Utilization of Nutrients, Amino Acids, and Energy from Compound Enzyme-Supplemented Palm Kernel Meal and Coconut Meal by Linwu Ducks (Post-print)

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Abstract

This experiment aimed to investigate the utilization rates of nutrients, amino acids, and energy from palm kernel meal (PKM) and coconut meal (CM) supplemented with compound enzyme in Linwu ducks. Forty healthy adult male Linwu ducks with a body weight of (2.0$±$0.2) kg were selected and randomly allocated to 5 groups, with 8 replicates per group and 1 duck per replicate. A force-feeding metabolism trial was conducted: ducks in groups 1 and 2 were force-fed 50 g/d of palm kernel meal, ducks in groups 3 and 4 were force-fed 50 g/d of coconut meal, and ducks in group 5 were force-fed 50 g/d of a nitrogen-free diet. Compound enzyme was added at 250 mg/kg to the ingredients in groups 2 and 4. The preliminary period lasted 7 days, and the formal experimental period lasted 4 days. The results showed: 1) The true utilization rates of dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF), and gross energy (GE) in palm kernel meal by Linwu ducks were 48.81%, 54.34%, 65.69%, 40.36%, and 39.37%, respectively; the apparent metabolizable energy (AME) and true metabolizable energy (TME) were 6.18 and 7.49 MJ/kg, respectively; the true utilization rates of 15 amino acids ranged from 50.28% to 87.97%; the true utilization rates of DM, CP, EE, CF, and GE in coconut meal by Linwu ducks were 52.23%, 58.49%, 70.28%, 34.67%, and 54.76%, respectively; the AME and TME were 7.47 and 9.64 MJ/kg, respectively; the true utilization rates of 15 amino acids ranged from 58.53% to 90.21%. 2) After compound enzyme supplementation, the apparent and true utilization rates of CP in both palm kernel meal and coconut meal were significantly increased ($P<0.05$); TME was increased by 5.61% and 3.63%, respectively ($P>0.05$); the true utilization rates of 15 amino acids were increased by 0.27%~7.36% and 0.67%~4.99%, respectively; the true utilization rates of tyrosine and proline in palm kernel meal, as well as aspartic acid, isoleucine, and tyrosine in coconut meal, were significantly improved ($P<0.05$). In conclusion, supplementation of a compound enzyme containing protease, cellulase, and xylanase can improve the utilization rates of nutrients and energy from palm kernel meal and coconut meal in Linwu ducks.

Full Text

Effects of Palm Kernel Meal and Copra Meal Supplemented with Compound Enzymes on Nutrient, Amino Acid and Energy Utilization Rates of Linwu Ducks

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Abstract: This study investigated the effects of palm kernel meal (PKM) and copra meal (CM) supplemented with compound enzymes on nutrient, amino acid, and energy utilization rates in Linwu ducks. Forty healthy adult male Linwu ducks with a body weight of (2.0$±$0.2) kg were randomly divided into 5 groups, with 8 replicates per group and 1 duck per replicate. A forced-feeding metabolism trial was conducted: ducks in groups 1 and 2 were force-fed 50 g/d of palm kernel meal, ducks in groups 3 and 4 were force-fed 50 g/d of copra meal, and ducks in group 5 were force-fed 50 g/d of a nitrogen-free diet. Compound enzymes were added at 250 mg/kg to the feedstuffs in groups 2 and 4. The experiment consisted of a 7-day pre-trial period and a 4-day experimental period. The results showed: 1) The true utilization rates of dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF), and gross energy (GE) in palm kernel meal were 48.81%, 54.34%, 65.69%, 40.36%, and 39.37%, respectively. The apparent metabolizable energy (AME) and true metabolizable energy (TME) were 6.18 and 7.49 MJ/kg, respectively, and the true utilization rates of 15 amino acids ranged from 50.28% to 87.97%. For copra meal, the true utilization rates of DM, CP, EE, CF, and GE were 52.23%, 58.49%, 70.28%, 34.67%, and 54.76%, respectively. The AME and TME were 7.47 and 9.64 MJ/kg, respectively, and the true utilization rates of 15 amino acids ranged from 58.53% to 90.21%. 2) Supplementation with compound enzymes significantly increased the apparent and true utilization rates of CP in both palm kernel meal and copra meal ($P<0.05$). The TME increased by 5.61% and 3.63% ($P>0.05$), respectively. The true utilization rates of 15 amino acids increased by 0.27%-7.36% for palm kernel meal and 0.67%-4.99% for copra meal. The true utilization rates of tyrosine and proline in palm kernel meal, and aspartate, isoleucine, and tyrosine in copra meal were significantly improved ($P<0.05$). These results indicate that supplementing palm kernel meal and copra meal with compound enzymes containing protease, cellulase, and xylanase can improve the utilization rates of nutrients and energy in Linwu ducks.

