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Research Reports

Evaluation of Feed Additive Nutmeg Seed Powder *(Myristica fragnans Houtt)* on Egg Quality Characteristics and Egg Production

Evaluasi Pemberian Pakan Tambahan Serbuk Biji Pala *(Myristica fragnans Houtt)* terhadap Karakteristik Kualitas Telur dan Produksi Telur

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ABSTRACT

Background: Poultry production faces food safety issues. Increasing public awareness of the risk of developing pathogen cross-resistance to antibiotics has resulted in the gradual elimination of antibiotics for therapeutic purposes. Transitioning from antibiotic supplementation to adoption of effective alternative control methods. Prohibition of the use of antibiotics in the feed of laying hens increase the usage of natural antibiotics from plants. The addition of feed additive nutmeg seed powder as helps the body to fight stress with anti-oxidative properties, improves immune function and restores normal physiology. The addition of polyphenols, withanolides, vitamins, minerals and other herbal products in the feed has shown considerable improvement in health in poultry. **Purpose:** This study aims to study the evaluation of feed additive nutmeg *(Myristica fragrans Houtt)* seed powder on egg quality characteristics and egg production. **Method:** A number of 200 chickens were used with 5 treatments and 5 replications and each repetition was occupied by 8 laying hens. The treatment given was R0 = 100% Basal Feed/BF (without nutmeg flour), R1 = 0.5% Nutmeg Seed Powder (NSP) + 99.5% BF, R2 = 1% NSP + 99% BF, R3= 1.5% NSP+ 98.5% BF, R4 = 2% NSP+ 98% BF. **Results:** The results of the study were egg weight, Haugh Unit, egg mass, shell index, egg shell thickness, yolk index, yolk color, egg yolk protein, egg white protein, egg yellow fat, cholesterol which gave very significantly different results ($p<0.01$). Feed Consumption (g/bird), HDP (%), Conversion ($p>0,05$). **Conclusion:** The feeding up to 2% of nutmeg seed powder given to laying hens can improve the egg quality characteristics and egg production.

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ABSTRAK

Latar Belakang: Produksi unggas menghadapi masalah keamanan pangan. Meningkatnya kesadaran masyarakat akan risiko berkembangnya resistensi silang patogen terhadap antibiotik telah mengakibatkan penghapusan antibiotik secara bertahap untuk tujuan terapeutik. Peralihan dari suplementasi antibiotik dengan mengadopsi metode pengendalian alternatif yang efektif. Larangan penggunaan antibiotik dalam pakan ayam petelur meningkatkan penggunaan antibiotik alami dari tumbuhan. Penambahan bubuk biji pala sebagai aditif pakan membantu tubuh melawan stres dengan sifat anti-oksidatif, meningkatkan fungsi kekebalan tubuh, dan mengembalikan fisiologi normal. Penambahan polifenol, withanolides, vitamin, mineral, dan produk herbal lainnya dalam pakan telah menunjukkan peningkatan yang signifikan dalam kesehatan unggas. **Tujuan:** Penelitian ini bertujuan untuk mempelajari evaluasi bubuk biji pala *(Myristica fragrans Houtt)* sebagai aditif pakan terhadap karakteristik kualitas telur dan produksi telur. **Metode:** Sebanyak 200 ekor ayam digunakan dengan 5 perlakuan dan 5 kali ulangan dan setiap ulangan ditempati oleh 8 ekor ayam petelur. Perlakuan yang diberikan adalah R0 = 100% Pakan Dasar/BF (tanpa tepung pala), R1 = 0,5% Tepung Biji Pala (TPL) + 99,5% BF, R2 = 1% TPL + 99% BF, R3 = 1,5% TPL + 98,5% BF, R4 = 2% TPL + 98% BF. **Hasil:** Hasil penelitian yang dilakukan adalah bobot telur, Haugh Unit, massa telur, indeks kerabang, tebal kerabang, indeks kuning telur, warna kuning telur, protein kuning telur, protein putih telur, lemak kuning telur, kolesterol memberikan hasil yang berbeda sangat nyata ($p<0,01$). Konsumsi Pakan (gr/ekor), HDP (%), Konversi ($p>0,05$). **Kesimpulan:** Pemberian tepung biji pala sampai dengan 2% pada ayam petelur dapat meningkatkan karakteristik kualitas telur dan produksi telur.

