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学位論文題目	Nutritional studies on the utilisation of shrimp by-products as a potential protein source for chicken feed (エビ加工副産物を養鶏用飼料のタンパク質源として利用するための栄養学的研究)		
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論 文 内 容 の 要 旨

[Objectives] The prime objective of this study was to boost up nutritional quality of shrimp meal (SM) as a potential source of protein for chicken feeds. Therefore, the specific objectives were: I) to measure the nutritional quality SM with autoclave and chemical treatments: an *in vitro* study, and II) to investigate the performances of layers and broilers fed treated SM to recognise the suitability of this SM as a protein source for chicken feed.

[Materials and Methods] At First, the sun-dried shrimp waste, composed of heads and hulls of black tiger shrimp (*Penaeus monodon*) was divided into five treatment groups namely, 1) control (intact SM), 2) autoclaved, 3) NaOH treated, 4) HCl treated, and 5) formic acid treated SM. The autoclaving process was conducted at 121°C with 2.09 kg/cm² for 10 min and then sun dried. The preparation of chemical treated SM samples was as follows: about 100 g of sun-dried shrimp waste was suspended in 300 ml of 1, 3, and 5% acids (HCl or formic acid) or alkali (NaOH) solutions at room temperature for 20 minutes. After that, they were sun-dried and milled through a 1.0 mm mesh screen. Finally, all the samples were used to determine chemical composition and *in vitro* digestibility. Accordingly, shrimp waste treated with 3% formic acid considered as treated SM (TSM), and conducted a feeding trial to investigate the palatability (choice-feeding) in layers for 5 d. The hens were distributed into four groups (4 birds each) with 7 experimental diets: a control diet, diets containing 3 SM (5, 10, and 15%), and 3 TSM (5, 10, and 15%) were prepared. Subsequently, laying performance and egg quality of layers fed dietary TSM were investigated. A total of 56 laying hens were placed in individual cages and offered 7 diets with the same manner for 30 d feeding trial. After that, the palatability of dietary TSM was investigated in broilers: 20 broiler chicks (15 d old) were distributed into five groups (4 chicks each) and freely fed 7 experimental diets (1 control, and 5, 10, and 15% of SM, and 5, 10, and 15% of TSM) for 7 d feeding trial. Accordingly, growth performance and nutrient digestibility of dietary TSM were examined in broilers. A total of 42 male broilers (8 d old) were distributed into 7 dietary groups where SM and TSM were added into the diets with the same manner, and offered diets till 35 d old. All the feeding trials, diets were formulated according to the Japanese feeding standard for poultry (2011).

[Results and Discussion] The results obtained in this study indicated that SM was rich in crude ash (CA), and chitin, hence poor in CP and comparable to the autoclaved SM. NaOH treatment exhibited decreased CP level and DM digestibility, and unchanged CP digestibility which means NaOH treatment affected the nutritional quality of SM adversely ($P<0.05$). In contrary, beneficial effects were obtained in acids treatment: increased CP level and *in vitro* digestibilities of DM and CP, and decreased CA level, showing that acid treatment can improve the nutritional quality of SM ($P<0.05$). The magnitude of improvement was greater in formic acid treatment than HCl, and the greater digestibility values were obtained in 3% formic acid treatment group. As a result, it is suggested that formic acid treatment is promising to improve the nutritional quality of SM and seemed to be used as a potential source of protein in chicken diets. Accordingly, dietary SM and TSM were used to investigate the palatability in laying hens, and the result revealed that dietary SM showed decreased feed intake (FI) as well as their feed preference ($P<0.05$). Instead, TSM groups exhibited the increased FI and preference of feed which was comparable to the control group. Thus, it may conclude that the dietary TSM was more palatable than SM which is associated with the pleasant aroma and comfortable taste. Subsequently, dietary SM and TSM were tested in laying hens for their laying performance along with egg quality, and the results indicated that the laying performance was decreased with increasing level of dietary SM, while TSM groups did not show such detrimental effects. However, egg quality parameters, such as egg weight, shell thickness and specific gravity did not differ among the dietary groups. Interestingly, eggshell strength and yolk colour were increased with the increased levels of dietary SM and TSM compared to the control group ($P<0.05$). Taking into account, the dietary TSM had the beneficial effects on laying performance, along with improved eggshell strength and yolk colour in laying hens, even though it can be included up to the level of 15% in the diets. Therefore, the preferences of dietary SM and TSM on palatability of broilers were investigated, and the results indicated that FI and preference of feed were significantly greater in TSM groups than SM groups. Thus, this results confirmed that dietary TSM was more palatable than SM. Accordingly, dietary SM and TSM were tested as a protein source in broiler diets, and the results showed that broilers received high levels of dietary SM, such as at and above 5%, exhibited adverse effects on body weight gain, FI and FCR ($P<0.05$). Similar trend was observed in the TSM groups, but the adverse effects of the TSM were milder in comparison to the SM groups ($P<0.05$). The nutrient digestibilities tended to decrease ($P<0.05$) with increasing levels of the SM but unchanged with increasing level of the TSM. Although N retention decreased ($P<0.05$) with increasing levels of the SM and TSM in diets but the decreasing trend was milder in the TSM groups than the SM groups. As a result, the dietary TSM had the beneficial effects on growth performance, along with improved digestibility and N retention in broilers as far it is included at and below 10% in the diets.

[Conclusion] The results obtained in this study revealed that the possible two factors such as chitin and ash in SM were overcome by formic acid treatment and successively improved their nutritional quality. In conclusion, it is suggested that this SM can be used as a potential protein source for chicken feed, and accordingly, by using this simple technology would help to reduce not only poultry production cost but also waste disposal and environmental pollution, especially for the developing countries.