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Feed intake and daily weight gain of madura cattle fed rice straw and basal diet using garlic powder and organic mineral

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ABSTRACT

The research explored the incorporation of garlic powder, organic chromium, and Zn-Lysinate affected Madura cattle with rice straw feed, as well as their average daily gain (ADG), and body condition score (BCS). The study used a real-life experiment with a totally random design, using three different approaches, each tried eight times. The different approaches were: R0: just the regular feed; R1: regular feed + 250 ppm garlic powder + 1.5 ppm organic chromium; R2: regular feed + R1 feed + 40 ppm Zn-lysinate. The data showed that adding garlic powder and organic chromium made it easier to digest the fiber and protein in the feed. The average daily weight gain for Madura cattle with treatments R0, R1, and R2 were 0.67±0.22 kg/day, 1.07±0.17 kg/day, and 0.70±0.09 kg/day, in that order. The average body condition scores for treatments R0, R1 and R2 were 4.67±1.03; 5.17±0.41 and 4.75±0.76. Adding garlic powder and organic chromium to the feed of Madura cattle can make them gain 59.75% more weight each day, however, adding garlic powder, organic chromium, and Zn-lysinate to the feed does not effectively improve the daily weight gain or physical condition of Madura cattle.

Introduction

The challenge for nutritionists in developing countries is utilizing rice straw as a fiber source for ruminants. The affordability, wide availability, and high volume of rice straw make it the go-to option for farmers with smallholder cattle. Rice production figures in Indonesia for 2023 and 2024 were 53.9 and 53.1 million tons, respectively (according to the Central Bureau of Statistics in 2024). This substantial rice output means that using rice straw, a byproduct of rice production, as feed for Madurese cattle offers considerable opportunities. However, rice straw has nutritional shortcomings, featuring elevated levels of crude fiber, insufficient protein, and an imbalance of minerals. The presence of high crude fiber can lead to a large production of acetic acid during rumen fermentation. The high amounts of acetic acid further results in the release of H2 ions in the creation of methane (Sari *et al*., 2022).

Rumen health, how well ruminants grow, and the quality of their products are all affected by their diets. Adding supplements to their diet is therefore a practical and helpful way to change what they eat to enhance rumen health, growth, and product quality. Plants and the things made from them include different active ingredients that have a number of biological effects; therefore, they work well as a substitute for antibiotics in animal diets. Research indicates that supplementing diets with plant products has the potential to enhance the well-being, performance, and product quality of animals. Garlic is composed of active ingredients such as allicin, allyl, and daiallyl sulphide (Khurana *et al*., 2023). Garlic serves as a natural feed supplement that greatly lowers the production of CH4 gas (Ahn *et al*., 2024). Methanogenic bacteria may be directly suppressed by the allicin and organic sulphur present in garlic (Bhatwalkar *et al*., 2021). The amount of organosulfur compounds in garlic powder varies from 0.56% to 0.80% when measured on a dry matter basis (Micová *et al*., 2018), which then improves the ability of rumen microbes to break down feed (both dry and organic matter) (Ikyume *et al*., 2017)

The absorption of minerals by the body of livestock could be increased when they are in organic form (Prayitno *et al*. 2016). Chromium (Cr) and Zinc (Zn) are trace minerals that are important for how feed is metabolized. Mineral Cr has an impact on how glucose and amino acids are moved during glycolysis, which leads to a higher energy supply (Azwar *et al*., 2023; Suryapratama *et al*., 2023). The efficiency with which rumen microbes absorb energy could be raised by organic chromium, which improves the digestion of feed (Ahreza *et al*., 2020; Zarczynska and Krzebietke, 2020). Mineral Zn plays a role in a number of enzyme activities, cell growth, and cell differentiation (Kiouri *et al*., 2025), as well as being involved in the synthesis of various hormones, including insulin and glucagon, and taking part in the metabolism of carbohydrates, acid-base balance, and vitamin A.

