects in processed foods such as in snack bars, etc. to increase its dietary protein content. RBLM could also be incorporated in rations of farm animals owing to its moderately high protein and high mineral contents.

Rhinoceros larvae are good sources of fat even when processed, as shown in this study has 6.50%, and are highly digestible to laying quails at 78.97%. This result is comparable to the findings of Anand *et al.* (2008) and Omotoso (2018) that insect larvae such as that of palm beetles have 5-8% and 7.47% fat contents, respectively. Most practical animal diets usually comprise three to five percent fats to attain the optimal dietary energy requirement of the animal. Also, fats enhance the palatability of a ration and reduce dustiness in feed mills and poultry houses. A requirement for linoleic acid, an essential fatty acid, has been recognized even though poultry does not have a definite requirement for fats as energy source. Linoleic acid, the lone essential fatty acid required by poultry species, primarily affects egg size of laying poultry (Ravindran, 2013). In humans, the dietary importance of this essential fatty acid is well-accepted mainly for the healthy development of infants and children (Michaelsen *et al.,* 2009). Insects are good sources of fat and oil. Oils of insect larvae contain more unsaturated fatty acids due to its high iodine number, low saponification values and are generally in liquid state at room temperature. *O. rhinoceros'* oil extracts have been ruled to have the highest levels of unsaturation of 65.61%, whereas that of *M. bellicosus* (termites) has 50.02%. The oils of all *O. rhinoceros'* developmental stages may have pharmaceutical and medicinal values (Ekpo *et al.,* 2009). Unsaturated fatty acids, generally liquid at room temperature, are composed of mono-unsaturated and poly-unsaturated fatty acids. Unsaturated fats are comprised of at least one double bond and yield slightly reduced energy during metabolism. They are commonly present in nuts, vegetable oils, and seafood. Unsaturated fatty acids are healthier for human health than saturated fat (FAO, 2014).

High fiber content can be detected in the larvae of the Rhinoceros Beetle, as shown in the analysis of the RBLM having 7.71% but is highly digestible to quails at 73.02%. The form of fiber in insects is chitin, an insoluble fiber derived from the exoskeleton (FAO, 2014). Finke (2007) revealed that the chitin content of insect species produced commercially as nourishment for insectivores range from 2.7 to 49.8 mg per Kg (fresh) and from 11.6 to 137.2 mg per Kg (dry matter). Chitin, a long-chain polymer of N-acetyl glucosamine–a derivative of glucose, is the foremost constituent of the exoskeleton of an insect. Chitin is substantially similar to the polysaccharide cellulose in plants that is believed to be indigestible by humans, however, chitinase has been found in human gastric juices (Paoletti *et al.*, 2007). Chitin has also been linked with defense against parasitic infections and some allergic conditions. Chitinase activity is predominant in tropical countries where insects are commonly consumed. Some contend that chitin resembles as a dietetic fiber (Muzzarelli *et al.*, 2001) and could imply a high-fiber composition in edible insects, especially species with hard exoskeletons (Bukkens, 2005). Also, chitin was reported to act as prebiotic by improving the immune response of birds (Bovera *et al.,* 2015) and by intensifying the caecal production of butyric acid (Khempaka *et al.,* 2011), which is considered the key energy source for enterocytes. The latter would effect in improved intestinal blood flow through the intestine, hence enhancing tissue oxygenation and nutrient transport and absorption (Mahdavi and Torki, 2009).

In this study, RBLM has a calcium content of 200 mg/Kg, wherein 59.11% can be utilized by laying quails. The phosphorus content of RBLM is 250 mg/Kg, where 31.06% is digestible. It has a high iron content of 51.1 mg/Kg, where digestibility is 36.88%.

