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Energy Values of Corn and Rice Bran and Energy Levels for Ducks – Basis in Establishing Energy Requirement for Improved Philippine Mallard Duck

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Abstract

New breeds of Philippine Mallard Ducks (PMD) were developed to ensure the availability of outstanding stocks for egg production. Maximizing the potentials of these new breeds can be achieved with sound nutrition. Energy is considered the most important and occupy big fraction in the diet of duck as it influences feed intake and proportion of other nutrients in the diet. Optimaldietary energy levels for the new breeds of PMD is yet to be established.. Determining the energy values of common and locally abundant basal feeds such as corn and rice bran for PMDwill serve as a basis in the inclusion of these feeds to duck's diet. Ducks are considered more efficient in maximizing the energy values of corn (CO) and rice bran (RB) despite of the large proportion of non-starch polysaccharides of RB compared to chickens. Dietary energy levels have not been established for PMD unlike in Pekin ducks (PD) and some indigenous or country ducks. Fast growing PD tend to require a denser energy ranging from 3008 to 3284 kcal/kg compared to 2700 to 2950 kcal/kg for indigenous breeds and khaki Campbell (KC) for optimal performance. It has been found out that the PMD is closely more related to KC than PD. Hence, the possibility of requiring a lower dietary energy than PD. The determination of energy values of CO and RB for PMD and establishment of optimal dietary energy level will facilitate the formulation of PMD specific diet. Thus, this condensed information will serve as concrete viewpoints in understanding bioenergetic dynamics of PMD.

Key Words: Keywords: Philippine Mallard Duck, Energy Values, Corn, Rice Bran.

Introduction

Poultry species have been a steady contributor to the food and protein requirements of the increasing human population. Their products such as meat and eggs have been considered cheap and near perfect food contributing to the stability of protein nutrition of consumers. The increasing demand for their products has led to the intensification of production including tapping native poultry species with outstanding productivity. In the Philippines, the development of the Philippine Mallard Duck (*Anas platyrhynchos*) was initiated in order to have additional protein sources and supply the developed niche market of duck's eggs. Three breeds of Philippine mallard ducks, popularly called "*ItikPINAS*" were selected and developed through intensive continuous selection and breeding from the Mongrel mallard duck population in the country. This includes two pure lines, "*IP-Itim*", "*IP-Khaki*" and hybrid line, "*IP Kayumangi*". These breeds outperformed their Mongrel counterparts in terms of productivity and have peculiar characteristics that make each genetic group distinctive.

Nutrition plays a vital role in maximizing the potential of these new duck strains. Traditionally, mallard duck raisers feed their flock with commercially formulated duck diets. Since there is no available or established data on the specific nutrient requirement of Philippine Mallard Duck, formulation is based on published data generated abroad using different breeds/strains of ducks with the nutrient values of feedstuffs used as a reference in the formulation. With this scenario, a high nutrient-dense diet is offered to Philippine Mallard Duck, which is mismatched with its genetic background as native poultry that naturally subsists on low to medium plane nutrition. Some of the consequences of non-breed or strain-specific diet formulation include high cost, high nutrient excretion, and higher production cost.

Establishing the nutrient requirements specific to Philippine Mallard Duck is necessary to formulate a breed-specific diet that is cost-efficient and with high nutrient utilization. Energy consideration is deemed the most important and comprises the bulk in animal nutrition. It is considered the most expensive nutrient when formulating poultry diets, which is unlikely to change given the stiff competition for available energy sources for human food (Owaga, 2020). Hence, it is necessary to establish the optimum energy requirements of the improved mallard duck. The first step in regulating their energy requirement is to look after feedstuffs' energy values, particularly those of high and low utilization values specific for improved mallard duck.

This paper reviews the concept of energy utilization and influence on ducks' growth and reproductive parameters to provide a theoretical foundation in the conduct of energy balance assays and biological trial experiments that will lead to the establishment of the energy requirement of improved Philippine Mallard Duck. It is crafted based on the following objectives: A) determine the energy values of corn and rice bran for chickens and ducks;B) appraise the influence of dynamic energy levels on the growth and reproductive parameters and performance of ducks; and C)to compare the energy metabolism of poultry species with emphasis on ducks.