Prior investigations indicated that incorporating garlic powder and organic minerals into the diets of lactating cows may lead to greater feed consumption (Prayitno *et al*., 2016), while Prayitno *et al*. (2013) highlighted that integrating Sapindus rarak, garlic, and organic minerals into the feed for beef cattle could raise the consumption of dry matter by 1.70±0.38 kg/day and organic matter by 1.41±0.43 kg/day. An increase in the consumption of dry matter and organic matter is anticipated to enhance the production performance of livestock. The current study aimed to determine the quantities of dry matter and organic matter consumed, feed digestibility, average daily gain (ADG), and body condition score (BCS) in Madura cattle that receive feed enhanced with garlic powder (*Allium sativum*) and organic minerals (organic Chromium and Zn-lysinate).

Materials and methods

Ethical approval

The experimental procedures used throughout this study were conducted under National guidelines for the proper care and use of laboratory animals established by the University of Jenderal Soedirman.

Livestock, experimental design, livestock treatment, and treatment design

The experimental procedures used throughout this study were conducted under National guidelines for the proper care and use of laboratory animals established by the University of Jenderal Soedirman. The materials used in this study consisted of 24 Madura bulls with an average

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initial weight of 253±18.97 kg, feed consisting of 45% straw, 5% corn stover and 50% concentrate, drinking water, organic Chromium 1.5 ppm, Zinc-lysinate 40 ppm, garlic powder (*Allium sativum*) 250 ppm, buckets, analytical scales with an accuracy of 0.05 kg, cattle scales with a capacity of 500 kg, analytical scales with an accuracy of 0.001 kg. The treatment feed used consisted of rice straw (25%), corn stover (25%), and concentrate (50%), with the composition shown in Table 1. The research design was a complete randomized design (CRD) with 3 treatments and 8 replications. The treatments consisted of R0= basal feed; R1= R0 feed + 250 ppm garlic powder (*Allium sativum*) + 1.5 ppm organic Chromium; and R2= R1 feed + 40 ppm Zn-Lysinate. The data obtained were analysed using analysis of variance.

Table 1. Feed formulation of the reseach.

Feed ingredients	R_0	R_1	R_2
Rice straw (%)	45	45	45
Corn stover (%)	5	5	5
Feed Concentrate (%)	50	50	50
- Cassava by product (%)	38	38	38
- Pollard (%)	16	16	16
- Copra meal (%)	15	15	15
- Palm kernel meal (%)	5	5	5
- Rice bran (%)	16	16	16
- Soybean meal (%)	3	3	3
- Molasses (%)	2.5	2.5	2.5
- Minerals (%)	1	1	1
- Dolomite lime (%)	0.5	0.5	0.5
- Salt (%)	2	2	2
- Urea (%)	1	1	1
Garlic powder (ppm)	-	250	250
Organic Cr (ppm)	-	1.5	1.5

R0= basal feed; R1= R0 feed + 250 ppm garlic powder (*Allium sativum*) + 1.5 ppm organic Chromium; and R2= R1 feed + 40 ppm Zn-Lysinate).

Sampling and analysis procedures

Feed intake was calculated from feed offered and refused daily. The DM of feed samples was determined by drying samples to a constant weight at 105ºC. Before the morning feeding of measurement d 0, 14, 28, and 42, all calves were weighed and the average daily gain (ADG) for each animal was observed. Before the morning feeding of d 0, 14, 28, and 42 of the feeding periods, the BCS of each bull (1 to 5, with 1 and 5 indicating very thin and fat, respectively) was determined according to the method described by Soares and Dryden (2011).

