BILINGUAL PUBLISHING CO.
Pioneer of Global Academics Since 1984

Journal of Zoological Research
https://ojs.bilpublishing.com/index.php/jzr

ARTICLE

Effect of Additional Feed Supplement Fermentation Shrimp Waste Extract on Digestibility in Sentul Chicken Growth Phase

Abun Abun[1*] **Nurhalisa**[2] **Kiki Haetami**[3] **Deny Saefulhadjar**[1]

1. Department of Animal Nutrition and Feed Technology, Padjadjaran University, Sumedang-West Java, Indonesia
2. Faculty of Animal Husbandry, University of Padjadjaran, Indonesia
3. Department of Fisheries, Padjadjaran University, Sumedang-West Java, Indonesia

ARTICLE INFO

Article history
Received: 23 July 2022
Revised: 26 August 2022
Accepted: 30 August 2022
Published Online: 9 September 2022

Keywords:
Fermented shrimp waste extract
Dry matter digestibility
Organic matter digestibility
Protein digestibility
Sentul chickens

ABSTRACT

This study aims to determine the effect of adding feed supplements of fermented shrimp waste extract in the ration on the digestibility of local chicken rations in the growth phase. The research was carried out in Jatinangor District as well as the Laboratory of Ruminant Animal Nutrition and Animal Feed Chemistry, Faculty of Animal Husbandry, Padjadjaran University, Sumedang. The method used in this study was experimental with a Complete Randomized Design (RAL). The data were analyzed by fingerprint test (ANOVA) with further tests using the Dunnet test. The object of this study consisted of 20 Sentul chickens raised from the age of 1 day to 12 weeks, divided into 5 treatments and 4 tests. The treatment consists of P0 = Basal ration without the addition of feed supplement fermented shrimp waste extract, P1 = Basal ration + 0.5% feed supplement fermented shrimp waste extract, P2 = Basal ration + 1.0% feed supplement fermented shrimp waste extract, P3 = Basal ration + 1.5% feed supplement fermented shrimp waste extract, and P4 = Basal ration + 2.0% feed supplement fermented shrimp waste extract. The changes observed are the digestibility of dry matter, the digestibility of organic matter, and the digestibility of proteins. The results showed that the addition of feed supplements for fermented shrimp waste extract had a significantly different influence on the digestibility of dry matter, the digestibility of organic matter, and the digestibility of protein. This study concludes that the addition of a feed supplement of 2% fermented shrimp waste extract in the ration can produce a high ration digestibility value for Sentul chicken in the growth phase.

**Corresponding Author:*
Abun Abun,
Department of Animal Nutrition and Feed Technology, Padjadjaran University, Sumedang-West Java, Indonesia;
Email: abunhasbunap@gmail.com; abun@unpad.ac.id

DOI: https://doi.org/10.30564/jzr.v4i3.4917

1. Introduction

Sentul chickens are one of the local chickens from Ciamis that has quite good ability and productivity compared to other local chickens. Sentul chickens have good productivity in their meat and egg production so Sentul chickens are dual-purpose chickens. Along with the increasing demand and consumption of local chickens, Sentul chicken has the potential to be developed, so there need to be improvements in the feed that support its products so that it can produce optimally [1-3].

Feed is one of the factors affecting livestock productivity in addition to genetics and maintenance management. The feed given must have a complete nutritional content so that the feed can meet the needs of livestock for basic living, production, and reproduction. Growth is the process of increasing the number and size of cells in all parts of the body. Good quality feeding will result in a good growth response. Good feed is feed that is formulated to meet all the nutritional needs of livestock, has good digestibility, and does not hurt livestock [3-5].

Digestibility is the number of nutrients absorbed by the body. Digestibility is a nutrient part of the feed that is not excreted in the faeces. Food substances present in faeces are considered undigested food substances. Digestibility is based on the assumption that nutrients not present in the faeces are depleted and absorbed. Feed that has a high digestibility value indicates that it is of good quality. High digestibility shows that the livestock can absorb well the nutrient content in the feed needed by the livestock so that if the digestibility of the feed is high, livestock productivity will be optimal [6-8].

