Pakistan J. Zool., pp 1-4, 2025. **DOI**: https://dx.doi.org/10.17582/journal.pjz/20240730150849

Short Communication

Effects of Dietary Chitosan on Nutrient Intake and Digestibility of Peranakan Etawa (PE) Goat (*Capra hircus* Linn.)

Rakhmad Perkasa Harahap[1]*, Sadarman[2], Yeti Rohayeti[1] and Nurwahid[1]

[1]*Study Program of Animal Science, Faculty of Agriculture, Tanjungpura University, Pontianak, 78124, Indonesia*

[2]*Department of Animal Science, Faculty of Agriculture and Animal Science, Universitas Islam Negeri Sultan Syarief Kasim Riau, Pekanbaru, 28293, Indonesia*

Article Information
Received 30 July 2024
Revised 15 September 2024
Accepted 23 September 2024
Available online 17 February 2025 (early access)

Authors' Contribution
RPH: Conceptualized the study, designed the experiments, and wrote the manuscript. S: Contributed to the data interpretation. YR: Assisted with the statistical analysis and provided critical revisions to the manuscript. N: Coordinated the fieldwork and data collection, and assisted in manuscript preparation.

Key words
Chitosan, Digestibility, Feed additive, *In vivo*, Nutrient intake, Peranakan Etawa goat

ABSTRACT

This *in vivo* experiment was carried out to assess the impact of increasing amounts of chitosan in feed on dry matter intake (DMI), organic matter intake (OMI), crude protein intake (CPI), dry matter digestibility (DMD), organic matter digestibility (OMD), and crude protein digestibility (CPD) of Peranakan Etawa (PE) goat. In the metabolism cages, four PE breed male goats aged six months (average BW = 12.32±0.15 kg) were individually fed rations based on their requirements. PE goats were assigned into four groups (one goat per treatment) according to a 4 × 4 Latin Square Design for four periods, with 13 days for each period consisting of 10 days as the preliminary period and three days for sample collections. The goats were given four different levels of chitosan as follows: (1) Control with no chitosan addition; (2) addition of chitosan 10 g/kg DM feed; (3) addition of chitosan 20 g/kg DM feed; and (4) addition of chitosan 30 g/kg DM feed. The results showed that adding chitosan decreased ($P<0.05$) on DMI, OMI, and CPI of PE goat. Moreover, adding chitosan 10 g/kg DM feed increased ($P<0.05$) on DMD, OMD, and CPD of PE goat compared with the control. However, adding chitosan 20 g and 30 g/kg DM feed decreased ($P<0.05$) the PE goat's DMD, OMD, and CPD. Therefore, we concluded that additional chitosan 10 g/kg feed could be used as a feed additive in rations to improve the digestibility of PE goats.

Peranakan Etawa (PE) goat has been widely developed in Indonesia, especially in rural areas, to produce milk and meat. In Indonesia, PE goat farming is considered a viable rural business. The strategy to increase the income of PE goat production is to reduce production costs. Reduction of production costs can be achieved through efficient use of feed. High feed digestibility can increase the efficiency value of feed use. Therefore, feed additives are needed to increase feed digestibility.

Chitosan is a natural feed additive that improves the digestibility of feed nutrient in ruminants and modulates rumen fermentation, especially in concentrated diets, through its antimicrobial mechanism (Jayanegara *et al*., 2021; Harahap *et al*., 2022). Chitosan is a biopolymer molecule (N-acetyl-d-glycosamide) generated from the deacetylation of chitin, which is the second most prevalent polysaccharide on earth and forms a significant part of crustacean and insect exoskeletons. Chitosan has antibacterial activity against various bacteria, fungi, and yeasts (Kong *et al*., 2010). Moreover, chitosan has also been reported as a non-toxic to living cell and tissue. The antibacterial activity of chitosan is known through the mechanism of chitosan binding to the bacterial outer membrane protein, causing cell membrane rupture and death (Matica *et al*., 2019).