II. Energy Utilization and Values of Common Feedstuffs

A. Feed Energy Utilization with Emphasis on Ducks

Evaluating the energy in the diet is imperative in animal nutrition because feed intake is strongly influenced by the energy content of the diet. This implies that the intake of other nutrients such as amino acids is affected by their ratio to the energy content of the feed consumed by the animal (Kim, 2014). For this reason, understanding energy metabolism in poultry is important to determine the exact energy utilization capacity and requirement of the poultry species specifically when comparing a native breed to their commercial breed counterparts. Borin and Lidenberg (2006) indicated that indigenous breeds reared in traditional systems have adapted to the available poor quality feedstuffs, which are generally bulky and with high fiber content and not readily degraded by the enzymes of the small intestine.

Carbohydrates is the main source of energy in the diets of ducks. It is common knowledge that ducks will consume an amount of energy required for maintenance, including basal metabolism and body temperature regulation, regular activity, and normal growth (Adeola, 2006). Like in mammals, the small intestine is the primary site for starch digestion and the absorption of glucose and other monosaccharides (Scanes, 2015). In addition, the simple sugar and starch components of carbohydrates are easily digested in the poultry gastrointestinal tract (GIT). However, some carbohydrate fractions, such as dietary fiber (DF), are not hydrolyzed by avian gastrointestinal enzymes but are fermented by the resident anaerobic microflora. Unfortunately, problems can occur with the feeding of dietary fiber due to the physicochemical properties (i.e., viscosity) of the non-starch polysaccharides (NSPs) (Josefiak et al., 2004). Early reports claimed that ducks have a greater ability to digest cellulose than chickens (Muztar et al., 1977) and ducks breeds such as Pekin and Muscovy ducks are more efficient to digest organic matter, crude fiber, crude protein, and nitrogen-free extract than laying hen (Schubert et al., 1982). These earlier claims have been validated with more recent experiments that yielded the same observations. Linden (2015) claimed that ducks have a higher capacity to digest fiber than chickens at all ages, which was also similar to Jamroz (2005) claim that waterfowls, including ducks, tend to better digest structural carbohydrates and utilize energy from non-starch polysaccharides. An earlier study of the latter researchers demonstrated that ducks have higher digestibility of the non-starch polysaccharides sugar residues and the formation of short-chain fatty acids in the gut at 3.2 kJ g^{-1} compared to 2.8 and 3.7 kJ g^{-1} of chickens and geese, respectively (Jamroz et al., 2002). A study presented by Linden (2015) demonstrated that digestibility of fibrous components in ryegrass for adult Pekin ducks digested 28.3 percent of the crude fiber, which was similar to adult geese and mule ducks suggesting that ducks have different bioenergetics compared with other poultry species particularly chicken due to their added capacity of utilizing energy from non-starch polysaccharides. For this, different dietary energy requirements might be observed with ducks compared with chickens. Poultry Hub Australia supported the latter idea wherein ducks perform optimally on high energy diets, but unlike chickens, they exhibit adequate growth on low energy diets.

