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The Effect of Chitosan Addition to the Digestibility of Dried Matter, Organic Matter and Crude Protein of Tegal's Duck Rations

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Abstract

The optimum performance of duck farm can be achieved by providing them with good quality rations. Rations with good digestibility will increase the productivity due to large amount intake of nutrients. Chitosan is type of animal fibre which assisted the growth of useful microbes in digestive system. Addition of chitosan in cattle rations will improve the ecologic of duck digestive system to be more conducive. The aimed of the research was to evaluate rations digestibility with the addition of chitosan. The research was used completely randomized design with 4 treatments and 5 repetitions. Each repetition consists of 2 ducks. The treatments are R0 stands for rations without chitosan and R1-R3 with addition of chitosan 0.5%, 2% and 2.5% respectively. Parameter measured were dried matter, organic matter and crude protein digestibility. Data processing was conducted by using SAS Windows 16. Result showed chitosan addition at 0.5% and 2.5% gave dried matter and crude protein digestibility does not higher than control (P>0.05) while chitosan addition at 2% gave result lower than control. Organic matter digestibility displays balanced in value.

Keywords: Chitosan, Dried matter digestibility, organic matter, crude protein, rations.

Abstrak (Indonesian)

Optimalitas peforma ternak itik dapat tercapai jika mendapat ransum berkualitas. Ransum berkualitas dengan kecernaan yang baik akan meningkatkan produktivitas ternak. Kitosan adalah jenis serat hewan yang bermanfaat untuk memicu kehidupan mikroba menguntungkan dalam saluran cerna. Jika diberikan dalam ransum akan menyebabkan ekologis saluran pencernaan ternak itik menjadi lebih kondusif. Tujuan penelitian adalah mengkaji kecernaan ransum dengan pemberian kitosan. Penelitian menggunakan Rancangan Acak Lengkap (RAL) dengan 4 perlakuan dan 5 ulangan. Masing-masing ulangan terdiri dari 2 ekor itik sebagai satuan percobaan. Perlakuan adalah R0 = 0% kitosan, R1 = 0,5% kitosan, R2 = 2% kitosan dan R3 = 2,5% kitosan. Peubah yang diukur adalah kecernaan Bahan Kering, Bahan Organik dan Protein kasar. Data diolah menggunakan program SAS Windows 16. Hasil penelitian menunjukkan bahwa pemberian kitosan 0,5% dan 2,5% memberikan rataan kecernaan Bahan Kering dan Protein Kasar tidak lebih tinggi dari kontrol (P>0,05), sedangkan dosis 2% kitosan nyata lebih rendah dari kontrol, Kecernaan Bahan Organik menunjukkan angka berimbang.

Kata Kunci: Kitosan, kecernaan bahan kering, bahan organic, protein kasar, ransum

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INTRODUCTION

The productivity of poultry farm is highly supported by rations quality given and amount of nutrients absorbed. Rations digestibility represents the amount of nutrients absorbed which can be calculated from subtracting nutrients in the rations by the faeces [1]. The percentage of dried matter, organic matter and crude protein digestibility characterized the quality of cattle rations. It means that ration digestibility can be consider as one of indicator which determined nutrient absorbed by the body and used to support its life and production. Another factor contributes to nutrients digestibility are the anatomy and physiology of digestive system. The ecologic of digestive system become more conducive by the presence of microflora which optimizing the production of digestive enzymes. Microbe population will grow well in the digestive system if the rations intake contains fibre composition.

Chitosan can be obtained from isolation of crustacea waste which known as animal fibre due to the structure has similarity with fibre. Chitosan does not degrade in digestive system because its monomer is bonded by (1-4) β-glyosidic [2]. The chitosan however is expected to be fermented by fibre digestion bacteria in the cecum to produce volatile fatty acid (VFA). This VFA is a useful substance which act as energy resource for the host creature. There is a relationship between non-digested food with the health of normal microflora in digestive system i.e. making the ecologic of digestive system more conducive. Fibre substances also make feed motion rhythm smoother [3].

Fibre-like structure of chitosan is not absorbable by small intestines. The solid form of chitosan with size of particles is not suited to be absorbed by small intestines pore. Chitosan is sold commercially in form of amorphous and shape which showed no uniformity [3]. Chitosan contribute to digestive system by increasing the population of primary bacteria as normal microflora of body and eliminate pathogenic harmful germs and create optimum condition for normal body metabolism. Based on this reason, we conducted research, aimed to evaluate the role of chitosan in dried matter, organic matter and crude protein digestibility of the rations.

MATTERS AND METHODS

Basal Feed/Rations

Rations used in the experiments was prepared with protein content 15.34% and metabolic energy 2809 kcal/kg (NRC, 1994) for layer period matched with Tegal's duck feed needed in productive age which was used in this research. The raw matter of basal feed used in this research was consists of corn, husk, soybean meal, coconut meal, fish powder, bone powder, premix and shells powder. Chitosan was provided in pure matter by Laboratory of fishery processing technology Bogor Institute of Agriculture. Rations with treatment was prepared by adding basal feed into chitosan powder in various amount. Chitosan dose used in this work was based on unpublished work of *in vitro* investigation of chitosan inhibition against *Salmonella sp.* The rations were treated as follow: R0 rations without chitosan, R1, R2 and R3 are rations in which basal feed added with 0.5%; 2% and 2.5% chitosan.