Chitosan is hypothesized to have the capacity to manipulate the rumen microbial population and affect rumen fermentation dynamics, resulting in improved digestibility. Previous studies on concentrate feed reported increased digestibility in feeds added with chitosan (de Paiva *et al*., 2017). However, Goiri *et al*. (2010a) revealed that chitosan raised ruminal propionate amounts in sheep without affecting digestibility and redirected ruminal

* Corresponding author: rakhmad@faperta.untan.ac.id
0030-9923/2025/0001-0001 $ 9.00/0

fermentation towards more efficient pathways. Further, *in vivo* studies are necessary to investigate the impact of chitosan, specifically in goat diets, due to the significance of ruminal fermentation in ruminant metabolism and performance and the possible use of chitosan as a substitute for ionophores. Hence, this *in vivo* study was conducted to evaluate the effects of escalating levels of chitosan in the diet on the intake of dry matter (DMI), organic matter (OMI), and crude protein (CPI), as well as the digestibility of dry matter (DMD), organic matter (OMD), and crude protein (CPD) in Peranakan Etawa (PE) goats.

Materials and methods

The *in vivo* study was conducted at the Research Farm of Study Program of Animal Science at Durian Village, Kubu Raya Regency, West Kalimantan, Indonesia. Commercial chitosan (viscosity 90-100 mpas and degree of deacetylation 99%) from shrimp shells was acquired for this study from CV. Nura Jaya, Surabaya, Indonesia.

Four Peranakan Etawa (PE) breed male goats aged six months (average BW = 12.32±0.15 kg) were confined in separate metabolism cages (0.51.21m). Chitosan was given to the animals from day 1 to day 13 (d 0 indicates the day before chitosan treatment), chitosan at 0, 10, 20, and 30 g/kg dry matter (DM) in a 4x4 Latin square design to diet. The basal diet was made of commercial feed (Superfeed F8) from PT. Sugeng Jaya Feed in Bogor, Indonesia. Corn, palm kernel meal, copra, cobs, coffee husks, molasses, and other ingredients are included in the basal diet. Dietary composition of the basal diet comprised dry matter, 85.8%; ash, 8.20%; crude protein, 15.0%; ether extract, 6.03%; fiber, 12.5% and carbohydrate, 44.1. All diets were fed as a total mixed ration (TMR) with a consumption dry matter diet of 3% body weight/day, three times a day in equal portions at 06.00, 12.00, and 17.00 WIB. At all times, clean water was freely available. The study had four periods. Each period they have spanned 13 days, with 10 days spent adapting to the experimental diet and three days spent collecting data.

Throughout the three-day collection period, the quantity of feed provided and the remaining feed after feeding were measured. The animal collected individual samples daily and combined them for dry matter (DM) examination. The composite samples were subjected to drying at 60ºC for 48 h and then crushed to a particle size that could pass through a 1-mm screen. These processed samples were then utilized for chemical analyses, including determining the dry matter, organic matter, and crude protein content. The combined weight of all feces samples was determined throughout the three-day collection period. Subsequently, a portion equivalent to 10% of the total daily output was selected for composite collection. The combined feces samples were thoroughly mixed, and two sets of samples were dried at a constant temperature of 60ºC for 48 h to determine the DM content. The dried samples were then crushed to a fine consistency, passing through a 1-mm screen for subsequent chemical analyses, including dry matter (DM), organic matter (OM), and crude protein (CP). The chemical analysis was conducted at the Laboratory of the Livestock and Plantation Office of West Kalimantan Province, Indonesia. The variables measured include: (a) nutrient intake of dry matter (DHI), organic matter (OMI), and crude protein (CPI); (b) digestibility of dry matter (DMD), organic matter (OMD), and crude protein (CPD).

Results and discussion

Table I demonstrated a significant reduction (P<0.05) in the DMI, OMI, and CPI of PE goats when chitosan was added. The outcome matched the prior discovery that the DMI, CPI, and neutral detergent fiber (NDFI) decreased when treated with dietary chitosan and a combination of chitosan and soybean oil (Del Valle *et al*., 2017). Furthermore, similar findings have been published indicating that the inclusion of dietary chitosan at a rate of

Table I. Effect of dietary chitosan on nutrient intake and digestibility of PE goat.