The digestibility trial consisted of a 5 metabolic cage adaption period and 7 days for total feces collection. The total collection of feces allowed the calculation of apparent digestibility (DM and nutrients) between d 36 and 42 of the measurement period. Daily collected fresh feces were subsampled (100 g/kg) and stored at 20ºC. Samples per bull for 7 d were thawed and pooled (500 g per bull) and dried at 105ºC to determine DM content. All feeds and the remaining feces samples were dried at 65ºC for 48 hours, ground to pass through a 1 mm screen (Wiley Mill, Arthur H. Thomas, Philadelphia, PA, USA).

Statistical analysis

Data were analyzed using a general linear model using SPSS ver.22. Measurements obtained per bull on different sampling days were treated as repeated measures.

Results

Effect of treatments on dry matter intake and organic matter intake

The results of the study on dry matter (DMI), and organic matter (OMI) intake of Madura cattle are shown in Table 2. The data indicated that the highest DMI occurred with the R1 treatment, reaching 8.08±0.13 kg, a rise of 0.57±0.07 kg/head/day compared to the R0 treatment. The R1 treatment exhibited the highest OMI, averaging 6.05±0.52 kg, which represents a 0.43±0.06 kg increase compared to the R0 treatment. Similar to what was observed with DMI, there was an increase in OMI in the R1 and R2 treatments relative to R0. The amount of OMI in the R2 treatment was lower than in the R1 treatment. The presence of minerals in the R2 treatment resulted in a decrease in organic matter intake compared to the R1 treatment.

Table 2. Average DMI (kg), DMI (% per BW) and OMI (kg) of Madura cattle.

	R_0	R_1	R_2	SEM	*p* value
DMI, kg	7.51	8.08	7.56	0.13	1.67
DMI of BW	2.45	2.36	2.45	0.07	1.75
OMI, kg	5.62	6.05	5.65	0.09	1.35

R0= basal feed; R1= R0 feed + 250 ppm garlic powder (*Allium sativum*) + 1.5 ppm organic Chromium; and R2= R1 feed + 40 ppm Zn-Lysinate).

Effect of treatments on digestibility

Dry and organic matter digestibility

The results of the study on dry matter (DMD) and organic matter (OMD) digestibility of Madura cattle are shown in Table 3. The outcomes for dry matter digestibility (DMD) and organic matter digestibility (OMD) were not statistically difference (P>0.05). The R0 method displayed a DMD of 55.1±1.07% and an OMD of 41.6±1.25%. The R1 treatment had the greatest DMD and OMD, at 58.4±1.07 and 47.8±1.25%, according to the data. It was 3.37 and 6.25 % more efficient than the R0 treatment.

Crude protein digestibility (CPD)

The results of the study on crude protein digestibility (CPD) of Madura cattle are also shown in Table 3. The research indicated that the treatments exerted a noteworthy influence on CPD (P <0.01). The R2 treatment exhibited the maximum CF digestibility value. Crude protein digestibility in Madura cattle supplemented with garlic registered at 84.7±0.38%.

Table 3. Average of dry matter, organic matter, crude protein, and crude fiber digestibility.

	R_0	R_1	R_2	SEM	*p* value
DMD (%)	55.1	58.4	57.9	1.07	3.95
OMD (%)	41.6	47.8	47.1	1.25	1.32
CPD (%)	82.2^{b}	84.3^{ab}	84.7^{a}	0.38	<0.01
CFD (%)	79.0^{b}	79.5^{ab}	81.4^{a}	0.39	<0.01

R0= basal feed; R1= R0 feed + 250 ppm garlic powder (Allium sativum) + 1.5 ppm organic Chromium; and R2= R1 feed + 40 ppm Zn-Lysinate). Means with different superscript letters in each parameter are significantly different.

Crude fiber digestibility (CFD)

The data revealed that supplying garlic and organic minerals can enhance the digestion of crude fiber (CFD), as detailed in Table 3. The R1 and R2 treatments displayed the greatest CFD levels. The data indicated that following the inclusion of garlic, the CFD rose to 79.50±0.39%. The enhanced fermentation activity of rumen microorganisms suggested that the CF digestibility had improved. According to the CFD measurement, the R2 treatment yielded a result of 81.4±0.39%. In comparison to R0 and R1, these findings were higher, demonstrating that organic mineral supplementation can enhance crude CFD.