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Kata kunci: Ayam Petelur; Bubuk Biji Pala; Kualitas Telur; Produksi Telur

INTRODUCTION

The increase in human population around the world leads to an increase in demand for food production. In food production prioritizing foods with high bioavailability, the fulfillment of protein sources is a bigger task. This factor paved the way for a wide market in the search for animal protein sources, one of which is poultry. The use of feed additives capable of increasing the efficiency of growth and/or egg production, preventing disease and improving feed utilization are options to overcome the challenges mentioned above.

The use of Antibiotic Growth Promoters (AGPs) in poultry production systems has declined since their use was banned. In Indonesia, the prohibition on the use of AGP in poultry production activities is based on the Livestock and Health Law No. 18, 2009 Junco No.41/2014, Article 22 Paragraph 4c which stated everyone is prohibited from using feed ingredients mixed with certain hormones or antibiotics as supplements (Varhan *et al*., 2022).

The European Feed Standard Agency (EFSA) described feed additives as products used in animal nutrition for the purpose of improving the quality of feed and the quality of food from animals, or to improve the performance and health of animals, for example providing increased retail power Feed additives should not have a harmful effect, on the health of livestock and the environment. EFSA recognized five categories of feed additives including zootechnical (enzymes, probiotics, prebiotics, certain phytogenics), nutritional (vitamins and amino acids), technological (organic acids, antioxidants) (Pirgozliev *et al*., 2019). In response to the continuous demand for eggs, higher efficiency is required in the production aspect of laying hens, one of which is to utilize feed additives that can improve egg production and health during the egg-laying period (Tona, 2018). The addition of feed additives improves immune function and restores normal physiology (Sjofjan *et al*., 2021). The addition of polyphenols, with anolides, vitamins, minerals and other herbal products in the feed has shown considerable improvement in health in poultry (Abd El-Hack *et al*., 2020).

The use of phytogenic feed additives (PGC) in laying hen feed can improve egg quality and production parameters in laying hens (Suresh *et al*., 2023). Eggs are a good source of protein with high bioavailability to meet the needs. Laying hens have potency to be developed in Indonesia because of demand increasing every year. Indonesian people are more selective in choosing organic food for healthy so that eggs are cheap source of protein that is accessible to the community. Egg protein can reduce malnutrition, improve muscle health, increase satiety and therefore contribute to weight loss. Eggs have other additional benefits including protection against infection, lowering blood pressure, as well as anti-cancer effects (Puglisi and Fernandez, 2022).

Natural products from the plant have been found to have beneficial effects i.e., appetizers, improved digestion secretion of enzymes, immuno-stimulants, bactericides, antivirals and antioxidants of chicken feed. Nutmeg is one of popular spices in Indonesia. This plant can be seen in Indonesia such as Aceh, West Sumatra, West Java, Sulawesi, Maluku, West Nusa Tenggara, and West Papua (Suloi, 2021). Based on phytochemical tests of mace extract and nutmeg seeds contain alkaloid compounds, flavonoids, phenols, saponins, and tannins (Arrizqiyani *et al*., 2017). The fruit of this plant has antiinflammatory, anticancer, antimalarial, anticonvulsant, hepatoprotective, antiparasitic, insecticidal, and nematocidal activities (Ashokkumar *et al*., 2022). Seeds, mace and nutmeg meat have potential as antioxidants.

Nutrients in the ration that can affect egg quality include protein, minerals and vitamins. Adding nutrients aim to make them similar to quality of commercial rations and to improve the quality of rations, usually in artificial rations an additive is added. A ration additive is a substance that is added to a ration in relatively small amounts to increase the value of the food's substance content to meet special needs. Feed costs reach 60-70% of the total production costs of livestock business. These costs include costs beyond the main feed, such as additional feed (feed supplement). Feed additives function as growth promoters and increase feed efficiency in chickens, including antibiotics and hormones. Commercial feed additives have been used which, apart from being high in price, also lack guaranteed safety aspects due to the presence of chemical and hormone residues in food products. Cases of residues of these substances in livestock products originating from poultry are often encountered. The high prices of medicines and commercial feed as well as increasing public awareness of the importance of the safety of the food they consume have encouraged the idea of utilizing various traditional plants both as feed supplements and/or medicines. Indonesia is rich in traditional plants which have positive functions and have not been explored optimally until now. Several traditional plants have been used as feed supplements and medicines in chicken cultivation include nutmeg. The nutmeg seeds used were taken from Tahuna Regency, North Sulawesi Province. Ripe nutmeg seeds are taken from the tree, then the flesh, mace and nutmeg are separated. Nutmeg seeds are dried in the sun for 4-5 days. After dried, the skin is separated from the nutmeg seeds. The dry nutmeg seeds are then ground until they become nutmeg flour.

