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The Potential Use of Humic Substance as Natural Organic Additives for Ruminants: A Review

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ABSTRACT

Humate substances (HSs) are raw materials that are very easy to obtain and are naturally occurring organic molecules found in soil due to the humification of dead organic components. Traditionally used as conventional medicine in China and India and as soil fertilizer in agriculture. Humic acids are widely utilized as feed additives and could enhance ruminant performance. The effect of humic acid on feed intake depends on the level of supplementation, a humic acid source, experimental animals used and the region experimented. Humic acid also increases the average daily gain, and sometimes increases feed digestibility and feed efficiency in goats, cows and cattle. Enhancement of milk yield, total solids, fat-corrected milk (FCM), and energy but does not influence milk composition. That supplementation also lowers blood cholesterol, excluding eosinophil and neutrophil, without affecting the haematological value. HSs also have anti-bacterial properties and HSs affect gut microbiota and rumen, such as increasing fungi counts and pH alteration, but the effect on bacteria and the protozoal population is non-consistent. In other trials, HSs have also been shown to reduce the process of methanogenesis.

Keywords humic acid, performance, digestibility, gut microbiota, haematological

INTRODUCTION

Many substances have been used as substitutes for antibiotics as promoters of livestock growth given in animal feed or drinking water. These compounds consist of prebiotics, probiotics, extracts of plants, essential oils, and organic acids/materials, with humic acid being one of the least expensive organic acids that could be utilized as livestock growth promoters (De Melo et al., 2016). Humic acids are organic substances with a complex molecular structure with a high molecular weight and an active compound. In nature, humic acids are formed through physical, chemical, and biological processes from materials derived from plants and animals that decompose and occur due to microbial biological activity. Humic compounds consist of carbon, oxygen, hydrogen and nitrogen, as well as trace amounts of Sulphur and phosphorus. Humic acids are long-chain, high-molecular-weight alkali-soluble chemicals (Goel and Dhingra, 2016); when the pH of aqueous media falls below 2, humic chemicals precipitate. Humic acids (HA) are also called polydisperse because of their varying chemical composition (Goel and Dhingra, 2016).

For more than 3000 years humic acid has been used for traditional medicine in several countries, especially India and China, this is documented in the books of 'Ayurveda' and 'Siddha'. During the time of 15th-century during Ming Dynasty the medical text called “Chinese Materia Medica pharmacological compendium” reports that HSs could be used as conventional medicine. HS has a lot of benefits; therefore humate substances were assigned as “Wujinsan”, which means “golden medicine” in China (Bradley, 2020)

Humates substances are raw materials that are very easy to obtain and can be employed in agricultural and animal husbandry as a supplement in drinking water or feed (Galip et al., 2009). The application of humate substances (HS) in agriculture is due to their being environmentally safe and affecting productivity and quality of the soil. Improvement in plant height and weight due to the addition of humic compounds has been reported by Nardi et al. (2021); De Hita et al. (2019) and Dhingra and Goel, 2016). However, most published studies show benefits such as higher growth with HS supplementation under control, so there is little evidence of efficacy in on-farm conditions. According to (Ampong et al., 2022) the efficacy of HS depends on soil type, HS source, application rate and soil solubility.

The application of humic acid as a functional supplement for aquafeeds was reported by (Prokešová et al., 2021) pig (Visscher et al., 2019) and chicken (Rizal and Marlida 2013); Disetlhe et al. (2019); Aristimunha et al.(2020) and (Hakan et al., 2012). The addition of organic acids in broiler feeds significantly boosts weight gain and improves protein digestion and absorption by addressing deficits in hydrochloric

acid output and enhancing pepsin enzymatic activity (Fascina et al., 2012), increase in meat quality (meat colour and water-holding- capacity) with no effect on intramuscular fat (IMF), increase in PUFA/SFA ratio (Disetlhe et al., 2019). Dietary humate supplementation mitigates the harmful effects of higher caging density in hens, and it could be due to the function of trace elements in humates with antioxidative characteristics. The use of humic acid for feed supplements in poultry and pigs is widespread due to its positive influence. However, there was a limited scientific publication on applying that substance to ruminants in Indonesia. This review provides information on current research on the effect of humic acid as a feed supplement on performance, feed intake and digestibility, gut microbiota, biochemical haematological and milk parameters of ruminants.

