OPEN ACCESS International Journal of Poultry Science

ISSN 1682-8356
DOI: 10.3923/ijps.2019.

Research Article
The Effect of Turmeric Filtrate Nanocapsule Levels in the Ration on Local Duck Meat Composition and Serum Cholesterol

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Abstract

Objective: This study aimed to determine the optimal level of supplementation with turmeric filtrate nanocapsules in rations and its effect on the meat composition (protein, fat, water, ash and serum cholesterol) of male local ducks. **Materials and Methods:** Sixty three male ducks were distributed in a completely randomized design. Data were analyzed using One-way ANOVA. The ducks aged 6-10 weeks were assigned to 21 cage units exposed to seven treatments (T), each with three replications of 3 ducks each. The treatments with turmeric filtrate nanocapsule or nanoparticle (NP) addition consisted of control basal ration (BR) without NP (T1); BR+1% NP (T2);BR+2% NP(T3); BR+3% NP(T4); BR+4% NP(T5); BR+5% NP(T6) and BR+6% NP(T7). The data were analyzed using analysis of variance followed by Duncan's test when significant differences occurred. **Results:** The results showed that the treatment had a significant effect ($p<0.05$) on protein, fat and meat water content but a non-significant effect on meat ash content and serum cholesterol. **Conclusion:** The addition of5% turmeric filtrate nanocapsules in rations was the ideal level for increasing protein content and reducing fat content in the meat of local ducks.

Key words: Animal protein, duck meat, local duck, nanocapsules, turmeric filtrate

Received: Accepted: Published:

Citation: Sundari Sundari, Anastasia Mamilisti Susiati and Achmad Faisal, 2019. The effect of turmeric nanocapsule levels on local duck meat composition and serum cholesterol. Int. J. Poult. Sci., CC: CC-CC.

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Indonesia is a developing country with abundant natural potential. Various animal and plant genetic resources can be found in almost all provinces in the country. The demand for animal-based protein increases as the population and community welfare grow. To meet this demand protein supply can be obtained in the form of eggs and meat from poultry such as chickens and ducks. Ducks are one type of water fowl that have long been integrated into the lives of Indonesian people. Ducks are potential sources of high protein because they are more resistant to disease than are broilers, have adequate adaptability and efficiently turn poor quality food into meat and eggs[1].

Duck meat is in great demand by consumers because of its savory taste unlike other broilers. In Indonesia duck meat production showed an annual increase from 2011 through 2013, namely, 28.184, 33.610 and 36.154 t, respectively[2]. However, duck meat has some drawbacks, such as the lower level of trade and higher fat content than broilers. The fat content in ducks is 8.2% per 100 g, higher (4.8% per 100 g) than the broilers[3]; therefore, an innovation is needed to produce quality duck carcasses with a more favorable meat to the consumers.

One effort to improve the chemical quality of duck meat is feed engineering. Curcumin (the active ingredient of the turmeric rhizome) supplementation results in antiviral, antibacterial, antifungal, antiprotozoal, anti-inflammatory, antioxidant, anticancer, hypolipidemic and hypocholesterolemic effects[4]. In poultry, the curcumin in turmeric extract shows 46% digestibility (low bioavailability) and 54% is excretedinfeces[5]. Because curcuminis insoluble at an acidic or neutral pH (as in the intestine). It shows poor absorbability[6]. Turmeric extract nano-encapsulation with a chitosan cross-linked sodium tripolyphosphate (STPP) capsule increases the digestibility of curcumin to 70.64%[5]. Turmeric extract nano-capsule powder has been successfully applied to broiler chickens; at the 0.4% level this powder significantly improved intestinal performance, digestibility, production performance and carcass quality and produced meat free from high antibiotic residue levels and rich in the fatty acids EPA/DHA and in minerals but low in abdominal fat, subcutaneous fat and cholesterol[5]. Technically, the powder of turmeric extract nano-capsules (PTEN) are improved alternatives to synthetic antibiotics because they improve meat quality; however, these PTEN are not economical for broilers or other livestock. Therefore, liquid turmeric filtrate nano-capsules (cheaper and better turmeric water extract) were developed. At 2% liquid turmeric filtrate nano-capsules can replace synthetic antibiotics in broiler chickens[7]. Accordingly, the substitution of synthetic antibiotics with an advanced liquid turmeric filtrate nano-capsule in local poultry/duck and meat processing is a solutions to meet the demands for animal protein on a national scale.

This study aimed to obtain healthy and safe livestock and the ir products through the provision of nanoparticle feed additives from turmeric as an alternative to synthetic antibiotics, supporting the government to achieve national food sovereignty, resilience and security. In addition, the study also investigated the effects of turmeric Nps on the meat quality of male local ducks.