Keywords: palm kernel meal; copra meal; nutrient utilization rate; metabolizable energy; compound enzymes; Linwu ducks

Introduction

Palm kernel meal (PKM), also known as palm kernel expeller, is a byproduct obtained after oil extraction from palm kernels. Copra meal (CM) is a byproduct derived from dried coconut endosperm (copra) after pre-pressing and solvent extraction of oil. As relatively inexpensive protein feed ingredients, palm kernel meal and copra meal can replace soybean meal in livestock and poultry diets. However, both feedstuffs contain high levels of crude fiber (CF), which can be well utilized by ruminants but show low nutrient and energy utilization rates in monogastric animals, even causing reduced growth performance in poultry. The addition of feed enzymes can degrade anti-nutritional factors in palm kernel meal and copra meal, thereby improving their utilization by livestock and poultry.

Previous studies have demonstrated the efficacy of enzyme supplementation. Zhang et al. [1] reported that adding β-mannanase to diets containing 30% palm kernel meal significantly improved the crude protein (CP) digestibility and metabolizable energy of palm kernel meal in Cherry Valley meat ducks. Abdollahi et al. [2] found that adding compound enzymes to broiler diets containing 8%, 16%, and 24% palm kernel meal improved the apparent digestibility of starch, fat, and neutral detergent fiber (NDF), and enhanced feed conversion ratio when palm kernel meal inclusion was 8%. Wang et al. [3] showed that supplementing diets containing 5% palm kernel meal and 10% copra meal with compound non-starch polysaccharide enzymes plus β-mannanase improved the growth performance of Cherry Valley meat ducks.

The present study used Linwu ducks as experimental animals to determine the metabolizable energy of palm kernel meal and copra meal and the utilization rates of conventional nutrients and amino acids through metabolism trials. Additionally, we investigated the effects of compound enzymes comprising protease and non-starch polysaccharide enzymes on nutrient and energy utilization of these feedstuffs, aiming to provide reference and basis for the use of palm kernel meal and copra meal in meat duck diets and feed formulation.

Materials and Methods

Test Materials

Palm kernel meal and copra meal produced in Malaysia were ground using a solid grinder (60–200 mesh) and passed through a 40-mesh sieve (450 μm), then stored in wide-mouth bottles and sealed bags for later use.

Enzyme Preparation

The compound enzyme preparation used in this experiment contained protease (6,000 U/g, measured by SB/T 10317—1999 method), cellulase (1,000 U/g, measured by GB/T 23881—2009 method), and xylanase (12,000 U/g, measured by GB/T 23874—2009 method).

Experimental Animals and Grouping

Forty healthy adult male Linwu ducks with a body weight of (2.0$±$0.2) kg, normal feed intake, no abnormal behaviors, and no adverse reactions after forced feeding were selected as experimental animals. They were individually housed in metabolic cages and randomly divided into 5 groups, with 8 replicates per group and 1 duck per replicate. The experiment was conducted in the poultry metabolism laboratory of the Waterfowl Experimental Farm at Hunan Institute of Animal Science and Veterinary Medicine under natural lighting with free access to water.

Determination of Nutrient Composition and Gross Energy

The contents of dry matter (DM), CP, ether extract (EE), CF, neutral detergent fiber (NDF), acid detergent fiber (ADF), crude ash, calcium (Ca), and total phosphorus (TP) were determined using methods described in reference [4]. Gross energy (GE) was measured using an automatic oxygen bomb calorimeter (Hunan Kaiyuan Instrument Co., Ltd.), and the contents of 15 amino acids in samples were determined using a German Sykam S-433D amino acid analyzer.

Determination of Utilization Rates of Conventional Nutrients, Amino Acids, and Energy