Variation on energy metabolisms among duck breeds was observed and might support the idea that breed and strain are factors in energy utilization capacity. This idea is supported by the claim of Begin (1967) indicating that there are variations among breeds, strains, and sexes in their nutritional requirements which, might be attributed to genetic and physiological variation. Sugden (1974) as cited by Ragland et al., (1997) demonstrated that differences in energy metabolism do exist between poultry species and have been observed in birds within the same species as well as across species. As proof, Lancaster et al., (2018) showed that bioavailable energy particularly total metabolizable energy (TME) of submersed aquatic vegetation, was highly variable among duck species, favoring mallard ducks compared with gadwall (*Mareca Strepera)*. A recent study demonstrated a similar result that mallards had slightly greater nitrogen-corrected total metabolizable energy (TME_N) than gadwall (*Mareca Strepera)* for submersed aquatic vegetation species such as Canadian waterweed (*Elodea canadensis*; 1.66 ± 0.26), followed by coontail (*Ceratophyllum demersum*; 1.51 ± 0.28), southern naiad (*Najas guadalupensis*; 1.37 ± 0.39), sago pondweed (*Stuckenia pectinata*; 0.50 ± 0.22), wild celery (*Vallisneria americana*; 0.05 ± 0.42), and Eurasian watermilfoil (*Myriophyllum spicatum*; –0.13 ± 0.42) (Gross et al., 2020). Likewise, the degree of growth is also a factor that influences energy metabolism and consequent utilization. Owaga (2020) pointed out that fast-growing animals require substantial amounts of energy to grow muscle tissue. In terms of energy utilization, the net efficiency of utilization of metabolizable energy for gain was 0.64 for ducklings compared with 0.50 for chickens, as reported by Siregar and Farell (1980). Furthermore, Siregar et al., (1982) emphasized that ducklings required more metabolizable energy per gram of gain but utilized it more efficiently than chickens.

At a molecular level, Zheng et al. (2014) revealed in their proteomic study that metabolic enzymes showed differential abundances in the livers of the lean and fat strains of Pekin duck. Specifically, fat ducks strongly expressed proteins related to glycolysis and ATP synthesis pathways, which is less expressed in lean strain Pekin duck. On breed-specific, Pekin ducks exhibit the highest expression of GLUT or enzymes implicated in glycolysis in their liver compared with Muscovy duck (Tavernier et al., 2020).

B. Apparent and True Metabolizable Energy Values of Corn and Rice bran for Ducks

The energy system for poultry is considered the first step in determining or evaluating ducks' energy utilization capacity for different types of feedstuffs. Different energy evaluating systems have been used to formulate poultry diets including digestible energy, total digestible nutrients, true metabolizable energy, apparent metabolizable energy (AME), and effective energy. The ME system or AME values of raw materials are most commonly and widely used to formulate poultry diets (Barzegar et al., 2020; Kim, 2014). This is because of the exceptional digestive anatomy of poultry species where the feces and uric acid excreted by the birds are mixed in the cloaca, a single opening at the end of the digestive tract (Dunaway, 2019). Likewise, ME levels regulate feed intake and feed efficiency (Owaga, 2020). At present, there is a growing interest in the use of net energy as a basis as it accounts for the energy lost as heat when calculating the available energy to produce meat and eggs. However, limited information on net energy values of various ingredients for poultry feed formulation limits its use (Barzegar, et al., 2020). Nevertheless, the nitrogen-corrected Apparent Metabolizable Energy (AMEn) and Total Metabolizable Energy (TMEn) have been well accepted and widely used energy systems for poultry. The nitrogen correction during the test period is attributed to the catabolized nitrogen excreted in the form of uric acid. Hence, the AME values are thus influenced by the amount of nitrogen retained during the test period. Because test diets are often imbalanced, nitrogen retention varies for different test diets. The ME correction for nitrogen retention in birds allows the comparison between animals. It improves measurement precision since the nitrogen balance is variable in a group of birds (Lessire, 2020).

Corn has been recognized worldwide as a major energy feed ingredient in poultry diets (Dei, 2017) and contains the highest starch content, which is 600–750 g/kg of dry matter (Zhou et al., 2010). In China, corn comprised more than 40 percent by weight of duck diet (Zhao et al., 2008). Presented in Table 1 are the energy values expressed in apparent metabolizable energy (AME), total metabolizable energy (TME), and nitrogen corrected AMEn and TMEn of corn for ducks.

Table 1. Classical and nitrogen corrected apparent and actual metabolizable energy values of corn for ducks from different literatures.