The main component of nutmeg is trimyristin that has function as an antibacterial and antifungal. Other component is phenolic compounds such as phenylpropanoids, lignans and neolignans (Suloi, 2021). The fruit contained flavonoids and phenolics and has antioxidant activity (Erza *et al*., 2022). Nutmeg pulp extract feed improved performance of broiler chickens (Sapsuha *et al*., 2022). Phytochemicals are bioactive non-nutritive plant compounds that are usually found in small quantities (Sharifi-Rad *et al*., 2021). There are have different classes according to their structure and include phenolic compounds, phytosterols, phytoestrogens, glucosinolates, saponins, terpenoids, protease inhibitors and organo-sulfur-containing compounds (Chou *et al*., 2021). Bioactive significant plants antioxidants are to reduce and protect oxidative, phenolic compounds work significantly

against antioxidants (Natasya *et al.*, 2023). The purpose of this research was to evaluate of feed additive nutmeg seed powder on egg quality characteristics and production.

MATERIALS and METHODS

Sample Collection

Nutmeg seeds were taken from Utarano Village, North Tabukan District, Tahuna Regency, North Sulawesi Province, which is local plant in Tahuna area. Nutmeg fruit is divided into the pulp (pericarp) and seed which consist of the mace, shell and flesh of the nutmeg seed. Mace is red or light-yellow thin fiber (areoles) that found between flesh and seed. Fresh nutmeg fruit has composition seed 83.3%, mace 3.22%, seed shell 3.94% and fruit flesh 9.54%. The part of the nutmeg that was picked then separated by the meat, seed and mace. The nutmeg seeds were dried for six (6) days, then the outer brown skin was broken. The nutmeg seed meat was dried using plastic sheet. The nutmeg mace was red after being separated from the flesh of nutmeg seeds when it was dried in the sun. Then, the nutmeg seeds were dried again until moisture content reduced to 10%. This drying period was 4-5 days.

Research Method

The research method was experimental research and proximate analysis. All proximate analysis were carried out at Laboratory Analysis of Biochemistry and Nutrition Department of Animal Feed and Nutrition, Gadjah Mada University, Indonesia. The results of analysis of nutmeg flour were protein content 6.90%, crude fat 25.17 %, crude fiber 24.79 %, calcium 0.02 %, phosphor 0.04 %, gross energy 5315.12 %/ 5315.12 kcal/kg.

Paat (2023) reported that adding black pepper flour up to 2% in chicken rations gave significantly effect on egg weight and Hen Day Production. This research used nutmeg pulp in broiler chickens. The treatments were given namely, R0 = 100% Basal Feed/BF (without nutmeg flour), R1 = 0.5% Nutmeg Seed Powder (NSP) + 99.5% BF, R2 = 1% NSP + 99% BF, R3= 1.5% NSP+ 98.5% BF, R4= 2% NSP+ 98% BF (Table 1). A total of 200 chickens were used for five (5) treatments and five (5) replications and each repetition was occupied with 8 laying hens. A total of 50 eggs were measured for internal and external egg quality and analyzed for egg protein and egg cholesterol.

Tabel 1. Nutritional Content of Treatment Ration.

Nutritional Content	R0	R1	R2	R3	R4
Protein (%)	17.69	17.69	17.69	17.69	17.69
Fat (%)	7.54	7.54	7.54	7.54	7.54
Crude Fiber (%)	5.31	5.31	5.31	5.31	5.31
Ca (%)	1.90	1.90	1.90	1.90	1.90
P (%)	1.03	1.03	1.03	1.03	1.03
Energy Metabolism (kcal/kg)	2754.10	2754.10	2754.10	2754.10	2754.10

Research Variables

There were several variables to be observed to evaluate of feed additive nutmeg seed powder on egg quality characteristics and production. Formula and definition of those variables describe in Table 2.

Tabel 2. Definition of Variables.