The addition of feed supplements to the feed can complement the nutrient content in the feed. A feed supplement is a feed additive that has nutritional value that serves to meet the nutritional content in the feed. The content contained in the feed supplement is amino acids, vitamins, and minerals. Feed supplements can be obtained from waste that still has nutritional value. Shrimp waste is fishery waste that can be used as a feed supplement [9,10] GIT morphometry, and microbiota populations. Four hundred one-day-old Ross 308 chicks were randomly distributed to four dietary treatments (10 replicates, 10 birds each. This shrimp waste has the disadvantage of chitin which can bind protein so that its digestibility is low. The treatment carried out on shrimp waste to optimize its potential is by fermentation using the bacteria *Bacillus licheniformis, Lactobacillus* sp., and yeast *Saccharomyces cerevisiae* [11-14]. This fermented shrimp waste is then extracted so that astaxanthin content is obtained which is beneficial for livestock productivity. Astaxanthin is a carotenoid derived from aquatic organisms such as shrimp. Several studies have shown that astaxanthin has antioxidant activities that can help maintain the body's health from free radicals. Antioxidant activity derived from astaxanthin is expected to maintain intestinal health in chickens which affects the digestibility of the chicken so that chickens can digest nutrients optimally and produce optimally as well [15]. The addition of feed supplement fermented shrimp waste extract can increase the digestibility value of feed in local chickens.

2. Materials and Methods

2.1 Experimental Livestock

The livestock used as the object of study was Sentul chickens raised from DOC with as many as 100 heads with an average body weight of 37.25 ± 1.95 grams. DOC was obtained from the Poultry Breeding Development Center (BPPTU) Jatiwangi, Majalengka. The livestock used as the study sample was a growth phase Sentul chicken (age 12 weeks) with as many as 20 heads which were not distinguished by sex (unsexed). Sentul chickens are kept in an individual cage and begin to be given treatment at the age of 2 to 12 weeks.

2.2 Trial Cage

The cages used for maintenance are 20 individual cage units with a size of 70 × 80 × 80 centimeters, while the cages used for sampling are 20 individual cage units with a size of 40 × 30 × 40 centimeters. The cage is equipped with a feed bin and a place to drink. Chickens are randomly placed according to the layout of the experiment.

2.3 Trial Ration

The rations used at the treatment stage in the study were made based on the need for metabolizable energy and proteins. The arrangement of feed ingredients that make up the ration used in the study was corn, soybean meal, MBM, rice bran, coconut oil, $CaCO_3$, premix, bone meal, NaCl, and fermented shrimp waste extract. The feed ingredients and the content of nutrients and metabolizable energy used in the study can be seen in Table 1.

The percentage of use of feed ingredients in the composition of the research ration is presented in Table 2 as follows.

Table 1. Nutrient content and metabolizable energy of feed ingredients constituents of rations

Feed Ingredients	Nutritional Content								
	ME	crude protein	crude fat	crude fibre	calcium	cystine	lysine	methionine	phosphorus
	Kcal/kg	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Yellow corn	3370	8.60	3.90	2.00	0.02	0.18	0.20	0.18	0.10
Soybean meal	2240	44.00	0.90	6.00	0.32	0.67	2.90	0.65	0.29
Meat bone meal	2300	48.00	9.40	1.40	10.30	0.00	1.77	0.49	5.10
Rice bran	1630	12.00	13.00	12.00	0.12	0.37	0.71	0.27	0.21
Coconut oil	8600	-	100	-	-	-	-	-	-
$CaCO_3$	-	-	-	-	38.00	-	-	-	-
Premix	-	-	-	-	80.00	-	-	-	-
Bone meal	-	-	-	--	22.00	-	-	-	19.00
NaCl	-	-	-		0.10	-	-	-	-
FSWE*	2614	39.29	-	7.79	6.81	0.54	3.04	1.46	2.83

*Fermented shrimp waste extract

Table 2. Basal ration formula

Feed Ingredients	Composition of the Ration
	(%)
Yellow corn	58.65
Soybean meal	25.00
Meat bone meal	1.50
Rice bran	10.21
Coconut oil	1.00
$CaCO_3$	0.40
Premix	0.50
Bone meal	2.39
NaCl	0.35

As for the content of nutrients and metabolic energy contained in the basal ration, it is shown in Table 3.