Parameter	Addition of chitosan (g/kg DM feed)				SEM	P-value
	0	10	20	30		
Nutrient intake						
Dry matter intake (g/head/day)	306.68[a]	304.58[a]	295.86[b]	291.67[c]	13.246	P<0.05
Organic matter intake (g/head/day)	212.87[a]	210.29[b]	205.77[c]	203.82[c]	9.182	P<0.05
Crude protein intake (g/head/day)	46.00[a]	45.69[b]	44.38[c]	43.75[c]	1.987	P<0.05
Nutrient digestibility						
Dry matter digestibility (%)	58.16[b]	59.54[a]	57.06[c]	56.22[d]	0.606	P<0.05
Organic matter digestibility (%)	71.16[b]	72.03[a]	70.23[c]	70.05[c]	0.409	P<0.05
Crude protein digestibility (%)	78.41[b]	79.48[a]	78.55[b]	75.36[c]	0.481	P<0.05

Significant differences exist between values in the same row that contain different superscripts.

4 g/kg of dry matter in raw whole soybeans resulted in a reduction in DMI, OMI, CPI, and NDFI (Zanferari *et al*., 2018). Nevertheless, several studies have indicated that including chitosan in ruminant diets did not affect DMI (Araújo *et al*., 2015; Henry *et al*., 2015; Mingoti *et al*., 2016; Vendramini *et al*., 2016).

The reduction in DMI was mostly caused by the changes in rumen fermentation generated by the ratio rather than the direct influence of chitosan (Harahap *et al*., 2022). In their study, Gandra *et al*. (2016) found that ruminants fed chitosan had a reduced dry matter intake compared to ruminants fed other feeds. It was likely owing to the higher digestibility of dry matter in chitosan, which resulted in increased levels of oxidized fuel reaching the liver. In addition, the increased absorption of nutrient by the colon might lead to the delivery of oxidized fuel to the liver, which can disrupt feed intake by transmitting information to the central nervous system (Allen *et al*., 2009). Furthermore, ruminants that were administered chitosan exhibited an elevation in rumen propionate fermentation (Araújo *et al*., 2015), which decrease in feed consumption (Allen, 2000). An alternative interpretation of this study is that the drop in dry matter intake was linked to a shorter period of rumination, which was caused by a decline in the effectiveness of chewing NDF (Haraki *et al*., 2018).

Table I showed that adding chitosan 10 g/kg DM feed increased ($P<0.05$) DMD, OMD, and CPD of PE goat compared with the control. However, adding chitosan 20 g/kg and 30 g/kg DM feed decreased DMD, OMD, and CPD of PE goat. The result lined up with previous research that found an increase in DMD and CPD with the addition of chitosan (Vendramini *et al*., 2016; Dias *et al*., 2017). In sheep research, chitosan tended to reduce the digestibility of NDF without affecting the digestibility of OM (Goiri *et al*., 2010b).

Adding chitosan caused alterations in the microbial population structure, increasing nutrient digestibility. Because of interactions between polycationic chitosan and electronegative charges on microbial surfaces, chitosan properties have been shown to influence protozoa cell permeability (Wencelova *et al*., 2014). Chitosan use has been connected to a decrease in the rumen protozoa population, which lessens the likelihood of protozoa predation on bacteria (Harahap et. al., 2020). Furthermore, chitosan can boost the overall bacteria population, which is necessary for nutrient breakdown and fermentation (Harahap *et al*., 2020). The rise in CPD was explained by the hypothesis that chitosan increased rumen intestinal permeability, enhancing nutrient digestibility (Del Valle *et al*., 2017). Furthermore, because chitosan can interact with rumen bacteria to enhance deamination and proteolysis, lowering protein breakdown in the rumen while boosting amino acid transport in the small intestine Mingoti *et al*. (2016), this may be related to the ionophore mechanism.