Research Objects: Duck Treatment

Duck used in this work was obtained from Tegal in its productive age. As much as 40 ducks were placed in cages equipped with light and feed and water vessel.

Research Methodology

This research was used completely randomized design with 4 treatments and 5 repetitions, each consist of 2 ducks. Prior digestibility test, test animal was acclimatized for 7 weeks. Water was given ad libitum, faeces was collected according to method by Sklan and Hurwitz [1]. The effect of rations was measured by using indicator (lignin) calculated from analysis result of lignin contained in the rations. Duck was treated with 150 g rations and then slaughter for each 4 treatments and 5 repetition, hence 20 ducks in total. Large intestine was collected from animal test to obtain faeces sampel. The faeces sampel was dried, grinded and subjected to analysis of dried matter content, organic matter and crude protein with used proximat analysis. Lignin as internal indicator was measured acoording to method by Van Soest.

$$Digestive\ Coeficient = 100\% - 100\% \left\{ \frac{Lr}{Lf} x \frac{Nf}{Nr} \right\}$$

Where: Lr = lignin in rations (%)
Lf = lignin in faeces (%)
Nf = nutrient in faeces (%)
Nr = nutrient in rations (%)

Data Analysis

Data obtained in this work was processed by analysis of variance (anova) assisted with SAS Windows 16 software. Duncan's multiple range test was conducted if there is a difference in means [4].

RESULT AND DISCUSSION

The Effect of Chitosan on Dried Matter Digestibility

The dried matter digestibility showed average value between 59.18% to 64.36% (Table 1). The exact value of digestibility is R0 62.88%, R1 62.44%, R2 59.18% and R3 64.36%.

Table 1. The effect of chitosan addition to dried matter digestibility of rations (%)

Treatment	Average DMD (%)	Sig. (P 0.05)*
R0	62,88 ± 1,982	Bc
R1	62,44 ± 0,649	B
R2	59,19 ± 0,843	A
R3	64,36 ± 0,730	C

Remark:
DMD: dried matter digestibility
*Different letter in the column indicate difference in means (P<0,05).

Dried matter digestibility indicates the digestible of all feed intake into the body. According to Table 1, the addition of chitosan at 0.5 and 2.5% gave dried matter digestibility at same level with control (P>0.05). Chitosan 2% (digestibility of dried matter 59.19%) showed difference in means i.e. lower than control (P<0.05) at all treatments. The cause for this is at 2% dose, nutrient molecules were trapped in chitosan. which inhibit nutrient release in the small intestine. However, 0,5% and 2,5% chitosan has increased of microflora population in digestive tract [5] (Sahara, 2016). Digestive microbes play a role in digestion and absorption [6] (Pokphand, 2008)

The enzyme work was affected and does not give optimum result to degrade nutrient molecules into smaller monomer. According to Piliang and Haj, enzyme activity is affected by pH, substrate concentration, enzyme concentration and temperature [7]. The enzymes that are active against a substrate will be saturated due to high concentration of substrate at the same time and place. Low acidity (pH) in the proventricular and ventricular affects significantly to the physical form of chitosan i.e. gel. As a polycation with positive charge, chitosan can freely bond to all negative molecule in surrounding. This situation will increase feed viscosity and density of rations. Furthermore, the rations will be digested slowly which in turn limit the enzymatic digestion of nutrient along the intestine. These feed and ecological aspects will form a new balance in digestion process of rations in animal test.

Different dose of chitosan influences its role as bonding agent and nutrient deliverer. At 0.5% chitosan dose, rations appear to have normal viscosity as digestive substance. Its function as emulsifier and enzyme control works well hence chitosan can deliver/release nutrient molecule in a steady rate. The interaction between chitosan and nutrient molecule is known as adsorption. This kind of interaction only allow the adsorbed molecule on the surface of chitosan via a weak Van der Waals bonding. The characteristic of chitosan adsorption i.e. weak interaction made nutrient molecule easily release back into environment. Chemist reveals that according to the mechanism, there are two types of sorption i.e. adsorption and absorption. Adsorption refers to sorption of ion or molecule onto the surface of adsorbent while absorption refers to sorption of ion or molecule into absorbing particle.

At chitosan dose 2.5%, not all of chitosan active sites were assumed to be occupied hence reduce swelling degree and viscosity. This situation created smoother chemical reaction pathway assisted by enzyme once the nutrient molecule released from chitosan. Feed degradation product in the digestion system moved normally following the peristaltic motion of intestine and the degradation products hence faster delivered assisted by chitosan to the corresponding organs.