The effect of humic acid on feed utilization and performance

Table 1 shows the overall impact of humic acid on cattle, sheep, and goat performance and feed utilization). Cusack (2008) feed MAX 15TM, a dietary humic and fulvic acid complex, was found to impact the growth rate and health of livestock, FCR, and carcass features of feedlot cattle. Humic acids have not been found to improve performance in ruminant diets (McMurphy, 2007). Cusack (2008) found the impact of Feed MAX 15TM, a dietary humic and fulvic acid complex, on the health, growth rate, feed conversion ratio, and carcass features of feedlot cattle; those organic acids can boost growth rate and feed conversion efficiency. Humic acids have not shown promise as a performance-enhancing supplement in ruminant diets (McMurphy, 2007).

Table 1. The effect of humic acid on feed utilization and performance

Humic acids source	Animal Used	Results	References
Humic acid (Feed MAX 15)	Cattle feedlot	Increase ADG and lower FCR, increase feed efficiency.	Cusack (2008)
Dark black humic acid (commercial)	Swiss Brown dairy cows	Did not affect post- partum vaginal odour and decreased postpartum problems and pregnancy.	Yüca and Gül, 2021)
Humic acids (commercial)	Crossbred beef steers	Dry matter intake depends on level supplementation, ADG, gain to feed, Rumen Amino Nitrogen and pH in finishing steers when compared to those fed Monensin	McMurphy et al. (2009)
Humate substances (GTX Technologies, Amarillo)	Lactation Friesian cows	There is no effect on feed intake, increased dry and organic matter, non-Structure carbohydrates, ND digestibility, and the concentration of total Volatile Fatty Acid.	Kholif et al. (2021)
Humic acids (Clay Derived-HS)	Holstein-Friesian dairy cows	No effect on feed intake and digestibility except crude protein digestibility coefficients	Hassan et al. (2020).
Humic substances (Canadian Humalite International Inc., Edmonton, AB,	Angus × Hereford crossbred heifers	No effect on dry matter intake, increased Protein digestibility, increased nitrogen retention, no effect methane production	Terry et al. (2018)
Humic acids	Arabi male lambs	Total volatile fatty acids increase, reducing methane emission.	Usser (2022)
Humic Acids (HUMAC nature AFM)	Sheep (in vitro)	increases the initial rate of ruminal cellulose degradation, reduce the rate of carbohydrate degradation in the rumen	Majewska et al. (2017)
Humic Acids (GTX Technologies, Amarillo, TX, USA)	Late pregnant Barki goats	reduce feed intake, no effect on nutrients digestibility	El-Zaiat et al. (2018)

In investigations by Yüca and Gül (2021), humate supplementation on pregnant Swiss Brown dairy cows did not affect Body Condition Score as well as Body Weight (McMurphy et al., 2009) in their experiment administered humate in different quantities to different sexes; as a consequence, they reported that humate increased live weight in female calves more than male calves when compared to control group calves (McMurphy et al., 2009).

McMurphy et al. (2011) observed supplementation of humic acid at 5 and 10 g/kg body weight decreased feed intake when the supplementation of 15 g/kg body weight feed intake increased. Furthermore, El-Zaiat et al. (2018) indicated increased feed intake in Barki goats with 2 g daily humic acid supplementation. Differences in results could be attributed to changes in feed composition, animal type, adaptation period, and humic acid supplement amount.

Several researchers reported that humic substances supplementation has no effect on feed intake in lactating cows (Kholif et al., 2021) and (Hassan et al., 2020) on dairy goats (Degirmencioglu 2014), on crossbred heifers (Terry et al., 2018). However, this supplementation enhanced dry matter, organic matter and NDF digestibility (Kholif et al., 2021), and crude protein digestibility (Hassan et al., 2020; Terry et al., 2018). According to Kholif et al. (2021 even though no effect on feed intake, increasing digestibility could be because humate administration increased ruminal microbial activity and fermentation. Humic acids can assist control of intestinal pH, boost the activity of digestive enzymes, increase nutritional bioavailability and usage, and improve overall digestibility. Humic substances (HS) increased proteolytic activities in the intestinal apparatus, resulting in a considerable increase in protein digestibility. (Marcin et al., 2021). Increasing digestibility could also be due to the reduction of faecal excretion.