Table 3. Nutrient content and metabolizable energy of basal ration

Nutrient and metabolizable energy	Content
ME (Kcal/kg)	2,807
Crude protein	17.90
Lysine (%)	0.93
Methionine (%)	0.30
Methionine + cystine (%)	0.61
Threonine (%)	0.68
Calcium (%)	0.98
Nonphytate P (%)	0.49
Na (Sodium) (%)	0.20
Na+K-Cl (mEq)	239.58

Fermented shrimp waste extract is not included in the formula because of the purpose of its use as a feed supplement. Fermented shrimp waste extract is used as a feed additive added to the ration. The rate of addition of fermented shrimp waste extract in the ration is in the range of 0.5% ~ 2%. Rations that are not given additional fermented shrimp waste extract are used as control rations to be used as a comparison with treatment rations.

2.4 Research Procedure

Process of making fermented shrimp waste extract

The process of making fermented shrimp waste extract begins with washing shrimp waste in running water, shrimp waste that has been thoroughly washed is put into a stainless jar for fermentation using *B.lincheniformis* inoculants at a dose of 2% and incubated into an auto-shaker-bath machine for 2 days in a temperature of 45 °C turns 120 rpm. After obtaining the deproteination product, inoculation is carried out using *Lactobacillus* sp. at a dose of 2% and incubated into the auto-shaker-bath machine for 2 days with a temperature of 35 °C at 120 rpm. After obtaining the demineralization product, fermentation is carried out using *S. cerevisiae* as much as 3% and incubated into an auto-shaker-bath machine for 2 days at a temperature of 30 °C revolutions of 120 rpm. The bioprocess product (Astaxanthin 26.75%) was extracted with mineral supplementation Se (selenium) 0.15 ppm (73 ppm in the form of selenite) and then added filler / compacting agent. The final process is carried out by grinding until it becomes flour with a particle size of 100 mash to be mixed with other ration constituent ingredients.

Maintenance and sampling process

As many as 100 Sentul chickens are kept from DOC up to 12 weeks of age. At the rearing stage, chickens are placed in individual cages measuring 90 × 80 × 85 centimeters. Chickens are given rations and drink adlibitum, the ration of each cage is different according to the treatment. At the age of 0 to 2 weeks, chickens are given a mash-shaped commercial ration on each cage. Commercial rations are intended as a preliminary stage, the treatment ration is carried out after the chickens are 2 weeks old until the age of 12 weeks. During maintenance, the ration is given in the form of mash and given as much as 2 times a day.

Measurement of digestibility is carried out at the age of chickens of 12 weeks. On the measurement of digestibility of chickens, Sentul is placed into individual cages. The administration of the treatment ration is carried out in the morning. Drinking water is given adlibitum. The sampling technique was carried out by taking the fecal mass from the cecum [16]. The method of determining the digestibility uses an internal indicator (lignin) as a comparison [17]. After 6 hours, the chicken is slaughtered and its colon is removed to obtain a sample of faeces. The faecal sample is then dried and so on analyzed the content of dry matter, organic matter, and crude protein, while its indicators (lignin ration and faeces) are analyzed by the Van Soest method.

Experimental Design and Statistical Analysis

This research was carried out using the Random Design Technique. Consists of five (5) treatments, namely without and with the addition of feed supplement fermented shrimp waste extract with five (4) repeats. Rations without the addition of feed supplements of fermented shrimp waste extract are used as control rations. As for the treatment, namely P0 = Basal ration (which is not added fermented shrimp waste extract), P1 = Basal ration + 0.5% fermented shrimp waste extract, P2 = Basal ration + 1% fermented shrimp waste extract, P3 = Basal ration + 1.5% fermented shrimp waste extract, P4 = Basal ration + 2% fermented shrimp waste extract.

The changes observed in this study were the digestibility of dry matter, the digestibility of organic matter, and the digestibility of protein. The data that is role-picked are tested with fingerprints. If the results of the fingerprints differ markedly, then to find out the difference between the treatment and the control ration, a Dunnet test was carried out.

3. Results and Discussion

The addition of various levels of feed supplement of fermented shrimp waste extract in the ration to the digestibility value of the dry matter, digestibility of organic matter, and protein ration efficiency, based on the results of the study can be seen in Table 4.