This study is expected to provide information to the general public and all stakeholders about the chemical quality of male local duck meat after feed supplementation (turmeric filtrate nano-capsules).

MATERIALS AND METHODS

Research material: The study used 63 male ducks aged 6-10 weeks, turmeric rhizome, 95% DD chitosan, technical grade STPP, citric acid and aquadest. The ducks were provided with drinking water and a basal ration of feed (Table1: composed of yellow corn meal, fish flour, soybean meal, rice bran, palm oil and limestone flour). Rodalon disinfectant was used to clean the drinking water and cages. The three analyses included in this experiment were chemical nutritional analysis

Table1: Composition and nutrient content of basalration*

Feed ingredients	Grower* (6-10 week) (%)
Ground corn	60.00
Rice bran	15.00
Soybean-waste/SBM45	20.00
Fish meal	3.00
Palm oil	1.00
Limestone	0.55
NaCl salt	0.15
Masamix**	0.30
Total	100.00
Nutrient contents	
Crude protein (%)	17.54
ME (kcal kg^{-1})	3094.37
Crude fat (%)	3.78
Crude fiber (%)	3.49
Calcium (%)	1.13
Available phosphate (%)	0.16
Lysine (%)	1.05
Methionine (%)	0.32

*The standard nutrient demand of 6-10 week-old ducks according to the (NRC[23] is 16% CP; 3000 kcal kg^{-1} ME; 0.65% Lys; 0.35% Met; 0.60% Ca; and Pav 0.30%. **Masamix composition per kilogram is as follows; Vit A: 810000IU, Vit D3: 212000 ICU, Vit E:1.8 g, Vit K3: 0.18 g, Vit B1: 0.112 g, Vit B2: 0.288 g, Vit B6: 0.3g, Vit B12: 0.0036 g, Co: 0.028 g, Cu: 0.5 g, Fe: 6.0 g, Mn: 6 g, Iod: 0.1 g, Zn: 5 g, Se: 0.025 g, DL-Met: 212.5 g, L-Lys: 31 g, As. folate: 0.11 g, As. Pantothenate: 0.54 g, Niacin (vitamin B3): 2.16 g, Choline chloride 60%: 75 g

(HCl, NaOH, boric acid), CHOD-PAP (cholesterol oxidase-phenol-amino phenazone) enzyme lipids and GPO-PAP (Glycerol phosphate oxidase-p-amino phenazone, production Diasys).

Research Tools. Analysis of the chemical composition of meat and serum cholesterol used the following: a set of maintenance tools (21-unit cages, thermometer and room hygrometer, etc.), a set of surgical instruments (knives, trays, scissors, curette, personal protective equipment) and a set of chemical analysis tools (oven, furnace, Soxhlet extractor, vortex, Hitachi U-2810 spectrophotometer, etc.).

Research methods: This experimental study was conducted in a completely randomized design allotting 63 male ducks aged 6-10 weeks in to seven treatment groups with three replications (three ducks each). The treatment groups included the following proportions of NP supplementation and basalration (BR): control without NP(T1); BR+1% NP(T2); BR+2% NP(T3); BR+3% NP(T4); BR+4% NP(T5); BR+5% NP(T6) and BR+6% NP(T7). Nanocapsules were added to the rations from April 15 to May 13, 2018 (for 4 weeks or 28 days) at Mercu Buana University, Yogyakarta. Limited feed (100 g head^{-1} day^{-1}) was given in the morning and evening and the average feed consumption was 138-148 g head^{-1} day^{-1}. Feed (in the form of wet pellets with a moisture content of 55%) and water was provided *ad libitum*.

Preparation of liquid turmeric filtrate nanocapsules: Turmeric filtrate was prepared by dissolving 4 kg of turmeric rhizomes in 5 L of distilled water (using a 20 L blender mixer for 60 min) and then filtered. The solution (turmeric filtrate) was mixed with 50 g of chitosan that had been dissolved in 4 L of 2.5% citric acid using a 20 L blender mixer for 30 min. Then 25 g of sodium-tripolyphosphate is solved in 1 L of distilled water was incorporated into the solution and blended for 30 min. This yielded the 100% concentration of liquid turmeric filtrate nano-capsules (NPs) that would be added to basal ration (Table1) according to treatment before preparing pellets with a moisture content of 55%.

Variable measurement and data analysis: At the end of 10 weeks of age, the meat of upper thigh (biceps femoris) of ducks was used for chemical quality analysis. Proximate analysis[8] was used to measure the moisture, protein, fat and ash content. Duck blood serum was collected and used to analyze total cholesterol (cholesterol oxidase–phenol aminophenazone/CHOD-PAP method), triglyceride (glycerol-3-phosphate oxidase–phenol aminophenazone/GPO-PAP method), high density lipoprotein-cholesterol (HDL) and low density lipoprotein-cholesterol (LDL)[9]. All data obtained were subjected to analysis of variance, followed by Duncan's new multiple range tests (DMRTs) when significant differences occurred[10].