Moreover, (Degirmencioglu 2014) reported HS could enhance animal performance. The administration of humic acid resulted in a similar birth weight. At 30 and 60 days after delivery, the average daily gain of children reared by goats administered with humic acid was significantly higher than that of those in the control groups (El-Zaiat et al. 2018). McMurphy et al. (2009) discovered that humic acid can be used as an ionophore because its effect was comparable to monensin.

Humic/fulvic acid supplementation reduces methane production (Usser, 2022), using a rumen batch culture approach in vitro Sheng et al. (2017) proved that including HSs reduces methane production. The presence of humic acid (HA) negatively affects energy efficiency and inhibits the methanogenic process (Li et al., 2019).

Table 2. Effect of humic acid on gut microbiota and rumen condition

Humic acids source	Animal Used	Results	References
Humic acids	Arabi male lambs	No effect on cellulolytic and the total bacteria count.	Usser (2022)
Humic acids (commercial)	Kivircik rams	No effect on rumen fermentation except Epidinium spp.	Galip et al. (2009)
Humic Acids (HUMAC nature AFM)	Sheep (in vitro)	Increases the initial rate of ruminal cellulose degradation, reduces carbohydrate degradation in the rumen	Majewska et al. (2017)
Sodium Humate	West African Dwarf Goats	Fungi counts increase 30 days after supplementation and decrease after 60 days. No effect on bacterial and protozoa counts	Ikyume et al. (2020)
Humate substances (GTX Technologies, Amarillo)	Lactation Friesian cows	Decreased ruminal protozoal population	Kholif et al. (2021)
Humic acids (Clay Derived-HS)	Holstein-Friesian dairy cows	Increase protozoal population	Hassan et al. (2020)
Humic Acids (GTX Technologies, Amarillo, TX, USA)	Late pregnant Barki goats	pH rumen increase	El-Zaiat et al. (2018)

Humic acid contains natural substances with antibacterial activities (Verrillo et al. 2022), which have been shown to enhance microbial growth. It is believed that these humic acid effects in soil may have similar responses in the rumen, improving nutrient fermentation and digestibility through increased microbial activity. The rate at which humic acid stimulates the growth of fibrolytic bacteria and degrades cellulose in the rumen was determined by the amount of humic acid in the diet and the timing of implementation (Majewska et al. 2017). Adding humic acid to the diet enhanced rumen acetate concentrations while decreasing rumen protozoan populations, pH, ammonia, N, and butyrate levels (Kholif et al. 2021). Ikyume et al. (2020) reported that supplementation of sodium humate in 30 days significantly increases the total number of fungi. Table 2 indicates that the effect of humic substance could enhance the protozoal population (Hassan et al. 2020), while Kholif et al. (2021) find the contrary. As dietary antiprotozoal drugs, dietary humic acid formulations are not always effective (Váradyová et al., 2009).

Humic acids can improve rumen digestion and livestock performance by modulating gut microbiota and improving digestive enzymes (Kholif et al., 2021). According to the findings Nagpal et al. (2009), fungi are known to adhere primarily to keratinized tissue that resides in the rumen for long periods and are more common in animals fed a high-fibre diet but primarily in foliar-fed animals. In the intestinal tract, for shorter periods of deprivation of feed retention. For animals grazing on lignified forages, this increase in fungi counts could help enhance the utilization of the nutrients in the forages.

The high rumen pH in HA-treated goats represents the buffering capacity of humic substances, which may lead to rumen acid stabilization and manipulation of rumen alterations to improve rumen microbial function efficiency (El-Zaiat et al. 2018). The buffering capacity of sodium humate may explain why it raises the pH of goat rumen. This stabilises ruminal acidity, leading to changes that improve the efficiency of microbial rumen processes (Ikyume et al., 2020). The effect of humic acids on rumen protozoal is not consistent. Throughout the trial, the levels of supplementing sodium humate did not affect protozoa and bacterial counts (Ikyume et al. 2020). (Kholif et al. 2021) HA decreased the ruminal protozoal population, while (Hassan *et* al., 2020) reported results to the contrary.