PROCEDURE	BREED/ STRAIN	ENERGY VALUE (Kcal/kg)				SOURCE
		AME	TME	AMEn	TMEn	
Observed*		3480	3742	3415	3590	Zhao et al., 2014
Observed	Cherry Valley	3620	3652	3501	3525	Hoai et al. 2011
Predicted		3480	3742	3440	3590	
Observed	White Pekin	3766	4026	3713	3886	Zhao et al., 2008
Predicted	White Pekin	3770	4034	3701	3877	
Observed, ME Assay	White Pekin	3280	3560	3320	3460	Adeola, 2003
Observed, ME Assay	White Pekin	3110	3310	3100	3270	King et al., 1997
	White Pekin	3160	3480	3240	3400	

*computer-controlled digestion system simulation in ducks

It can be observed in Table 1 that there is a variation in the energy values of corn from the different literatures. The variations are attributed to the procedure of bioassays, age and breed of ducks used and the protocol of bioassays that were followed. Likewise, the computer-aided controlled digestion system simulation in determining corn's energy values is almost similar to the results or values derived from bioassays. Comparing it with chicken, Tyagi et al. (2008) recorded that quality protein maize and commercial maize or corn has an AME of 3185±59 and 3171±77 kcal/kg for adult cockerel. For AMEn value, Amerah et al. (2008) claimed that fine and coarse corn has an AMEn value of 3164 and 3114 kcal/kg, respectively, for broiler starter, and Bartov (1996) revealed that corn stored from 6 to 100 months has an AMEn value of 3275 kcal/kg for male cobb chicks. Higher AMEn value for broilers reported recently by Mtei et al. (2019) showed that fine, medium, and coarse corn particle sizes have 3449, 3456, 3471 kcal/kg, respectively, for Ross cobb broilers. On the other hand, Mtei et al. (2019) reported that fine, medium, and coarse corn particle sizes have an AMEn of 3421, 3477 and 3462 kcal/kg, respectively for Hy-line brown layer chickens. Liu et al. (2020) reported slightly lower energy values on two corn samples stored for three years where the recorded AME and AMEn values were 3294 and 3389 and 3222 and 3294 kcal/kg dry matter for samples 1 and 2, respectively for 35-week old Hy-line brown layers.

On the other hand, rice bran is the most important rice by-product. It is an ingredient of great value in feed formulation because it contains 15 to 18 percent protein, 14 to 18 percent oil, and 30 to 40 percent digestible carbohydrates (Ruiz, 2016). The major carbohydrates of rice bran are cellulose and hemicelluloses. A fraction of starch originating from the endosperm breakage during the milling process (Shaheen et al., 2015) of paddy rice grain. Farrel (1994) claimed that, unlike chickens, it is believed that ducklings can tolerate high levels of rice bran in the diet without depressing performance. In terms of its energy value for ducks, early reports revealed that rice bran has 3070, 2945, 3108 and 2974 kcal/kilogram AME, AMEn, TME and TMEn for meat type growing ducks (Hoai et al., 2011) while Huynh et al. (2013) found that it contains an AME value of 3073 and 2897 kcal/kg analyzed through total and partial collection methods, respectively, for 21-day old Cherry Valley ducks. In a more recent study, Zhang et al. (2019) reported that rice bran has a determined and predicted TME value of 2972 and 2937 kcal/kg for 18 weeks old drakes. The determined TME was obtained through a duck assay system while the predicted was determined through in vitro digestion system using a simulated small intestinal fluid with specific digestive activity.

In contrast with chicken, Attia et al. (2003) asserted that rice bran has AMEn, TME and TMEn values of 3214, 2861, 2976 kcal/kg for broiler chickens. However, recent studies (Xie et al., 2021) claimed that the AME and AMEn values for 14-day and 28 day old broilers were 2390 and 2280 and 2190 and 2087 kcal/kg, respectively which is a lower energy value. In addition, the findings of Gallardo et al. (2020) are almost similar with an AMEn value of 8.47 MJ/Kg or 2023 kcal/kg for growing cobb broilers. Reports of Dalolio et al. (2019) showed that a parboiled brown rice bran has an AMEn value of 2638 kcal/kg for broilers.