The broader the antimicrobial spectrum, the greater the chitosan dose, which affects DMD, OMD, and CPD reduction. Gram-positive bacteria have easier access to the outer peptidoglycan layer than Gram-negative bacteria, which account for most fibrinolytic bacteria (Kong *et al*., 2010). Kirwan *et al*. (2021) discovered *in vitro* reductions in OM digestibility with chitosan addition, indicating action towards cellulolytic bacteria. Other investigations have found that dietary chitosan affects protozoal activity Belanche *et al*. (2016b) and rumen cellulolytic bacteria (Belanche *et al*., 2016a), the components that cause feed degradation and fermentation activity to decrease. Reduced chitosan solubility (85% deacetylation) and inclusion amount may mitigate the negative effect on feed digestibility (Belanche *et al*., 2016b).

Conclusion

It can be concluded that feeding chitosan at 10 g/kg DM feed can raise DMD, OMD, and CPD in PE goats. However, dietary chitosan to PE goats can lower their nutrient intake.

DECLARATIONS

Acknowledgments

This study was supported by the Study Program of Animal Science, Faculty of Agriculture, Tanjungpura University, Pontianak, Indonesia.

Funding

All authors were grateful to the DIPA Tanjungpura University fiscal year 2022 following the study implementation agreement letter number: 2808/UN22.3/PT.01.03/2022 dated April 6, 2022.

IRB approval

The research protocol on the use of Peranakan Etawa goats was reviewed and approved by the Institutional Review Board (IRB) of the Animal Husbandry Program, Faculty of Agriculture, Universitas Tanjungpura, with approval number IRB-PTN/2022/015. All procedures involving animal subjects adhered to the Ethical Standards of the Institutional Research Committee.

Ethical statement

The current study was conducted in accordance with ethical guidelines of the Animal Care Commettee of Study Program of Animal Science, Faculty of Agriculture, Tanjungpura University, Pontianak, Indonesia.

Statement of conflict of interest

The authors have declared no conflict of interest.

References

Allen, M.S., 2000. *J. Dairy Sci.,* **83**: 1598–1624. https://doi.org/10.3168/jds.S0022-0302(00)75030-2

Allen, M.S., Bradford, B.J. and Oba, M., 2009. *J. Anim. Sci.,* **87**: 3317–3334. https://doi.org/10.2527/jas.2009-1779

Araújo, A.P.C.D., Venturelli, B.C., Santos, M.C.B., Gardinal, R., Cônsolo, N.R.B., Calomeni, G.D., Freitas, J.E., Barletta, R.V, Gandra, J.R., Paiva, P.G. and Rennó, F.P., 2015. *Anim. Feed Sci. Technol.,* **206**: 114–118. https://doi.org/10.1016/j.anifeedsci.2015.05.016

Belanche, A., Pinloche, E., Preskett, D. and Newbold, C.J., 2016a. *FEMS Microbiol. Ecol.,* **92**: p.fiv160. https://doi.org/10.1093/femsec/fiv160

Belanche, A., Ramos-Morales, E. and Newbold, C.J., 2016b. *J. Sci. Fd. Agric.,* **96**: 3069–3078. https://doi.org/10.1002/jsfa.7481

de Paiva, P.G., de Jesus, E.F., Del Valle, T.A., de Almeida, G.F., Costa, A.G.B.V.B., Consentini, C.E.C., Zanferari, F., Takiya, C.S., da Silva Bueno, I.C. and Rennó, F.P., 2016. *Anim. Prod. Sci.,* **57**: 301–307. https://doi.org/10.1071/AN15329

Del Valle, T.A., de Paiva, P.G., de Jesus, E.F., de Almeida, G.F., Zanferari, F., Costa, A.G., Bueno, I.C. and Rennó, F.P., 2017. *Livest. Sci.,* **201**: 22–29. https://doi.org/10.1016/j.livsci.2017.04.003

Dias, A.O.C., Goes, R.H.T.B., Gandra, J.R., Takiya, C.S., Branco, A.F., Jacaúna, A.G., Oliveira, R.T., Souza, C.J.S. and Vaz, M.S.M., 2017. *Anim. Feed Sci. Technol.,* **225**: 73–80. https://doi.org/10.1016/j.anifeedsci.2017.01.015