Table 3. Effect of humic acid on biochemical haematological and milk parameters

Humic acids source	Animal Used	Results	References
Humate substances (GTX Technologies, Amarillo)	Lactation Friesian cows	Decreased cholesterol, triglycerides and urea nitrogen. Increase milk yield and constituent, also increase total milk solids, fat, and energy.	Kholif et al. (2021)
Humic acids (commercial)	Crossbred beef steers	No differences in Serum Urea Nitrogen, when compared to those fed Monensin	(C. P. McMurphy et al. 2009)
Humic acids (product Humac Nature AFM)	Dairy cows	Decrease Somatic cell count and milk urea, increase neutrophil activity	(Zigo et al. 2020) Teter et al. (2021)
Humic acids (Clay Derived-HS)	Holstein-Friesian dairy cows	Increasing milk yield, blood glucose, decrease blood urea nitrogen, and cholesterol	Hassan et al. (2020)
Humic acids (commercial)	Kivircik rams	No effect on haematological parameters	Galip et al. (2009)
Humic Acids (GTX Technologies, Amarillo, TX, USA)	Late pregnant Barki goats	Increased blood protein, Milk yield, and milk content such as fat, protein, lactose, Fat Corrected Milk and Energy Corrected Milk	El-Zaiat et al. (2018)
Humic Acids (Bovifarm, Bio Remedies)	Saanen goats	Lowering blood cholesterol but does not affect protein, increased milk yield, no effect on milk composition	(Degirmencioglu 2012)
Dark black humic acid (commercial)	Swiss Brown dairy cows	Enhanced the yield of milk and fat content	(Yüca and Gül 2021)

The current study investigates the impact of natural additions of humic acid in ruminant diets on animal health and product qualities. Total cholesterol was considerably significantly lowered by humic acid delivery (Kholif et al. 2021) (Degirmencioglu 2012). (Hassan et al. 2020), Treatment did not affect serum total protein, glucose, or high-density lipoprotein levels (Kholif et al. 2021); similar findings were published by (Degirmencioglu 2012).

El-Zaiat et al. (2018) reported different results, administrated with humic acid on goats causing higher total protein and globulin in the blood. Higher total protein levels in HA-treated goats imply that HA may regulate protein metabolism. Higher globulin concentration could indicate the capacity of humate compounds to boost animal immune systems. According to (Kholif et al., 2021) humate supplementation increases eosinophil levels, while supplementation of 100g HA per cow per day had nutritional benefits by increasing the activity of neutrophils, which may protect against bacterial pathogens and reducing mortality in acute bacterial infections (Zigo *et al.* 2020)**.** Zigo *et al.* (2020) also reported that their indirect positive effects increased the development of immunological responses, resulting in lower Somatic Cell Count and the incidence of coagulase-negative staphylococci (CNS)-induced mastitis. This opinion is supported by (Verrillo et al. 2022); humic acid has antibacterial activity against *Staphylococcus aureus* and *Enterococci.* Research conducted by Kumar *et al.* (2021)the data suggest that blended organic acid could be used instead of zinc bacitracin to protect an animal from necrotic enteritis, as indicated by improved Feed Conversion Ratio, immunity, and feed digestibility

Table 3 showed several findings on increasing milk production by humate substances (Kholif *et al.,* 2021; Hassan *et al.* (2020); (El-Zaiat et al. 2018); Degirmencioglu (2012) and Yüca and Gül (2021). Moreover, humate substances also affected increasing total solids in milk, milk energy and fat (Kholif *et al.*, 2021) (Yüca and Gül, 2021), protein, lactose, FCM and ECM yields (El-Zaiat *et al.* 2018). The potential of humic compounds is to minimize the absorption and availability of bacterial endotoxins, restrict the growth of harmful bacteria and fungi, and enhance gastrointestinal health (Marcin *et al.* 2021). This may contribute to increased milk production. According to Degirmencioglu (2012), increasing milk output because of its feeding had no negative impact on goats' health.

CONCLUSION

Humic has been used for traditional medicine in several countries; this substance has generally been used as a soil fertilizer. The application of humic acids in ruminants is commonly as a feed supplement. Humic acid increases the performance of ruminants, increases Average Daily Gain, and milk yield, has no effect on milk composition, sometimes increases feed digestibility, lowering blood cholesterol, have the capability as antimicrobial. However, the effect on the protozoal population and methane production is inconsistent. No effect on haematological value except increasing eosinophil and neutrophil. In some experiments, HSs also reduce the process of methanogenesis.

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