Dose of chitosan at certain level provide a supportive environment for small intestine microflora. Chitosan become raw material for fermentation process by microbe benefits to the body. The beneficial microbe is thriving and helping digestion system. The process imply that chitosan is biodegradable and has role as prebiotic [8]. Product of fermentation in form of volatile fatty acid will be re-absorbed by mucosa and treated as energy resources for the host. In principle, the nature of chitosan as anti-microbial [9], binding lead (Pb) from toxic metals [10] and the role as prebiotics [11] will improve the body's health and increase livestock productivity.

Chitosan can be used for encapsulation, removing chemical substances and dangerous metals [12]. It means, chitosan can eliminate harmful matter produced from waste of enzyme degradation in form of gas, precipitate or free radical hence create conducive environment for microflora of digestive system.

The Effect of Chitosan Treatment on Organic Matter Digestibility

Analysis result of organic matter digestibility of rations after chitosan treatment is shown at Table 2. The digestibility average value exhibit similarity at range 68.74%- to 70.18%.

The similarity of organic matter digestibility between different treated chitosan represent its general potential utilization to improve organic matter digestibility at all chitosan level. Seven-week duration used in this research did not showed any distinction statistically between dosage used.

high-quality feed has digestibility above 70%. Low digestibility of R2 compare to R0, R1 and R3 exists due to the chitosan trapped protein and pepsin (protein digested enzyme) located in proventricular and ventricular. At acidic condition (low pH) of proventricular and ventricular, positively charge amine and hydroxyl groups on chitosan become

Table 2. The average of organic matter digestibility value of chitosan treated rations

	Treatment			
	R0	R1	R2	R3
Organic matter digestibility	69,32 ± 5,000	68,74 ± 3,035	70,18 ± 1,782	71,22 ± 1,365

The organic component in rations as the major contributor to this digestibility consist of protein, carbohydrate (nitrogen-free extract and crude fibre) and lipid. The organic matter digestibility has the similar value which also indicates that rations contributed to the production performance in a similar extent.

The Effect of Chitosan Treatment on Crude Protein Digestibility

Data analysis of crude protein digestibility statistically show different in means at all chitosan level ($P<0.05$) as shown in Table 3.

Table 3. Duncan test result of chitosan effect on crude protein digestibility

Treatment	Average of crude protein digestibility (%)	Sig. (P 0,05)
R0	68,64 ± 1.499	C
R1	66,47 ± 1.432	B
R2	62,08 ± 1.596	A
R3	69,86 ± 0.725	C

Remark: *Different letter in the column indicate difference in means ($P<0,05$).

Chitosan treatment at 2.5% (R3) has crude protein digestibility value almost the same chitosan without treatment ($P>0.05$). The value however show difference in means with ration with chitosan treatment R1 and R2 i.e. R3 has higher value ($P<0.05$). Crude protein digestibility value in total can be concluded that the rations as having mid quality feed. Reid (1973) as cited by Abun (2007) described there were 3 category of feed quality according to its digestibility: feed with low quality has 50-60% digestibility, feed with mid quality has 60-70% and

reactive to form bond with the surrounding molecules. Acidic condition in the intestines also causing the chitosan to swell which make the digested feed more viscous. Chitosan has an amine group that will be ionized in an acidic atmosphere. It will produce an electrostatic lifting force that facilitates the ability to expand it in an acidic atmosphere [13]. The optimum mixing between digested feed with protease cannot be achieved.

The flexibility of chitosan bonding corresponds linearly with the smoothness of digested feed system flows. The slowly molecule release of a trapped one means slower digested feed flows which make nutrient absorption in the intestines was limited. The digestion efficiency henceforth decreases.

Chitosan 0.5% can provide optimum acceleration of enzymatic reaction. The viscosity of digested feed along with chitosan swelling is not so rigid which make digestion mixture flows smoothly from ventricular (acidic condition) to small intestines. In the acidic condition alteration between segment, the mixture suffer stretching of chitosan bond complexity with other molecules. This situation could conduce protein release and then hydrolysed over protease (produced by pancreases) in duodenum. Similar occurrence happens on protein bonds pattern at chitosan 2.5%. Even more, due to unoccupied site on chitosan, the complexity of chitosan-protein molecule is not solid. Segmentation process and peristaltic motion of intestines runs well. Protein molecules released when transported into small intestine reduced the viscosity of digested feed. As the process continued, protease works optimally along small intestines tract to degrade protein. The decrease of digested feed viscosity moreover, triggers useful-bacteria performance effectivity on fermenting fibre in cecum.

Feed quality has linear correlation with high digestibility [14]. In connection therewith, even so the rations were composed iso-protein and iso-calorie, the physical and property of chitosan create variance of protein digestibility in the digestion system of duck as animal test.

CONCLUSION

Chitosan mixing in rations at 2.5% dose showed digestibility of dried matter and crude protein does not give value higher than control (P>0.05). However, it has the potential to increase. On the contrary, chitosan gives balance in average of organic matter digestibility.

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