Variables	Definition
Feed Consumption (g/head/day)	Feed Consumption or Feed Intake is the amount of feed given minus the remaining uneaten feed divided by the number of livestock (Setiawati et al., 2016).
Daily Egg Production or Hen Day Production (HDP) (%)	Egg production was calculated every day during the study by comparing the number of eggs produced with the number of chickens during the study multiplied by 100% (Setiawati et al., 2016).
Feed Conversion Ratio	Amount of feed consumed (kg)/ number of eggs (kg).
Egg Weight	Egg weight was obtained by weighing the egg before breaking it using a digital scale expressed in grams.
Egg Shape Index	Egg shape index was determined by comparing the width of the egg with the diameter of the egg length and then multiplying it by 100 (Hughes, 1974).
Haugh Unit	The length of the egg was measured on the longest axis through the blunt end and pointed end of egg while width of egg was measured through the parallel position of the egg with a caliper.
Egg Mass (g)	HDP (%) x egg weight (g).
Shell Index	Shell weight /shell surface x 100.
Eggshell Thickness	Eggshell thickness was measured using a micrometer with an accuracy of 0.01 mm. Measurement of eggshell thickness was done by breaking the egg first and removing content of egg.
Yolk Index	Tall and the diameter of the yolk by the way after the eggs were weighed using eggs scales then the eggs are broken on a flat table then measure the height of the yellow egg and yolk diameter in both sides using a caliper.
Yolk Color	The value of egg yolk color was determined by egg yolk color. The color of the yolk was determined using a Roche color fan (1 to 15).
Egg Nutrients	Egg yolk protein, protein egg white, egg yellow fat, and egg cholesterol based on laboratory analysis of biochemistry and fodder.

Data Analysis

The data were tabulated using Minitab 16 software program and completely randomized design was applied in this experiment. Data were analyzed by Analysis of variance (ANOVA). If there was a significant difference ($p \leq 0.05$), then Duncan's test was further used with multiple distance tests.

RESULTS

The effect of treatment with nutmeg seed flour up to level of 2% can increase egg weight, Haugh Unit, egg mass, shell index, egg shell thickness, yolk index, and yolk color (Table 2). The result showed that nutmeg flour can affect egg weight. Nutmeg flour contains many phytobiotic active ingredients such as free acids, minerals, vitamins C and B, folic acid, riboflavin, niacin, vitamin A, and many flavonoid anti-oxidants. The essential oil contained in nutmeg seeds is source of

antioxidants and inhibits the growth of *E. coli* bacteria thereby facilitating the digestive system so as to provide an increase in the quality of egg production. The results showed that the egg weight was 59.28–61.88 g/hen. The giving nutmeg flour up to 2% increased Haugh Unit from 78.11 to 80.57. The HU value increased with addition of nutmeg flour. Protein content of nutmeg flour can increase HU because protein affects the viscosity of albumin so that eggs are good.

The giving nutmeg flour up to 2% produced egg mass of 50.61-53.50. The egg mas values showed different results between 1%-2% treatments. This was due to the increase in egg weight up to 2% treatment. The egg mass value obtained from multiplying HDP and egg weight showed no different results. The average of nutmeg flour up to 2% produced shell index of 7.65-8.29 and egg shell thickness of 0.31–0.32. The average of nutmeg seed flour up to 2% produced yolk index of 0.35-0.38 and yolk color of 10.14-12.06. Nutmeg flour increased weight and color of the yolk because nutmeg contains fat 25.17% which affects the performance of egg production. The giving nutmeg flour up to 2% increased egg protein and egg white protein (Tabel 3).

DISCUSSION

Egg quality is a general term that refers to several standards that determine internal as well as external quality. External quality of eggs focused on egg weight, egg length, egg width, and egg index, while internal egg quality focused on eggshell thickness, eggshell weight, egg yolk color, egg white height, pH and Haugh Units (Harmayanda *et al.*, 2016). Feed consumption, HDP, Feed conversion ratio in the addition of nutmeg leaf flour up to 2% did not have noticeable effect. Clark *et al.*, (2019) said feed consumption of laying hens in production ranges from 120 g- 136 per day, egg mass 63,6 – 65,6 g . Feed Conversion Ratio 1,8 – 2,2 and egg weight of 55 g, as specified in the breed description BLE (Bundesanstalt für Landwirtschaft und Ernährung., 2021). Egg production can be expressed by size HDP and egg mass. The HDP is generally accompanied by feeding that meet basic necessities of life and production. Average HDP percentage and feed consumption and conversion not statistically significantly different from the administration of 2% nutmeg seed flour Laying hens produced egg weights of 59.00 – 60.38 g/hen, egg shell thickness of 0.35 (Leke *et al.*, 2019).

