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Research article

Effect of dietary supplementation of a combination of lysolecithin and chromium on the performance, blood profile, and carcass characteristics of Ongole crossbred bulls

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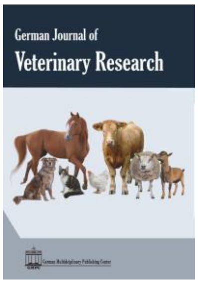

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Abstract

This study investigated the effects of combining lysolecithin and chromium as dietary supplements on the performance, blood profile, and carcass characteristics of Ongole crossbred bulls. A total of 24 bulls were randomly assigned to four groups under a 120-day feeding regime: control (no lysolecithin or chromium), L20gC5mg (20 g lysolecithin + 5 mg chromium), L30gC5mg (30 g lysolecithin + 5 mg chromium), and L50gC5mg (50 g lysolecithin + 5 mg chromium). Parameters observed included dry matter intake, body weight gain, nutrient digestibility, blood profile, and carcass traits. Bulls fed the L50gC5mg diet exhibited higher average daily gain (ADG) (1.11 vs. 0.56 kg/head/day; p=0.063) and significantly lower feed conversion ratio (FCR) (6.44 vs. 18.7; p=0.043) than controls during the 31-day feeding period. This group also demonstrated the highest neutral detergent fiber (NDF) digestibility (p=0.015). Blood plasma analyses revealed higher lipase concentrations (p<0.001), and carcass analysis indicated more trimmed fat (p=0.045) for bulls receiving L50gC5mg compared to control or L20gC5mg groups. Overall, supplementation with 50 g lysolecithin and 5 mg chromium significantly improved early-stage ADG and FCR, fiber digestibility, and lipid deposition in Ongole crossbred bulls.

Keywords: Bull, Chromium propionate, Digestibility, Fat deposition, Lysolecithin, Performance

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Introduction

Crossbred cattle have been extensively developed and widely adopted in tropical countries like Indonesia due to their enhanced stability and productivity, with muscularity and body condition linked to survival (Buonaiuto et al., 2023). Their genetic diversity contributes to better adaptability and resilience against environmental stressors, which is essential for maintaining health in challenging climates (Buonaiuto et al., 2024). For instance, the Ongole crossbreed cattle's adaptability in tropical climates allows them to resist endemic diseases and parasites while thriving on low-quality feeds, such as paddy straw (Widodo et al., 2022; Soetanto and Fatchiyah, 2023). Consequently, they are preferred for sustainable livestock production in tropical regions.

Paddy straw is abundant in most Southeast Asian countries and relatively affordable because it is a byproduct of rice consumption, the main staple food. However, paddy straw has low palatability, nutrient content, and digestibility

(Van Soest, 2006; Ramdani et al., 2020), making it necessary to supplement it with concentrate to improve the quality of beef cattle diets. Moreover, concentrates in Indonesia are typically high in fiber fractions owing to the utilization of agricultural byproducts that also consist of highly fibrous compounds (Ramdani et al., 2020). Therefore, it is necessary to include relevant feed additives to improve the digestibility of livestock ruminants fed low-quality diets (de Quelen et al., 2021).

Lysophospholipids are potent emulsifiers that are derived from the enzymatic hydrolysis of lecithin. It enhances fatty acid digestion through the hydrolysis of pancreatic juice (Dawson and Isselbacher, 1960) and selectively stimulates bacterial growth (Huo et al., 2019). This compound is more effectively absorbed in organic than inorganic form (Pechova and Pavlata, 2007). Dietary supplementation with lysophospholipids, such as lysolecithin, has shown significant benefits in improving the growth performance and feed conversion ratio (FCR) of dairy cows (Rico et al., 2017), small ruminants (Gallo et al., 2019) and calves (Reis et al., 2021), offering promising application in animal nutrition.