RESULTS AND DISCUSSION

Supplementation with turmeric filtrate nano-capsules at the 0-6% level in duck rations significantly ($p<0.05$) increased protein levels, reduced fat content and reduced duck meat water content (Table 2) and did not impact ($p>0.05$) the ash content and serum cholesterol of local ducks (Table 3). The addition of 5% nano-capsules/nano-particle (NP) in the ration produced meat with 21.20% protein, 5.37% fat and 70.2% water. This result is appealing to consumers, namely, to obtain meat with high protein content of low fat.

The increased meat protein content in this study, in accordance with a study by Sundari[5], indicated that the medium level of administration (0.4-0.6%) of turmeric extract nanocapsule powder was the optimal level and provided the best improvements in broiler meat quality. This finding is in accordance with Sundari[5], in which 0.4% supplementation with PTEN increased intestinal villi growth, for the location of the synthesis of digestive enzymes. Next, this increased villi group promoted nutrient digestibility, enhancing protein availability for meat muscle growth and thus increasing the protein content of meat. The addition of 0.5-1.0 g of chitosan kg^{-1} of feed increased nitrogen retention[11]. This effect occurs because chitosan is a linear polysaccharide that

Table 2: Chemical composition of duck meat with supplementation of turmeric filtrate nanocapsules in feed

Treatments	Protein* (%)		Fat** (%)		Water** (%)		Ash^{ns} (%)	
(NP level in ration)	Mean	SD	Mean	SD	Mean	SD	Mean	SD
T1 (0%)	20.61^{ab}	0.298	7.39^{bc}	0.512	72.60^{c}	0.318	1.85	0.149
T2 (1%)	20.06^{a}	0.691	9.91^{d}	0.667	71.34^{b}	0.432	1.69	0.248
T3 (2%)	20.20^{ab}	0.491	8.49^{cd}	1.052	70.16^{a}	0.627	1.79	0.280
T4 (3%)	20.08^{a}	0.711	5.09^{a}	0.415	72.43^{c}	0.295	1.61	0.259
T5 (4%)	20.50^{ab}	0.427	4.97^{a}	0.506	74.03^{d}	0.464	1.64	0.146
T6 (5%)	21.20^{c}	0.223	5.37^{a}	1.355	70.20^{a}	0.748	1. 60	0.287
T7 (6%)	21.11^{bc}	0.326	5.80^{ab}	1.365	70.00^{a}	1.075	1.57	0.274

ns: Non significant, *,^{ab}values with different superscripts within column shows significant differences ($p<0.05$), **,^{ab}values with different superscripts within column show significant differences($p<0.01$). SD: Standard deviation.

Table 3: Serum cholesterol and triglycerides in 10 week-old local duck induced by treatment with turmeric filtrate nanocapsules in feed for 4 weeks

Treatments (level of turmeric filtrate nanocapsule)	Total cholesterol (mg dL^{-1})^{ns}	Triglyceride (mg dL^{-1})^{ns}	HDL (mg dL^{-1})^{ns}	LDL (mg dL^{-1})^{ns}
T1 (0%)	131.147±015.49	104.263±12.90	55.083±12.41	54.450±12.90
T2 (1%)	129.190±3.342	106.597±2.470	55.340±1.784	52.857±1.656
T3 (2%)	129.440±21.31	102.493±11.57	57.913±12.76	50.733±15.46
T4 (3%)	132.363±15.00	106.017±4.933	53.540±10.51	54.980±10.36
T5 (4%)	124.333±3.29	101.003±4.410	58.690±3.538	47.010±4.849
T6 (5%)	129.683±22.21	102.343±13.92	54.513±8.568	57.903±12.35
T7 (6%)	123.847±4.40	101.500±3.760	58.690±3.538	51.727±9.169

ns: Non significant

is arranged randomly from β-(1-4)-linked D-glucosamines and N-acetyl-D-glucosamines, which can be degraded *in vivo* to glucosamine[12] and contains a reactive amino group and functional hydroxyl groups[13]. The addition of sodium tripolyphosphate inhibited the decrease in protein and amino acid levels or maintained protein levels[14] due to hydrolysis reactions and increased protein digestibility but did not increase protein levels. The combined administration of curcumin, chitosan and STPP to livestock in nanocapsules results in mutually reinforcing interactions to increase meat protein content.