Suloi (2021) reported that the content of nutmeg seeds is anti-inflammatory, antimicrobial, antioxidant and anti-fungal. The main component of nutmeg is trimyristin which can function as an antibacterial and antifungal. Apart from that, other phenolic compounds such as phenylpropanoids, lignans and neolignans.

Egg weight is a phenotypic trait that can be inherited so the eggs produced from each bird have a distinctive shape according to the shape and size of the reproductive organs. The Haugh Unit is one of the parameters that can be used to determine the quality of an egg through albumin viscosity and egg weight. According to the classification for albumen consistency based on the USDA (2000), the SaChi and LB eggs showed a firm albumen (>72 HU), whereas the GLB eggs falled into the class of reasonably firm (60–72 HU).

The eggs analyzed in this study were fresh eggs that had not undergone a storage process so that the viscosity of the albumin was good condition. The HU value also determines quality of the inner egg by measuring the albumen height and

Tabel 3. Feed Consumption, Egg Quality Characteristics, and Egg Production of Layer Chicken Fed Contain of Nutmeg *(Myristica fragrans Houtt)* Seed Powder .

Egg Quality	R0	R1	R2	R3	R4	SEM	p Value
Feed Consumption	120+0.40	121.0 + 2.38	120.3+ 1.37	119.6+ 0.49	117.8+4.04	0.972	0.981
HDP	80.30+0.68	82.00+0.95	83.33+1.02	84.00+1.09	83.30+1.07	0.431	0.000
Feed Conversion Ratio	1.92 + 0.09	1.91+0.05	1.90+ 0.03	1.90+ 0.02	1.92+ 0.07	0.285	0.981
Egg Weight (g/egg)	59.28^{a}+0.61	60.80^{b}+0.55	60.99^{b}+0.38	61.08^{c}+0.64	61.88^{c}+0.62	0.253	0.000
Haugh Unit	78.11^{a}+0.21	78.49^{a}+1.51	80.00^{b}+1.92	80.03^{b}+1.07	80.37^{b}+0.94	0.569	0.034
Egg Mass	50.61^{a}+0.41	51.06^{b}+0.31	51.58^{b}+0.52	52.62^{c}+1.13	53.50^{d}+1.19	0.360	0.000
Shell Index	7.65^{a}+0.07	8.15^{b}+0.17	8.29^{b}+0.05	8.26^{b}+0.43	8.29^{b}+0.20	0.128	0.009
Egg Shell Thickness	0.31^{a}+0.00	0.32^{b}+0.00	0.31^{a}+0.00	0.32^{b}+0.00	0.32^{b}+0.00	0.003	0.113
Yolk Index	0.35^{a}+0.00	0.37^{b}+0.01	0.38^{c}+0.00	0.38^{c}+0.00	0.38^{c}+0.00	0.003	0.000
Yolk Color	10.14^{a}+0.10	11.15^{b}+0.16	12.06^{c}+0.15	11.55^{b}+0.20	11.78^{b}+0.57	0.253	0.000

Note: Mean values within followed by the different letters are significantly different at p < 0,05 according to Duncan's Multiple Range Test.

Tabel 4. Egg Yolk Protein, Egg White Protein, Egg Fat and Egg Cholesterol of Indonesian Chicken Egg Nutrients.

Egg Nutrients	R0	R1	R2	R3	R4	SEM	p Value
Egg Yolk Protein (%)	13.42a+0.27	15.16b+0.10	15.65b+0.09	15.65b+0.10	16.56c+0.34	0.253	0.000
Protein Egg White (%)	10.25a+0.18	11.48b+0.07	11.92b+0.21	12.68c+0.34	12.61c+0.09	0.15	0.000
Egg Yellow Fat (%)	25.25d+0.43	25.82d+0.08	24.65c+0.38	23.16b+0.25	22.49a+0.17	0.503	0.001
Egg Cholesterol (mg/g)	226.4e+4.01	200.0c+2.03	202.3d+2.83	193.8b+1.19	189.4a+7.19	5.674	0.002

Note: Mean values within followed by the different letters are significantly different at p < 0,05 according to Duncan's Multiple Range Test.

egg weight. High HU values indicate that the viscosity of the albumen is getting thicker. Albumen contains ovomucin. Ovomucin plays role in binding water to form albumen gel so that albumen can be thick. Albumen becomes thicker if the nets of ovomucin are large and strong so that the viscosity of albumen becomes high. The higher the Haugh unit value, the higher the ovomucin and the better the quality of the egg interior. Haugh units, egg protein quality based on high albumin, and yolk color, are both important properties of egg quality (Mierlită, 2020).