Effect of treatments on average daily weight gain and body condition score

Average daily gain

As demonstrated in Table 4, the R1 treatment had an impact on the body weight of Madura cattle when compared to the R0 and R2 treatments. Based on the findings, the highest average observed in the R1 treatment was 1.07±0.35 kg, which signifies a 59.7% surge. In the R1 treatment, an elevation in the consumption of dry matter and organic matter was noted, together with improved crude protein and crude fiber digestibility. Since these nutrients were accessible and utilized, R1 exhibited a higher daily gain than Ro and R2, and there was also a trend suggesting that the body condition score (BCS) from R1 was higher than those from Ro and R2.

Table 4. Average daily body weight gain (kg/day) and body condition score of Madura cattle.

	R_0	R_1	R_2	SEM	*p* value
Average body weight, kg					
- Initial	247	246	252	8.6	0.96
- Final	307.3	342.3	315	15.6	1.01
ADG (kg/day)	0.67b	1.07a	0.70b	0.35	<0.01
BCS	4.67	5	4.75	0.56	0.06

R0= basal feed; R1= R0 feed + 250 ppm garlic powder (*Allium sativum*) + 1.5 ppm organic Chromium; and R2= R1 feed + 40 ppm Zn-Lysinate). Means with different superscript letters in each parameter are significantly different.

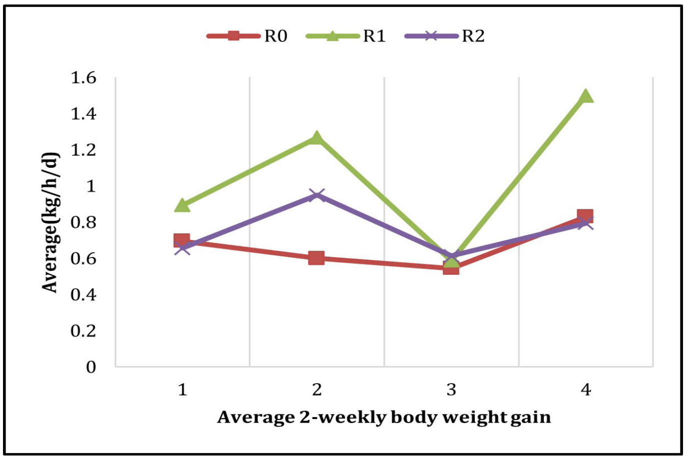

Fig. 1. Average daily gain of each treatment per 2-weekly.

Body condition score

Table 4 indicated that adding garlic powder, organic chromium, and zinc-lysinate to the diet of Madura cattle did not produce statistically meaningful differences, although treatment R1 seemed to perform better compared to treatments R0 and R2. Considering these observations, the highest Body Condition Score was achieved with treatment R1, averaging 5.0±0.56.

Discussion

Garlic is well known to contain active components like allicin and saponin (Shang *et al*., 2019). The result of DMI is lower than those from research by Prayitno *et al*. (2013), who used a blend of Sapindus rarak, garlic, and organic minerals in the feed given to beef cattle. Zhong *et al*. (2019) found that adding garlic powder to sheep diets did not change DMI, but it did boost VFA and lower the ratio of acetic acid to propionic acid. Conversely, Usur (2019) suggested that including garlic in beef cattle diets could lead to an increase in feed intake.

Allicin works to reduce methane production, whereas saponin serves as a defaunation agent by diminishing protozoa numbers. A decrease in the protozoa population is linked to a decline in methane production, because methanogenic bacteria rely on protozoa within the rumen (Martin and Chaudhry, 2024). Adding garlic powder with organic Chromium (R1) or garlic powder plus organic minerals (R2) boosted DM intake, likely by enhancing microbial activity in the rumen (Ikyume *et al*., 2017).