Based on the above literature, there is a variation or difference in terms of the metabolizable energy values of corn and rice bran between and within poultry species. This trend was also validated in the study of Preetam and Qudratullah (2009) where they found that the AME values (kcal/kg) were significantly higher in drakes than cocks for corn (3.19 vs 3.58) and rice bran (2.27 vs 1.87). The latter researcher also reported the same trend on the TME values as the endogenous excretory losses (EEL) were less in drakes than in cocks leading to their conclusion that significant differences exist between ducks and chicken for both AME and TME values confirming that species variation do exist in the energetic values of feedstuffs. A recent study revealed that the Itik Pinas (Philippine Mallard Duck), particularly the "*Kayumangg*i" strain, has a higher absorptive capacity for monosaccharides, leading to a higher energy value feed ingredients compared to layer chicken. This is due to the relatively higher mRNA expression of monosaccharide transporter, SGLT1 in the intestinal segments of Itik Pinas compared to commercial layer chicken (Pinca et al., 2019). Accordingly, Adeola (2006) claimed that the energy in the feedstuffs had additives when compounded into a diet for ducks.

III. Energy Levels on Ducks Performance – Predicting Optimum Dietary Energy Requirement

In terms of comparing the energy requirements of the different duck breeds, it is common knowledge that variations in terms of energy density requirements occur as discussed in the previous chapter. It is worthy to consider the genetic relationship of the Philippine Mallard Ducks with the other duck breeds and make this a cornerstone in determining their optimum energy requirements. Majority of studies relative to bioenergetics of ducks utilized Pekin Duck as bio-assay material with minimal studies on other breeds. Relationship analyses revealed that the Philippine Mallard is genetically closer to the Khaki Campbell (0.0944) than to the Pekin (0.1523) (Agatep et al., 2018).

A. Growth Performance

A dietary energy increase from 2,600 to 3,100 kcal of AME/kg, the weight gain of white Pekin ducks, increased significantly while significantly decreased in feed intake and feed: gain was attained. A broken-line regression analysis revealed that the AME requirement of White Pekin duck from 2 to 6 weeks of age for optimal weight gain and feed: gain were 3008 and 3030 kcal/kg, respectively peg at 18 % dietary protein. Dietary AME above 2700 Kcal/kg significantly increased (P <0.05) accumulation of abdominal fat (Fan et al., 2008). Xie et al. (2010) presented an almost similar AME requirement for the same duck breed from hatch to 3 weeks of age at 12.63 MJ/kg or 3017 kcal/kg. This energy level is required for optimal feed conversion efficiency. At the same time, increasing does not affect (P>0.05) the percentage of breast and leg meat in the carcass, and a similar observation on abdominal fat accumulation was reported by Fan et al. (2008). Wen et al. (2017) conform to the results of Xie et al. (2010) on the same breed and age of ducks with slightly higher energy levels (2750 and 3050 kcal/kg). Wen et al. (2017) also revealed that increasing energy levels did not affect the overall body weight gain and even decreased the feed intake and feed to gain. Only the accumulation of abdominal fats increased due to the increasing energy levels. However, it is noteworthy that their study also considered the levels of lysine supplementation. On the other hand, higher energy levels and AMEn requirements were determined by Zeng et al. (2015) and indicated that 15-30 days old Pekin ducks fed with increasing dietary energy levels (11. 8, 12.8 and 13.8 MJ/kg or 2818, 3057 and 3296 kcal/kg) manifested an increased body weight gain, dressing percentage, and subcutaneous fat but decreased breast yield. Determining the AMEn value of the dietary energy levels, they found that 13.75 MJ/kg or 3284 kcal/kg at 19 % CP concentration yielded the best body weight gain and feed conversion ratio.