Table 4. Average digestibility of dry matter, digestibility of organic matter, and digestibility of protein rations

Parameters	Treatment				
	P0 (0%)	P1 (0.5%)	P2 (1.0%)	P3 (1.5%)	P4 (2.0%)
Digestibility of dry matter	63.80[a]	67.90[a]	68.24[a]	72.24[b]	73.56[b]
Digestibility of organic matter	65.85[a]	69.84[a]	70.11[a]	73.00[b]	74.65[b]
Digestibility of protein	66.03[a]	74.22[b]	75.29[c]	79.58[d]	79.73[d]

The results of the fingerprint test (ANOVA) showed that the addition of various levels of feed supplement of fermented shrimp waste extract in the ration had a significant effect on the digestibility value of the dry matter, and digestibility of organic matter, and the ration protein density ($P<0.05$). Based on the results obtained, it shows that the higher the level of adding feed supplements to fermented shrimp waste extract, the value of digestibility of dry matter, digestibility of organic matter, and digestibility of ration proteins will increase. Dunnet test results showed that the addition of 1.5% ~ 2% feed supplement of fermented shrimp waste extract had a markedly different effect on the digestibility value of dry matter and organic matter compared to the control ration. Whereas in protein digestibility, the addition of 0.5% ~ 2% exerts a markedly different influence compared to the control ration.

The digestibility of a feed ingredient is a reflection of the high low value of the benefits of the feed ingredient. If the digestibility is low, the benefit value is low, on the other hand, if the digestibility is high, the benefit value is also high [4,8,18]. Digestibility that has a high value reflects the large contribution of certain nutrients in livestock, while feed that has a low digestibility value indicates that the feed is less able to supply nutrients for basic living and production [19,20].

The digestibility of dry matter of the ration is measured to determine the number of nutrients digested by chickens. The digestibility of dry matter will be one of the indicators to determine the quality of the ration. The higher the digestibility of dry matter, the higher the nutritional opportunities used by livestock for their growth [18,21]. The addition of a feed supplement of fermented shrimp waste extract in the ration has a good effect so that it results in a higher average digestibility value of dry matter compared to basal rations that are not fed feed. The increase in digestibility value is partly due to the different compositions in the ration so that the value of food substances in the ration is different, in this study the composition of the rations was different due to the addition of various levels of fermented shrimp waste extract. The normal amount of digestibility value of dry matter is influenced by various factors, including the content of food substances, the amount of ration consumed, and the rate of digestion in the digestive tract. In addition to the composition of different rations, the treatment of feed ingredients can affect the digestibility value. In this study, the feed supplement added to the ration was a fermented product.

Shrimp waste that has a limiting factor in the form of chitin which is difficult to digest is fermented using *B. licheniformis, Lactobacillus* sp., and *S. cerevisiae* which can produce chitinase and protease enzymes. Chitinase and protease enzymes produced during the fermentation process can catalyze and degrade chitin complex compounds by cutting the glycosidic bond between N-acetyl glucosamine (the monomer that makes up chitin) to make it simpler and easier to digest. Shrimp waste treatment with the fermentation method increases the protein content and reduces some of the chitin content with the help of the chitinase enzyme. The final product of fermentation usually contains compounds that are simpler and easier to digest than the original material [12].

The fermented process in feed ingredients, in addition to increasing nutrient content and digestibility, can also increase palatability. Feed ingredients undergoing a fermentation process produce good feed physical quality and high palatability. Palatability of the ration affects the consumption of dry matter of the ration. Consumption of dry matter rations is influenced by several factors including the quality, quantity, and palatability of the ration. The consumption of dry matter greatly affects the digestibility value of dry matter [22,23].

The ration added to fermented shrimp waste extract contains astaxanthin which is an antioxidant. The fermented shrimp waste extract contains Astaxanthin as much as 436 ppm [7]. The use of Astaxanthin derived from fermented shrimp waste as much as 10 mg/mL ~ 20 mg/mL or equivalent to 10 ppm ~ 20 ppm can show strong antioxidant activity. Astaxanthin has benefits for poultry digestion, which can reduce structural damage to the poultry digestive system under certain stress conditions [15]. Digestive health in chickens is something that must be considered, considering the process of absorption of nutrients contained in feed occurs in the digestive tract, namely in the small intestine. Disturbance and damage to the digestive tract will cause problems in the process of absorption of nutrients in the feed consumed by livestock.