The experiment consisted of two stages: a pre-trial period and a formal trial period (fasting and emptying, forced feeding, and collection of excreta). The pre-trial period lasted for one week, during which a complete diet was fed. Before the formal trial, the experimental feedstuffs were fed for one meal, followed by a 48-hour fasting period with free access to water and daily supplementation of 50 g glucose per duck through drinking water. After fasting, forced feeding was conducted to the extent that ducks would not vomit. Ducks in groups 1 and 2 were force-fed 50 g/d of palm kernel meal, ducks in groups 3 and 4 were force-fed 50 g/d of copra meal, and ducks in group 5 (endogenous group) were force-fed 50 g/d of a nitrogen-free diet (composed of 45.5% corn starch, 45.5% sucrose, 5% cellulose powder, 4% dicalcium phosphate, trace mineral premix, and vitamin premix). Compound enzymes were added at 250 mg/kg to the feedstuffs in groups 2 and 4. Immediately after forced feeding, collection trays were placed under the metabolic cages, and the forced feeding time was recorded individually. Excreta were collected for 48 hours. Based on the fresh excreta weight and moisture content, 1-10 mL of 10% HCl was added for nitrogen fixation and 3-5 drops of toluene for preservation. The samples were mixed thoroughly and immediately stored at 4°C. After complete collection, samples were dried in a 60–65°C oven with forced air to constant weight, equilibrated at room temperature for 24 hours, weighed, ground through a 40-mesh sieve, and stored in sealed bags for analysis. The GE, DM, CP, EE, CF, ash, Ca, TP, and amino acid contents of excreta were determined using the same methods as described in section 1.3.1. The utilization rates of nutrients and energy, as well as the effective nutrient improvement values (ENIV) after enzyme addition [5], were calculated using the following formulas:

Nutrient apparent utilization rate (%) = [(nutrient intake -nutrient excretion) / nutrient intake] × 100;
Nutrient true utilization rate (%) = [(nutrient intake -nutrient excretion + endogenous nutrient) / nutrient intake] × 100;
Apparent (true) available nutrient (g/kg) = nutrient apparent (true) utilization rate × nutrient content in feed × 1,000;
ENIV (g/kg) = true available nutrient in enzyme-supplemented feedstuff -true available nutrient in unsupplemented feedstuff;
Apparent metabolizable energy (AME, MJ/kg) = (GE intake -GE in excreta) / intake of air-dry matter;
True metabolizable energy (TME, MJ/kg) = (GE intake -GE in excreta + endogenous energy) / intake of air-dry matter;
Energy apparent utilization rate (%) = (AME / GE of feedstuff) × 100;
Energy true utilization rate (%) = (TME / GE of feedstuff) × 100;
ENIV of TME (MJ/kg) = TME of enzyme-supplemented feedstuff -TME of unsupplemented feedstuff.

Data Processing

Data were initially processed using Excel 2003 software. Independent samples t-tests were performed using SPSS 19.0 statistical software, with significance level set at $P<0.05$. Results are expressed as "mean ± standard deviation."

Results

Conventional Nutrient, Amino Acid Contents, and Gross Energy of Palm Kernel Meal and Copra Meal

The conventional nutrient and amino acid contents of palm kernel meal and copra meal are detailed in Table 1 . The gross energy values of palm kernel meal and copra meal were 19.025 and 17.768 MJ/kg, respectively.

Effects of Compound Enzymes on Utilization Rates of Conventional Nutrients and Energy, and on AME and TME of Palm Kernel Meal and Copra Meal

As shown in Table 2 , supplementation with compound enzymes significantly improved the apparent and true utilization rates of CP in both palm kernel meal and copra meal ($P<0.05$). The TME increased by 5.61% and 3.63% ($P>0.05$), respectively. The ENIV values for CP and CF in copra meal were slightly higher than those in palm kernel meal.

Effects of Compound Enzyme Supplementation on Amino Acid Utilization Rates of Palm Kernel Meal and Copra Meal

Table 3 presents the effects of compound enzyme supplementation on amino acid utilization rates. The true utilization rates of 15 amino acids increased by 0.27%-7.36% for palm kernel meal and 0.67%-4.99% for copra meal. The true utilization rates of tyrosine and proline in palm kernel meal, and aspartate, isoleucine, and tyrosine in copra meal were significantly improved ($P<0.05$).