Gandra, J.R., Takiya, C.S., Oliveira, E.R.D., Paiva, P.G.D., Gandra, É.R.D.S. and Araki, H.M.C., 2016. *Rev. Bras. de Zootec.,* **45**: 130–137. https://doi.org/10.1590/S1806-92902016000300007

Goiri, I., Indurain, G., Insausti, K., Sarries, V. and Garcia-Rodriguez, A., 2010a. *Anim. Feed Sci. Technol.,* **159**: 35–40. https://doi.org/10.1016/j.anifeedsci.2010.05.007

Goiri, I., Oregui, L.M. and Garcia-Rodriguez, A., 2010b. *J. Anim. Sci.,* **88**: 749–755. https://doi.org/10.2527/jas.2009-2377

Harahap, R.P., Setiawan, D., Nahrowi, N., Suharti, S., Obitsu, T. and Jayanegara, A., 2020. *Trop. Anim. Sci. J.,* **43**: 233–239. https://doi.org/10.5398/tasj.2020.43.3.233

Harahap, R.P., Suharti, S., Ridla, M., Laconi, E.B., Nahrowi, N., Irawan, A., Kondo, M., Obitsu, T. and Jayanegara, A., 2022. *Anim. Sci. J.,* **93**: e13676. https://doi.org/10.1111/asj.13676

Haraki, H.M.C., Gandra, J., De Oliveira, E.R. and Takiya, C., 2018. *Iran. J. appl. Anim. Sci.,* **8**: 397–405.

Henry, D.D., Ruiz-Moreno, M., Ciriaco, F.M., Kohmann, M., Mercadante, V.R.G., Lamb, G.C. and DiLorenzo, N., 2015. *J. Anim. Sci.,* **93**: 3539–3550. https://doi.org/10.2527/jas.2014-8844

Jayanegara, A., Harahap, R.P., Suharti, S. and Nahrowi, N., 2021. Chitosan as a feed additive: Its modulatory effect on methane emission and biohydrogenation under artificial rumen system. *In: IOP Conf. Ser. Mater. Sci. Eng.,* pp. 42101. https://doi.org/10.1088/1757-899X/1098/4/042101

Kirwan, S.F., Pierce, K.M., Serra, E., McDonald, M., Rajauria, G. and Boland, T.M., 2021. *Animals*, **11**: 1–14. https://doi.org/10.3390/ani11030771

Kong, M., Chen, X.G., Xing, K. and Park, H.J., 2010. *Int. J. Fd. Microbiol.,* **144**: 51–63. https://doi.org/10.1016/j.ijfoodmicro.2010.09.012

Matica, M.A., Aachmann, F.L., Tøndervik, A., Sletta, H. and Ostafe, V., 2019. *Int. J. mol. Sci.,* **20**: 5889. https://doi.org/10.3390/ijms20235889

Mingoti, R.D., Freitas Jr, J.E., Gandra, J.R., Gardinal, R., Calomeni, G.D., Barletta, R.V., Vendramini, T.H. A., Paiva, P.G. and Rennó, F.P., 2016. *Livest. Sci.,* **187**: 35–39. https://doi.org/10.1016/j.livsci.2016.02.008

Vendramini, T.H.A., Takiya, C.S., Silva, T.H., Zanferari, F., Rentas, M.F., Bertoni, J.C., Consentini, C.E.C., Gardinal, R., Acedo, T.S. and Rennó, F.P., 2016. *Anim. Feed Sci. Technol.,* **214**: 12–21. https://doi.org/10.1016/j.anifeedsci.2016.01.015

Wencelova, M., Varadyova, Z., Mihalikova, K., Kisidayova, S. and Jalc, D., 2014. *Turk. J. Vet. Anim.,* **38**: 26–33.

Zanferari, F., Vendramini, T.H.A., Rentas, M.F., Gardinal, R., Calomeni, G.D., Mesquita, L.G., Takiya, C.S. and Rennó, F.P., 2018. *J. Dairy Sci.,* **101**: 10939–10952. https://doi.org/10.3168/jds.2018-14675