The duck meat fat level significantly decreased with the administration of 5% nanocapsules. This result possibly occurred because increased curcumin can inhibit fat synthesis/cholesterol and induce the release of cholesterol, which eventually reduces meat fat. The administration of curcumin increased the activity of phosphorylated 5' AMP-protein kinase (P-AMPK), which plays a role in suppressing the expression of glycerol-3-phosphate acyltransferase-1 (GPAT-1) and increases the expression of carnitine palmitoyltransferase-1 (CPT-1), resulting in increased oxidation and decreased esterification fattyacids[15]. In line with Sundari[5], at a low level (0.1%) turmeric extract nanocapsule powder showed an antioxidant role by improving fat metabolism and reducing subcutaneous and abdominal fat deposition. At a high level, turmeric extract nanocapsule powder (>0.4%) served as a pro-oxidant by irreversibly modifying the antioxidant thioredoxin reductase (TrxR)[16,17] and therefore, it was unable to reduce the deposition of subcutaneous fat even carcinogenic by increasing ROS(H_2O_2).

The duck meat water level significantly decreased from 72.6% in the control to 70.2% with the administration of 5% nanocapsules. This result is possible because of increased levels of protein, thereby reducing other contents such as fat and water. Turmeric extract contains curcumin, which has a 2-sided electrophilic structure and β-unsaturated ketones that can react with nucleophilic groups (for example, the SH groups of muscle protein) through a reaction called the Michael addition[17] to inhibit the ability of muscle cells/myofibril protein to bind to water, causing a decrease in meat water levels. The NH^{3+} group of chitosan can interact with negatively charged proteins, thereby increasing water holding capacity because it can repair proteins to bind water and fat[18]. In line with Yuanita[14] an increase in the concentration of sodium tripolyphosphate (STPP) followed by a decrease in water content results in a decrease in free water and water is bound or immobilized because the proteins binding the water are less effective. The combination of curcumin chitosan and STPP in nanocapsules results in a decrease in the water content of duck meat.

Table 3 shows that 0-6% nanocapsule addition resulted in no significant difference in total cholesterol (TC), triglycerides (TG), HDL and LDL. The addition of 4% results in the smallest TC, TG, HDL and LDL values. This is not in line with Zingg *et al.*[19] opinion that the hypolipidemic activity of curcumin increases lipid uptake in the intestine, decreases lipid biosynthesis and decreases adipose cell differentiation, there by decreasing size/weight. In addition, curcumin increases bile production by removing lipids/cholesterol from tissues and increasing lipid metabolism through β-oxidation to heat/physical energy. These results are in accordance with Yau and Chiang[20], who stated that supplementing chitosan to hamsters with hypercholesterolemia can reduce serum cholesterol and show hypocholesterolemic activity by increasing the excretion of bile acids and total steroids. Moon *et al.*[21] stated that chitosan supplementation in the diet increases the activity of cholesterol-7α-hydroxylase (CYP7A1) enzyme in the liver, which plays a role in cholesterol metabolism, i.e. converting cholesterol to bile acids. The hypolipidemia effect of chitosan is mostly due to the interruption of enterohepatic circulating bile acids, while fat uptake was inhibited due to low viscosity in the small intestine. Curcumin and chitosan potentially decrease meat fat and blood cholesterol. However, STPP shows an opposing function that is once inside a cell. STPP can be metabolized to produce tripolyphosphate as a component of ATP, which provides cellular energy. Excess energy will be stored in the form of fat so that the circulation of fat/cholesterol in the

blood is normal. This is added to the excess of lysin in the basal ration (Table 1), which encourages the synthesis of insulin[17] and stimulates the activity of HMG-CoA reductase in cholesterol synthesis[22]. This situation can result in no significant change in the cholesterol in the serum.

CONCLUSION

Supplementation with 5% liquid turmeric filtrate nanocapsules in rations showed the optimal results, namely, increased meat protein levels and reduced meat fat content in local ducks, resulting in a composition of21.20% protein, 5.37% fat and 70.2% water.

SIGNIFICANCE STATEMENT

This study reveals the possible synergistic effect of turmeric, chitosan and sodium tripolyphosphate (STPP) as feed additive combinations in nanocapsules that can improve the meat quality of local ducks. This study will help the researcher uncover the critical approaches to obtain the best quality duck meat using turmeric, chitosan and STPP separately. Thus a new theory on the combined use of these feed additives in the form of nanocapsules may be developed.

ACKNOWLEDGMENTS

Acknowledgments are conveyed to (1) The Directorate of Research and Community Service, the Directorate General of Strengthening Research and Development of the Ministry of Research Technology and Higher Education of the Republic of Indonesia, who provided funding for this research by decree No. 7/E/KPT/2019 dated February 19, 2019 and contract No. 170/LPPM/UMBY/IV/2019 dated April 22, 2019 and (2) The research assistants for their support and cooperation during the conduct of this study.

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