The expansion of the bacterial population assisting in the digestion of feed nutrients sped up the digestion process, which made the bulls get hungry faster because their stomachs emptied at a quicker rate. Adding garlic powder and organic Cr and Zn did not significantly improve DMI, possibly because it did not greatly influence the microbial processes within the rumen. Providing Zn as Zn lysinate has been shown to positively affect the development and nutrient usage in livestock (Kiouri *et al*., 2025), and organic Cr enhances the uptake of nutrients from feed (Suryapratama *et al*., 2023). The S. cerevisiae found in organic Cr can increase feed intake by making the feed taste better due to the generation of glutamic acid (Prayitno *et al*., 2013).

The dry matter intake relative to body weight ranged from 2.36 to 2.45%. These data aligned with National Research Council (2000) guidelines, which state that beef cattle need a DM intake of 2 to 4% of their body weight. DMI is influenced by factors like the animal's weight, their physical state, and how much they are producing (Ahmed *et al*., 2021), as well as how palatable and digestible the feed is (Mehrabadi and Jamshidi, 2019; Kewan *et al*., 2021). The presence of minerals in the R2 treatment resulted in a decrease in organic matter intake compared to the R1 treatment.

Minerals are inorganic substances that are needed by the livestock body in small amounts. OMI is related to the digestibility of organic matter. Bacteria in the rumen only excrete enzymes to digest feed organic matter for growth so that feed intake increases. Increased feed intake will be followed by increased intake of organic matter (Ahmed *et al*., 2021). Martin and Chaudhry (2024) stated that supplemented garlic improved DMI but did not have significant effects on DMI and NDFI. The outcomes revealed that incorporating garlic powder and organic minerals (Zn-lysinate and organic Cr) into the diet of Madura cattle did not notably alter DMI and OMI.

The results of the study on dry matter (DMD), organic matter (OMD), crude protein (CPD), and crude fiber digestibility (CFD) of Madura cattle are shown in Table 3.

The research revealed that the inclusion of garlic powder in the R1 and R2 treatments had no effect on DMD. However, Kongmun *et al*. (2010), Zhong *et al*. (2019), and Kekana *et al*. (2021) found substantial effects in DMD and OMD, implying that adding garlic (powder, extract, or juice) to feeds may boost DMD and OMD. As a natural antioxidant, allicin, a key ingredient in garlic, improves DMD and OMD by reducing inflammation in the rumen epithelium, lowering oxidative stress, and boosting immune function (Liu *et al*., 2024). Garlic supplementation also enhanced blood immunity and changed the rumen environment, both of which helped animal performance (Rabee *et al*., 2025).

According to Chen *et al*. (2021), garlic is composed of allicin and saponin compounds. Research by Borlinghaus *et al*. (2014) suggests allicin compounds present in garlic have the capacity to diminish methane gas production by directly curtailing methanogenic bacteria. Saponin functions as a defaunation agent, proficient in diminishing the quantity of protozoa. The observed CPD increase in Madura cattle after receiving garlic, as opposed to R0, stems from the growth in proteolytic bacteria count, following a reduction in the protozoa population attributed to the presence of saponin compounds. Solomon *et al*. (2022) highlighted the principle that the reduction of the rumen protozoa population leads to heightened proteolytic bacteria activity. Research by Kekana *et al*. (2021)

has demonstrated that providing garlic-treated feed can also amplify rumen microbial activity, thereby boosting the digestibility process. As suggested by Aschenbach *et al*. (2019) the rumen barrier's protective action is critical for ruminant growth and health, and tight junction proteins play a key role in maintaining both the structural barrier functionality of the rumen epithelium and cellular connections.