Discussion

Feed Value of Palm Kernel Meal and Copra Meal

Palm kernel meal and copra meal are rich in protein and can be used in diets for beef cattle, dairy cows, sheep, goats, growing pigs, poultry, and freshwater fish. Copra meal has good palatability for ruminants and can also be used in monogastric animal diets. However, due to its high CF content, poor digestibility, and strong water-holding capacity, copra meal can reduce feed intake in monogastric animals and is not suitable for diets of chicks and piglets. Non-starch polysaccharides in palm kernel meal account for more than 80% of total carbohydrates [6], containing substantial amounts of β-mannan and lignin, resulting in low metabolizable energy. Research on growing broilers found that the average amino acid availability values of palm kernel meal were slightly lower than those of soybean meal, cottonseed meal, and rapeseed meal (84.5%, 97.3%, 92.5%, and 91.9%, respectively). Glycine and arginine showed low availability values in palm kernel meal, while lysine availability was higher than in cottonseed meal and methionine availability was higher than in rapeseed meal [7]. Shi et al. [8] reported that replacing corn with palm kernel meal at levels below 20% had no significant effect on growth performance of finishing pigs, and inclusion levels below 15% did not significantly affect carcass quality. Other researchers formulated layer diets with copra meal and coconut oil, finding that egg production rate was highest when copra meal was included at 20% with 0% coconut oil [9]. Wang et al. [10] observed that adding different levels of copra meal to diets of Sichuan white geese significantly increased feed-to-gain ratio and reduced slaughter percentage when inclusion exceeded 20%, adversely affecting growth performance. Qin et al. [11] determined the true digestibility of amino acids in copra meal for Cherry Valley ducks to be 65.68%-89.68%, which is similar to our results. The amino acid digestibility of copra meal is higher than that of palm kernel meal but lower than that of soybean meal. Using palm kernel meal and copra meal as protein feed ingredients to replace soybean meal can reduce feed costs and is therefore feasible.

Effects of Compound Enzymes on Nutrient Utilization and Metabolizable Energy of Palm Kernel Meal and Copra Meal in Ducks

The main non-starch polysaccharides in palm kernel meal are β-mannan, lignin, and cellulose, while copra meal contains large amounts of β-mannan and cellulose, plus small amounts of xylan, glucan, and galactose. Some researchers have used fermentation treatment to improve the utilization of palm kernel meal and copra meal by laying hens [12], while others have added enzyme preparations to reduce the adverse effects of anti-nutritional factors. Sinurat et al. [13] found in a study replacing soybean meal with palm kernel meal in laying hen diets that adding compound enzymes containing β-mannanase, cellulase, β-mannosidase, and α-galactosidase improved ileal amino acid digestibility and AME of fermented palm kernel meal. Replacing 25%–50% of soybean meal with fermented palm kernel meal plus compound enzymes did not adversely affect laying hen performance. Similarly, adding a compound enzyme preparation containing xylanase, glucanase, cellulase, pectinase, protease, amylase, phytase, and lipase improved ileal amino acid digestibility of palm kernel meal but did not increase AME. This difference suggests that mannanase plays an important role in improving metabolizable energy of palm kernel meal, consistent with its high mannan content. Similar conclusions were drawn in meat duck studies. Zhang et al. [1] reported that adding β-mannanase to diets containing palm kernel meal significantly improved CP digestibility and metabolizable energy in Cherry Valley ducks. Wang et al. [3] found that adding compound non-starch polysaccharide enzymes plus β-mannanase to diets containing palm kernel meal and copra meal improved growth performance of Cherry Valley meat ducks. Su et al. [14] observed that adding 15% palm kernel meal to diets of 15–45 day-old mule ducks adversely affected growth, which was ameliorated by mannanase supplementation. Wu and Luo [15] reported that adding 2 g/kg of mannanase, galactosidase, and protease to broiler diets containing 20% palm kernel meal could offset the negative effects on growth performance. Diarra [16] found that supplementing enzyme preparations (containing xylanase, β-glucanase, cellulase, pectinase, amylase, protease, phytase) to growing pullet diets containing 15% copra meal maintained normal growth performance and reduced diet costs when copra meal was used as the protein source. However, Kwon and Kim [17] obtained different results, finding that adding 0.3% (2,400 U/kg) β-mannanase to pig diets containing palm kernel meal and copra meal did not significantly affect energy utilization. This discrepancy may be related to the high inclusion level (30%) of these feedstuffs, as excessive fiber content can reduce diet protein and fat digestibility [18], potentially offsetting the energy increment from improved fiber utilization by enzymes.

In this study, the combination of cellulase, xylanase, and protease added to palm kernel meal and copra meal significantly improved the utilization rates of CP and several amino acids, with some improvement in other nutrient utilization rates. The ENIV values for CP and CF in copra meal were slightly higher than those in palm kernel meal. When formulating animal diets with palm kernel meal and copra meal, enzyme supplementation can facilitate feed digestion and utilization, reducing feed costs. For diets containing palm kernel meal, supplementation with β-mannanase and cellulase is needed to degrade mannan and other anti-nutritional factors. For copra meal-based diets, β-mannanase, cellulase, and xylanase should be added, with optional supplementation of glucanase and galactosidase. To better utilize amino acids in these feedstuffs, protease can also be added.

Conclusion

Supplementing palm kernel meal and copra meal with compound enzymes containing protease and non-starch polysaccharide enzymes can improve the utilization rates of nutrients and energy in Linwu ducks.

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