Increasing the thickness of the centipede will have an impact on increasing the value of specific gravity (Kibala *et al.*, 2018). The increase in the thickness of the centipede generally depends on the number or component of the weight of the centipede relative to the surface of the egg area (Sapkota *et al.*, 2020). The thicker the centipede, the smaller the pore density (pores /cm²) so that the empty space in the centipede material decreases (Sabah and Şahan, 2018). The temperature and duration of storage affected value of yolk index evaporation of water and CO_2 gas takes place faster because the amount of liquid is more (Wibawanti *et al.*, 2017). During the storage period, evaporation occurs as a result of the temperature and humidity in the room of the premises egg storage and causes a decrease in the index value at the time of egg storage last.

Nutmeg flour can increase weight and color of the yolk. This is because the composition of the feed used a mixture of nutmeg flour concentrate, fine bran and corn. The color of the yolk mainly depends on the food, the difference in the color of the yolk produced in the herbaceous material consumed by chickens (Kuźniacka *et al.*, 2020). Yolk height 5.88–6.36 (mm), yolk color 7.41– .91, HU 66.65–71.07, egg hight 5.30 – 5.39 (cm), egg shell thickness 0.39 – 0.40, and egg shape index 78.73-78.89 (Dilawar *et al.*, 2021).

The protein and fat content of nutmeg flour can increase the egg yolk index height. Another factor that influences egg quality is hormone action. Estrogen and progesterone stimulate protein synthesis, both egg white protein and yolk protein so that overall weight of intact egg increases. Estrogen stimulates synthesis of proteins ovalbumin, ovotransferrin and lysozyme which are produced by the tubular glands of the magnum. The hormone progesterone stimulates hypothalamus to activate factor releasing hormone to stimulate secretion Luteinizing Hormone (LH) from the anterior pituitary. Progesterone together with androgens functions to regulate the development of the oviduct for the secretion of albumin from the magnum. The pituitary gland will secrete 2 hormones, namely FSH (Folicle Stimulating Hormone) and LH (Luteinizing Hormone). The FSH hormone serves to mature the egg follicle while the LH hormone serves to bluff the ovulation process. This hormone affects the follicles and ovulation process (Kustiawan *et al.*, 2019).

Average egg cholesterol 191.2 – 212 mg/100 g (Leke *et al.*, 2022). Nutmeg flour can reduce level of egg fat and egg cholesterol. Nutmeg seed flour contains phenols, terpenoids, flavonoids and alkaloids (Arrizqiyani *et al.*, 2017). Nutmeg has optimum concentration of inhibiting bacteria, namely 25%. The mechanism of action of flavonoids as antibacterial is to form complex compounds with extracellular proteins to damage bacterial cell membranes. Flavonoids also inhibit energy metabolism. The compounds will interfere with energy metabolism which requires sufficient energy for the absorption of various metabolites and for the biosynthesis of macromolecules. The yolk has more complete nutritional composition than the egg white. The cholesterol content of eggs is influenced by many factors, such as productivity, tension and age of chickens., housing system, season. Fatty acids are abundant in egg yolks are linoleic, oleic and stearic (Zita *et al.*, 2018). Cholesterol in egg yolk is synthesized in the liver, secreted as very-low-density lipoprotein (LPL) in blood, and deposited via receptor-mediated endocytosis in yolk (Dilawar *et al.*, 2021). This enzyme form mevalonic in cholesterol biosynthesis. Synthesis of cholesterol and beta-carotene together through mevalonic and derived from acetyl CoA. The consumption of beta-carotene is greater than saturated fatty acids then biosynthetic process by the HMG-CoA enzyme will be directed to synthesis of beta-carotene so that saturated fatty acids are not converted into cholesterol.

CONCLUSION

In conclusion, up to 2% of nutmeg seed powder *(Myristica fragrans Houtt)* given to laying hens can improve the feed additive nutmeg seed powder *(Myristica fragrans Houtt)* on egg quality characteristics and egg production.

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CONFLICT of INTEREST

The author has no conflict of interest and commercial or financial.

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ETHICAL APPROVAL

This experiment was performed based on approval for the laboratory animals use by the Animal Ethics Committee [03/KEH-UNSRAT/REC/2023], Sam Ratulangi University, Indonesia.

AUTHORS' CONTRIBUTIONS

Data processing and data accuracy: JRL, EW, manuscript draft: FN, HK, NK, JL, manuscript revision: CK, RS.

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