The digestibility of organic matter is closely related to the digestibility of dry matter because some dry matter is organic matter consisting of crude protein, crude fat, crude fibre, and no nitrogen extract. The digestibility of organic matter shows the number of nutrients such as fats, carbohydrates, and proteins that can be digested by livestock [6,19,24]. The digestibility value of organic matter has a higher value than the digestibility value of dry matter. The digestibility value of dry matter is lower than the digestibility of organic matter, this is because organic matter does not contain ash, while dry matter still contains ash. Ash content can slow or inhibit the dry matter digestibility of rations [19].

The digestibility value of the organic matter of the ration is related to the digestibility value of the dry matter in the ration. The increase in the digestibility of organic matter is in line with the increase in dry matter digestibility because most of the dry matter components consist of organic matter, so the factor that affects the high and low dry matter digestibility is the digestibility of organic matter [6]. The increase in the digestibility value of dry matter rations caused by the addition of feed supplements of fermented shrimp waste extract influences the digestibility of organic matter rations. In this study, the addition of a 2% feed supplement of fermented shrimp waste extract provided the highest digestibility value of organic matter. This is related to the high digestibility value of the dry matter in the ration to which a 2% feed supplement of fermented shrimp waste extract is added, the high digestibility of dry matter describes the high content of organic matter because most of the dry matter components are composed of organic matter.

Protein digestibility depends on the protein content contained in the ration. Rations that have low protein content generally have low digestibility and vice versa [6]. In this study, the supplementary feed of fermented shrimp waste extract ration had a higher protein digestibility value than the basal diet. This is caused by the addition of shrimp waste extract that has undergone bioprocess, namely the fermentation process by *B. licheniformis, Lactobacillus* sp., and *S. cerevisiae*. Shrimp waste has a fairly high protein content but shrimp waste has a limiting factor in the form of chitin which causes the protein to be difficult to digest. The fermentation process uses *B. licheniformis, Lactobacillus* sp., and *S. cerevisiae* which have the enzymes protease and chitinase so that they can reduce the chitin content and increase protein digestibility. The fermentation process in shrimp waste with microorganisms *B. licheniformis, Lactobacillus* sp., and yeast *S. cerevisiae* can improve the protein quality of shrimp waste containing chitin by increasing the completeness and balance of essential amino acids and having optimal digestibility [11].

In addition to having protein content, shrimp waste contains Astaxanthin which is an antioxidant. Shrimp waste contains protein and minerals, as well as Astaxanthin, which illustrates the potential for use as a feed additive in poultry rations [11]. Astaxanthin has an effective role in increasing the proportion of beneficial microorganisms in the intestine, astaxanthin works to inhibit pathogenic bacteria that compete for food as well as maintain the balance of beneficial microbes in the intestine [25]. Astaxanthin can increase the activity of beneficial microbial organisms and digestive enzymes so that the digestibility of and absorption of nutrients contained in the feed increase. The addition of fermented shrimp waste extract in the ration can increase the ability of the intestines to digest and absorb nutrients so that the digestibility value increases.

Based on the results of the study, the average value of basal ration digestibility was in the range of 63-66% while the average value of digestibility of the treatment ration was in the range of 67-79%. The quality of feed based on the level of digestibility is divided into 3 categories, namely digestibility values ranging from 50-60% indicating low feed quality, moderate digestibility levels ranging from 60-70%, and high digestibility of more than 70% [26]. This indicated that the treatment ration had better quality than the basal ration which was not added with fermented shrimp waste extract. This increase in feed quality was due to the addition of various levels of fermented shrimp waste extract feed supplements in the ration.

4. Conclusions

Based on the results of the study, it was concluded that the addition of feed supplements fermented shrimp waste extract in the ration influences the digestibility of dry matter, the digestibility of organic matter, and the digestibility of protein rations of Sentul chicken. The addition of a feed supplement of fermented shrimp waste extract in the ration of as much as 2% provides the digestibility value of dry matter digestibility, digestibility of organic matter, and the highest digestibility of ration protein in the Sentul chicken growth phase.