However, different energy density requirements are observed on native ducks compared with fast-growing White Pekin ducks. Kim et al. (2012) reported that Korean Native male ducks efficiently utilized diets with 2800 kcal of ME/kg and 23% CP or with 2900 kcal of ME/kg and 17% CP at 0 to 3 weeks and 4 to 8 weeks, respectively. However, diets with 3000 kcal of ME/kg at 4 to 8 weeks tend to increase carcass rate quadratically. On younger (hatch -21 day-old) Korean native ducks, the estimated AME requirements were 2953, 3007, and 2950 kcal AME/kg for maximum daily gain, daily feed intake, and minimum feed conversion ratio, respectively (Wickramsuriya et al., 2016). On the other hand, Thongwittaya (1992) claimed that ducks (Khaki Campbell x Thai native ducks) could be raised with a diet low in ME as 2.7 Mcal/kg during the whole growing period.

On the available data on dietary energy density for Philippine mallard ducks or *ItikPINAS*, Diego et al. (2021) used 2814 and 2839 kcal/kg AME obtained by calculation and analyses, respectively, for 12-18 weeks (developer) *Itik*PINASwithout affecting performance. On the other hand, Martin et al. (2020) formulated diet for growing *ItikPINAS -Kayumanggi* at 2800 Kcal/kg AME.

B. Laying Performance

Metabolizable energy (ME) levels in the diet of cage ducks affected the feed consumption and feed-egg ratio and the appropriate ME level is 11.30 MJ/kg (Hong -min et al., 2008). Similarly, the same energy level was identified to be suitable for the optimal egg production for Shaoxing ducks (Dai Xianjun et al., 1999). On Longyan laying ducks, diets containing ME of 12.9 kcal/g protein optimized both egg production and egg mass, while the feed conversion was optimized at 12.8 kcal ME/g protein. Using ME to CP ratio of 12.9 kcal/g protein, i.e., 2451 kcal ME/kg at 19% CP, maximized the reproductive performance (Xia et al., 2019). While, on Khaki Campbell x Thai native ducks, no significant difference in egg production was found among the energy levels (2.70, 2.75, 2.80, 2.85 and 2.90 Mcal ME/kg). However, feed cost to produce 1k eggs was lower in the 2.70 Mcal than in the higher ME levels (Thongwittaya et al., 1992). On Philippine mallard duck, Pasebre (2014) reported that a diet with 2800 kcal ME/kg had the highest egg production and egg mass while 3000 kcal ME/kg had the lowest egg production and egg mass attributed to its large final body weight. There were no significant treatment effects on the ducks' egg weight and feed efficiency. However, significant differences were observed in egg mass and feed consumption. Increasing the energy content of the diet beyond 2800 kcal ME/kg did not improve egg production and egg mass. The identified optimum dietary energy level for laying ducks from weeks 23 to 32 is 2800 kcal ME/kg.

Conclusion

There is a variation in the energy metabolism and utilization among poultry and within the species. Ducks compared with chicken, have higher energy utilization from carbohydrates and have the capacity to digest and use the non-starch polysaccharides to yield energy for metabolic processes. This knowledge provided an idea that Philippine Mallard Ducks including the improved strains have higher energy utilization from feeds thereby, maximizing the energy content of feed ingredients especially those with relatively high non-starch polysaccharides. Available information on energy values of feedstuffs was obtained from White Pekin duck, a fast-growing breeds duck. There is no data obtained from native ducks. The energetic values of corn and rice bran for ducks are relatively higher than other poultry species, particularly chicken. Energetic values of corn and rice bran when used in duck feed formulation were based on commercial chicken. With this, the Philippine Mallard ducks might elicit further higher energy values of corn, a common basal feed ingredient and extensively influence the cost of the diet and rice bran, a less utilized basal feed in the chicken ration. Energy levels are well documented to affect ducks' growth and reproductive performance. Most literature focused on Pekin duck with only a few on other and indigenous breeds. Pekin duck has a higher energy requirement for optimal performance compared with indigenous or country breeds and khaki Campbell. Philippine Mallard Duck might require a lower dietary energy level as it is closely related to Khaki Campbell than the Pekin duck. This idea needs scientific study to optimize the feeding management and performance of the Philippine Mallard Ducks.

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