The enhanced fermentation activity of rumen microorganisms suggested that the CFD had improved. According to the CFD measurement, the R2 treatment yielded a result of 81.4±0.39%. In comparison to R0 and R1, these findings were higher, demonstrating that organic mineral supplementation can enhance crude CFD. Rumen microbes utilize Zn-lysinate, an organic mineral, to facilitate their growth. These findings were in disagreement with Rahayu *et al*. (2021) study, which recorded non-significant results but reported a higher CFD value. Rahayu *et al*. (2021) showed that adding garlic husk powder and organic minerals to the basal feed was able to increase CFD to 86.32±1.42 %.

Ding *et al*. (2023) provides additional support for the outcomes of this study. In the R1 treatment, an elevation in the consumption of dry matter and organic matter was noted, together with improved crude protein and crude fiber digestibility. Since these nutrients were accessible and utilized, R1 exhibited a higher daily gain than Ro and R2, and there was also a trend suggesting that the body condition score (BCS) from R1 was higher than those from R0 and R2.

It is believed that the 59.7% rise in body weight results from the conservation of energy, which would have been used in methane production and can now be used to develop muscle and meat. It is also thought to be due to an increase in protein and energy metabolism, as well as an elevation in rumen microbial activity, which leads to an increase in feed consumption. The work of Ghosh *et al.* (2010) corroborates the conclusions of this investigation, demonstrating that giving garlic resulted in a decrease in the depth of crypts in the ileum, which leads to improved nutrient absorption and, consequently, better growth and nutrient consumption.

Garlic is composed of active compounds, namely allicin and saponin (Zhong *et al*., 2019). Allicin functions as a methane inhibitor, preventing the formation of methane (Usur 2019). Saponin is a defaunation substance that has the ability to lower the population of protozoa. The decrease in the protozoa population leads to decreased methane gas concentration because methanogenic bacteria and protozoa have a symbiotic relationship in the rumen (Prayitno *et al*., 2016). Kewan *et al*. (2021) back up this information, demonstrating that a drop in CH4 corresponds to a decrease in protozoa in the rumen. Allicin exhibits toxicity towards ciliate protozoa (Zhang *et al*., 2025).

The incorporation of garlic powder boosts dry matter intake by promoting microbial activity inside the rumen (Kekana *et al*., 2021). Consequently, there is an increase in the population of bacteria responsible for digesting feed nutrients, which in turn accelerates the rate of digesta, leading to more frequent hunger in livestock due to increased stomach emptying. Furthermore, this treatment resulted in greater body weight gain when compared to the results of Prayitno *et al.* (2013) research on Madura cattle, which indicated an average daily weight gain of 0.8 kg.

There was a decline in body weight across all treatments during the sixth week of the feeding experiment. The reason for this occurrence was the substandard quality of rice straw given during that specific week due to the high intensity of sunlight. Microbial fermentation was suppressed under these circumstances, most likely as a result of the high lignin content of the straw that was administered. Lignin is a polysaccharide molecule that is challenging for rumen microbes to break down because of the robust glycosidic linkages it possesses.

Body Condition Score (BCS) offers a way to assess the physical state of farm animals by observing and feeling the amount of fat stored beneath the skin, especially near the tail, spine, and pelvic bones. The Body Condition Score (BCS) typically uses a scale with 5 different ratings. However, certain systems simplify this into just three categories: underweight, moderate, and overweight. Some systems use a more detailed scale with 9 ratings. The 5-level system – which includes very underweight, underweight, moderate, overweight, and very overweight – is both straightforward and frequently used.

Conclusion

Introducing garlic powder and organically sourced Chromium to the diet of Madura cattle has the potential to enhance how well they digest their feed, specifically improving the digestibility of crude protein and crude fiber, and leading to a substantial body weight increase of 59.75%. On the other hand, adding garlic powder, organic Chromium, and Zn-lysine to their feed does not seem to have a positive impact on boosting their average daily gain or body condition score.

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Conflict of interest

No potential conflict of interest relevant to this article was reported. All authors have agreed with the contents of the manuscript.

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