Conflict of Interest

There is no conflict of interest.

References

[1] Widjastuti,T., Wiradimadja, A.R.R., Setiyatwan, H., et al., 2018. The Effect of Ration Containing Mangosteen Peel Meal (*Garcinia mangostana*) on Final Body Weight, Carcass Composition and Cholesterol Content of Sentul Chicken. Social Science Electronic. DOI: https://doi.org/10.2139/ssrn.3201106

[2] Widjastuti, T., Setiawan, I., Balia, R.L., et al., 2020. Application of mangosteen peel extract (*Garcinia mangostana* L) as a feed additive in ration for performance production and egg quality of sentul chicken. International Journal Advance Science. Enginering Information Technology. 10(2), 789-794. DOI: https://doi.org/10.18517/ijaseit.10.2.10666

[3] Widjastuti, T., Adriani, L., Asmara, I.Y., et al., 2021. Effect of Mangosteen Peel Extract (*Garcinia mangostana* L.) with Supplemental Zinc and Copper on Performance and Egg Quality of Sentul Laying Chicken. Jordan Journal Biology. Science. 14(5), 1015-1020. DOI: https://doi.org/10.54319/jjbs/140520

[4] Abun, A., Rusmana, D., Widjastuti, T., et al., 2021. Prebiotics BLS from encapsulated extract of shrimp waste bioconversion on feed supplement quality and its implication of metabolizable energy and digestibility at Indonesian local chicken. Journal Applied Animal Research. 49(1), 295-303. DOI: https://doi.org/10.1080/09712119. 1946402

[5] Abun, A., Widjastuti, T., Haetami, K., et al., 2018. Utilization of liquid waste of chitin extract from the skin of shrimp products of chemical and biological processing as feed supplement and its implication on the growth of broiler. AgroLife Science. 7(1), 148-155.

[6] Sahara, E., Widjastuti, T., Balia, R.L., et al., 2018. The Effect of Chitosan Addition to the Digestibility of Dried Matter, Organic Matter and Crude Protein of Tegal's Duck Rations. Indonesian Journal Fundamental Applied Chemistry. 3(2), 35-39. DOI: https://doi.org/10.24845/ijfac.v3.i2.35

[7] Abun, A., Widjastuti, T., Haetami, K., 2019. Value of Metabolizable Energy and Digestibility of Nutrient Concentrate from Fermented Shrimp Waste for Domestic Chickens. Pakistan Journal Nutrition. 18(2), 134-140. DOI: https://doi.org/10.3923/pjn.2019.134.140

[8] Kaczmarek, S.A., Hejdysz, M., Kubiś, M., et al., 2020. Effects of feeding intact, ground, and/or pelleted rapeseed on nutrient digestibility and growth performance of broiler chickens. Archive Animal Nutrition. 74(3), 222-236. DOI: https://doi.org/10.1080/1745039X.2019.1688557

[9] Trela, J., Kierończyk, B., Hautekiet, V., et al., 2020. Combination of bacillus licheniformis and salinomy-

cin: Effect on the growth performance and git microbial populations of broiler chickens. Animals. 10(5). DOI: https://doi.org/10.3390/ani10050889

[10] Zampiga, M., 2018. Effect of dietary arginine to lysine ratios on productive performance, meat quality, plasma and muscle metabolomics profile in fast-growing broiler chickens. Journal Animal Science Biotechnology. 9(1), 1-14. DOI: https://doi.org/10.1186/s40104-018-0294-5

[11] Abun, A., Widjastuti, T., Haetami, K., et al., 2017. Nutrient Concentrate Fermentation Based Shrimp Waste and Effect on Production Performance Phase Layer Native Chicken. Science Paper D-Animal Science. 60, 55-60.

