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主　論　文　の　要　旨

論文題目　Study on novel feeding systems using coconut co-products in swine in the Philippines
（フィリピンにおけるココナツ由来副産物を用いたブタの新たな飼養体系に関する研究）

氏　　名　DE CASTRO Ronilo Onigo

論　文　内　容　の　要　旨

Swine and coconut productions are two important agricultural industries in the Philippines. Pig and coconut production provide food and livelihood to many Filipinos and also greatly contribute to the agricultural economy. However, cost of feed accounts to about 70% of the total cost in animal production. Currently, because of the increasing cost of traditional ingredients (e.g. corn, soybean meal, wheat, fish meal etc.), the importance and use of agricultural co-products as feedstuff for swine has increased. Thus, co-products of the coconut industry become more important to be used as animal feed. The Philippines, as the top producer of coconut, alongside also produced large volumes of coconut co-products (CCP) which are being used as feed for pigs. Majority of these CCP include copra meal (CM) or copra expellers and white copra (WC), which are traditionally and mainly used as ingredient in making animal feeds. The CM is produced by expeller extracting or solvent extracting the oil from dried coconut kernels. It is believed to contain high energy value because of its residual oil content. The WC is a co-product in the manufacture of virgin coconut oil (VCO) which is reported to have about 35 to 48% residual oil content. The VCO is the natural oil obtained from fresh, mature kernel of the coconut by mechanical extraction. The residues of WC are used as feeds or processed into high-value products. The protein enriched copra meal (PECM) is produced by subjecting raw CM in a solid-state fermentation process, using *Aspergillus niger* to increase the protein content. The crude protein (CP) of PECM ranges from 35 to 38% on a dry matter (DM) basis.

Despite being available in the Philippines, data on nutrient compositions and feeding values of locally produced CCP in swine are very limited. This lack of data may lead to use of inaccurate nutrient values for CCP. Such situation will also lead to

inaccurate feed formulation if CCP is used in the mixed feed. This may affect the production efficiency of pigs. Feeding experiments and laboratory analysis, and use of highly specialized equipment are needed to generate data, but are expensive. Thus, this study aims to determine the nutritive value of CCP to effectively utilize in swine diets and also, to develop novel tools to accurately predict the nutrient value of CCP. In this study, instrumental color was used to develop tools such as prediction models to estimate the nutrient value in CCP. A special equipment called colorimeter was used to quantify the color. The principle in measuring instrumental color in CCP lies behind the fact that varying degrees of heat treatment is applied to CCP during its production and this process results to differences in the physical color and nutrient compositions in CCP.

In Chapter 2, samples were collected from different sources to establish the nutrient composition and physical characteristics of CCP and to develop equations to estimate nutrient composition in CCP. Wide variation in the chemical compositions were observed in 28 CCP, particularly the ether extract (EE), CP, and crude fiber (CF) content. Also, wide variation was observed in particle size and color values in CCP. This suggests that the differences in processing methods and source influenced the chemical composition and physical characteristics in CCP. Prediction models were successfully developed to estimate the gross energy (GE), CP using EE and ash, respectively as well as prediction of essential amino acids (AA) (isoleucine, leucine, methionine, phenylalanine, threonine and valine) using CP in CCP. The instrumental color was found useful to estimate the content of selected essential AA (arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, tryptophan, threonine and valine) and other chemical compositions (GE, CP, EE, neutral detergent fiber [NDF]) in CCP.

In Chapter 3, an energy balance experiment using 22 growing pigs placed in a metabolism cage was conducted to determine the concentration of digestible (DE), metabolizable (ME) and net energy (NE), and to develop prediction equations for DE and ME in CCP fed to growing pigs. The CCP used were CM, PECM and WC, which were obtained from different sources in the Philippines. A total collection of feces and urine method using marker to marker approach was used in the experiment. The DE, ME and NE concentrations differed among CCP sources fed to growing pigs, and ranged from 1,843 to 3,284, 1,666 to 3,211, and 1,008 to 2,352 kcal/kg DM, respectively. This may be due to differences in the residual oil and fiber content observed in CCP samples. A positive correlation was observed between the DE and ME and acid detergent fiber (ADF) using 8 CCP samples (excluding WC samples). Moreover, DE and ME values in CM can be predicted using ADF as independent variable. Lastly, instrumental color cannot be used to estimate the digestibility of DE and ME in CCP fed to growing pigs.

In Chapter 4, a feeding experiment using 22 growing pigs was conducted to determine the apparent (ATTD) and standardized total tract digestibility (STTD) of phosphorus (P) and calcium (Ca) in CCP fed to growing pigs, and to develop prediction equations to estimate ATTD and STTD of P and Ca. The CCP used were CM, PECM and WC. The ATTD and STTD of P and Ca among CCP sources were not significantly different when fed to growing pigs. The STTD P and ATTD Ca in CCP may be best predicted using total P and Ca as independent variables, respectively. However, it was found that instrumental color cannot be used to estimate the digestibility of P and Ca in CCP fed to growing pigs.

In Chapter 5, a feeding experiment using 6 pigs (surgically equipped with T-cannula in the distal ileum) was conducted to determine the apparent (AID) and standardized ileal digestibility (SID) of AA in CCP and soybean meal (SBM) fed to growing pigs and also to develop equations to estimate SID of AA in CCP. The CCP used were: 1) CM and 2) WC; 3) oven-dried CM (ODCM, oven-dried at 150°C for 30 min) and; 4) PECM. The AID and SID of most AA were not significantly different among pigs fed diets with different CCP sources. The concentration of standardized ileal digestible CP and AA in CCP were less than SBM. The standardized ileal digestible arginine, glutamic acid, and tyrosine in CCP were negatively correlated with CP. The lower amount standardized ileal digestible lysine in ODCM is most likely due to heat damage (oven-drying at 150°C for 30 min) as a result of the Maillard reaction. Lastly, instrumental color particularly can be used to estimate the standardized ileal digestible lysine in CCP fed to growing pigs.

In conclusion, the present study has successfully established the chemical composition and physical characteristics, determined the digestibility values of energy (DE, ME, NE), P and Ca (STTD of P and ATTD of Ca), and the digestibility of AA (SID of AA) in locally produced CCP. Also, the study has developed prediction equations to estimate nutrient composition and feeding values in CCP. Lastly, instrumental color was found useful to estimate the GE, CP, EE and NDF contents, the total arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, tryptophan, threonine and valine, and the standardized ileal digestible lysine in CCP fed to growing pigs, using the prediction models developed. The established nutrient values and the novel tools developed for CCP in this study are expected to maximize the utilization of CCP as alternative feedstuff in swine diets.