The mineral salts obtained in the developmental stages of the palm beetle, *O. rhinoceros* are sodium (Na+), Calcium (Ca), Potassium, (K), Magnesium (Mg), Phosphorus (P), Iron (Fe), Zinc (Zn), Manganese (Mn) and Chromium (Cr). The highest mineral salt obtained in all the developmental stages of *O. rhinoceros* was phosphorus. Herbivorous insects derive the mineral salts from the plants they consume, where phosphorus is a very prominent mineral found in plants (Omotoso, 2018).

Minerals are required for the development of the skeletal system, for general health, as constituents of general metabolic activity, and maintenance of the acid-base balance of the body. The two most abundant mineral elements in the body are calcium and phosphorus. Calcium and phosphorus are classified as macrominerals, along with potassium, sodium, sulfur, chloride, and magnesium. Macrominerals are mineral elements necessary in the diet at concentrations of more than 100 mg/Kg. Calcium and phosphorus are both required for the skeletal structure's development and maintenance and for the enhancement of eggshell quality. Generally, sixty to eighty percent of the total phosphorus present in plant-derived ingredients is in the form of phytate-phosphorus. Phytate phosphorus is poorly utilized by poultry owing to the lack of endogenous phytase in their digestive enzymes under normal dietary conditions. Phosphorus requirement for poultry is expressed as non-phytate phosphorus rather than total phosphorus since only about one-third of the phosphorus in plant feedstuffs is non-phytate and is biologically available to poultry. To optimize the absorption of these two minerals, a ratio of 2:1 must be maintained between calcium and non-phytate phosphorus in growing birds' diets. For good shell quality, calcium's proportion to non-phytate phosphorus in the diet of laying poultry is 13:1 (Ravindran, 2013).

Quails aged 7 to 20 weeks can be raised optimally on 2.5% calcium and 0.35% available phosphorus (Amoah *et al.,* 2012; Aguda et al., 2015; Shrivastav, 2000).

Iron is essential in the formation of red blood cells. Red blood cells are vital in oxygen carriage to respiring cells in the body (Soetan *et al*., 2010). Edible insects are definitely rich sources of iron, and their inclusion in the daily diet could improve the iron status and help avert anemia in developing countries. WHO has identified iron insufficiency as the world's most common nutritional disorder. In developing countries, fifty percent of pregnant women and 40 percent of preschool children are presumed to be anemic. Health concerns include poor pregnancy outcomes, impaired physical and intellectual development, amplified risk of morbidity in children, and diminished work output in adults. Anemia contributes to 20 percent of maternal deaths but is an avoidable deficiency. Given the high iron content of several insect species, further assessment of more edible insect species is necessary (FAO/WHO, 2001b). Likewise, when iron-rich insects are given to egg-producing poultry such as in chickens and quails, then this could increase the iron content of eggs and meat that are more affordable for low-income families.

The larval stage of *O. rhinoceros* have low anti-nutritional contents (Omotoso, 2018). Comparable observations of lower anti-nutrient values have been detected in *R. phoenicis* (Omotoso & Adedire, 2008). The low levels of saponin, oxalate, tannic acid, alkaloid, and flavonoids obtained in the developmental stages of palm beetles are indications that all the stages are safe for human, and livestock consumption. Oxalates are naturally-occurring elements found in plants, animals, and humans (Rahman *et al.,* 2013). Likewise, saponins are naturally-occurring compounds that are broadly distributed in all cells of legumes (Shi *et al.,* 2004). Saponins have some positive effects on humans. These include improving the immune system for disease protection, lowering the risk of contracting cancer, lowering cholesterol levels, inhibiting dental caries, lowering blood glucose response and platelet aggregation (Shi *et al*., 2004). Flavonoids are abundant in plants and are renowned for pigmentation (Theoharis, 2000).

4. Conclusion

RBLM used in this study has a rate of recovery of 33% and has high protein, fat, fiber, and mineral (Ca, P, and Fe) composition. Furthermore, the aforementioned nutrients have satisfactory to high digestibilities in laying quails. Therefore, RBLM has high nutritive composition and these nutrients are highly digestible in laying quails. Thus, RBLM can be an alternative nutrient resource for laying quails.

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