[12] Cheba, B.A., Zaghloul, T.I., El-Mahdy, A.R., 2018. Demineralized crab and shrimp shell powder: Cost-effective medium for bacillus Sp. R2 growth and chitinase production. Procedia Manufacture. 22, 413-419. DOI: https://doi.org/10.1016/j.promfg.2018.03.065

[13] Mao, X., Guo, N., Sun, J., et al., 2013. Antioxidant properties of bio-active substances from shrimp head fermented by *bacillus licheniformis* OPL-007. Applied Biochemistry and Biotechnology. 171(5), 1240-1252. DOI: https://doi.org/10.1007/s12010-013-0217-z

[14] Liu, Y., Xing, R., Yang, H., et al., 2020. Chitin extraction from shrimp (*Litopenaeus vannamei*) shells by successive two-step fermentation with *Lactobacillus rhamnoides* and *Bacillus amyloliquefaciens.* International Journal Biology Macromolecule. 148, 424-433. DOI: https://doi.org/10.1016/j.ijbiomac.2020.01.124

[15] Hu, J., Lu, W., Lv, M., et al., 2019. Extraction and purification of astaxanthin from shrimp shells and the effects of different treatments on its content. Revista Brastica Farmacogn. 29(1), 24-29. DOI: https://doi.org/10.1016/j.bjp.2018.11.004

[16] Mirzah, M., Montesqrit, E., Choirul, A., et al., 2020. Effect of the Substitution of the Fish Meal with Shrimp Head Waste Fermented in Diet on Broiler Performance. IOP Conference Series Earth Environment Science. 478(1). DOI: https://doi.org/10.1088/1755-1315/478/1/012076

[17] Haetami, K., Junianto, J., Iskandar, I., et al., 2017. Durability and Water Stability of Pellet Fish Supplementation Results pairing Coconut Oils and Hazlenut Oil. International Journal Environmental Agriculture Biotechnology. 2(3), 638-642. DOI: https://doi.org/10.22161/ijeab/2.3.40

[18] Xie, Y., 2019. The effects of partially or completely substituted dietary Zinc sulfate by lower levels of Zinc methionine on growth performance, apparent total tract digestibility, immune function, and visceral indices in weaned piglets. Animals. 9(5), 1-11. DOI: https://doi.org/10.3390/ani9050236

[19] Brito, C.O., Ribeiro Junior, V., Del Vesco, A.P., et al., 2019. Metabolizable energy and nutrient digestibility of shrimp waste meal obtained from extractive fishing for broilers. Animal Feed Science Technology. 263, 114467. DOI: https://doi.org/10.1016/j.anifeedsci.2020.114467

[20] Benzertiha, A., Kierończyk, B., Rawski, M., et al., 2019. Insect oil as an alternative to palm oil and poultry fat in broiler chicken nutrition. Animals. 9(3), 1-18. DOI: https://doi.org/10.3390/ani9030116

[21] Soares, K.R., Lara, L.J.C., Martins, N.R., et al., 2020. Protein diets for growing broilers created under a thermoneutral environment or heat stress. Animal Feed Science Technology. 259, 114332. DOI: https://doi.org/10.1016/j.anifeedsci.2019.114332

[22] Fiszman, P., Varela, P., Díaz, M.B., et al., 2014. What is satiating? Consumer perceptions of satiating foods and expected satiety of protein-based meals. Food Respiratory International. 62, 551-560. DOI: https://doi.org/10.1016/j.foodres.2014.03.065

[23] Şengül, Ö., Daş, A., 2019. The Possibilities of Using Fruit Waste in Nutrition of Poultry. Turkish Journal of Agriculture - Food Science Technology. 7(5), 724. DOI: https://doi.org/10.24925/turjaf.v7i5.724-730.2343

[24] Shirzadi, H., 2020. Plant extract supplementation as a strategy for substituting dietary antibiotics in broiler chickens exposed to low ambient temperature. Archive Animal Nutrition. 74(3), 206-221. DOI: https://doi.org/10.1080/1745039X.2019.1693860

[25] Sowmya, R., Sachindra, N.M., 2012. Evaluation of the antioxidant activity of carotenoid extract from shrimp processing byproducts by in vitro assays and membrane model system. Food Chemistry. 134(1), 308-314. DOI: https://doi.org/10.1016/j.foodchem.2012.02.147

[26] Saleh, B., Paray, A., Dawood, M.A.O., 2020. Olive cake meal and bacillus licheniformis impacted the growth performance, muscle fatty acid content, and health status of broiler chickens. Animals. 10(4). DOI: https://doi.org/10.3390/ani10040695