On the other hand, high temperatures and humidity significantly impair feed intake, growth performance, and overall productivity in cattle, particularly in tropical systems, necessitating adaptive strategies such as crossbreeding to enhance resilience. Physiological adaptations of the ruminants, nutritional and management strategies, and thermoregulatory mineral supplementation have been shown to mitigate the adverse effects of heat stress in ruminants, improving their thermal comfort and productivity (Felini, 2024). For instance, Previous studies have demonstrated that the inclusion of dietary chromium (Cr) in rations can enhance the performance of calves, steers, and dairy cattle (Kegley et al., 1997; Chang et al., 1995; Hayirli et al., 2001). The novel combination of lysolecithin and Cr shows promise in improving fatty acid digestion and absorption, glucose utilization, energy metabolism, overall cattle productivity, and carcass quality (Pacheco et al., 2023; Kneeskern et al., 2016; Poolthajit et al., 2022).

However, there is limited research on the combined use of lysolecithin and Cr in ruminants, particularly Ongole crossbreed bulls in tropical environments. Hence, this study aimed to investigate whether incorporating lysolecithin and Cr as dietary additives could significantly enhance the performance, blood profile, and carcass characteristics of Ongole crossbred bulls. We hypothesized that incorporating lysolecithin and Cr in the diet can enhance performance in areas such as average daily gain, feed intake, nutrient digestibility, blood profiles, and carcass characteristics of Ongole crossbreed bulls.

Materials and methods

Ethics approval: This study was reviewed and approved by the ethical committee of Universitas Padjadjaran (registration number 2204010511; approval number 690/UN6). KEP/EC/2022), and was carried out in compliance with the ARRIVE guidelines.

Experimental design and feeding trials

The current experiment was conducted in the Beef Cattle Research and Teaching Farm Unit of the Animal Production Laboratory, Department of Animal Production, Faculty of Animal Husbandry, Universitas Padjadjaran, Jatinangor, Indonesia. Twenty-four Ongole crossbred bulls with an average body weight of 196.5 kg±25.2 kg variation and aged 24 months were used in the present study.

Immediately after arrival at the experimental farm, each bull was randomly allocated to an individual pen (1.5 m×1.8 m×1.5 m) equipped with feed bunks and ad libitum access to clean water. All bulls were fed an experimental control basal diet (30% paddy straw and 70% concentrate on a dry matter basis) for 14 days during the adaptation period and were orally administered 20 mL of a commercial anthelmintic containing 10% albendazole (Albenol 100, Interchemie, Netherlands), 10 mL of Introvit B-Complex multivitamins (Interchemie, Ede, Netherlands) via intramuscular injection, and 10 mL of Limoxin-200 LA containing 20% oxytetracycline (Interchemie, Ede, Netherlands) via intramuscular injection to maintain the controlled health and physiological conditions of the animals during the experimental period.

Paddy straw was obtained from local paddy farmers, and a mixed concentrate diet was produced by a commercial feed mill company (PT. Dilar Lintas Raya, Tasikmalaya West Java, Indonesia). The experimental concentrate feed consisted of 18% cassava pulp, 15% palm kernel meal, 14% coffee skin, 12% copra meal, 9.5% rice bran, 8.5% molasses, 6% soybean meal, 5%

chocolate skin, 4% distillers dried grains with soluble (DDGS), 3.6% pollard, 2% premix (Lagantor F1 Customix, Kalbe Animal Health), 2% limestone, and 0.4% salt. Lysolecithin (LysoforteTM) and Cr (KemTraceTM Chromium 0.04%) were obtained from Kemin Animal Nutrition and Health Asia Pacific Pty. Ltd. (Singapore). Lysolecithin originates through an enzymatic process in which soy lecithin is converted into lysophospholipids (Joshi et al., 2006), whereas Cr is produced in the form of chromium propionate. During the preparation of the concentrate diet for each treatment, appropriate levels of lysolecithin supplemented with 5 mg Cr, along with other micronutrients such as premix, limestone, and salt, were initially mixed with pollard as a carrier ingredient in a smaller-sized mixer (200 kg capacity), before being further mixed with the overall concentrate ingredients in a larger mixer (2-ton capacity). The chemical compositions of paddy straw and each experimental concentrate diet (control, L20gC5mg, L30gC5mg, and L50gC5mg) are listed in Table 1.

Table 1: The experimental concentrate diets.

Content	Paddy Straw	Control	L20gC5mg	L30gC5mg	L50gC5mg
DM	420	884	873	876	873
g/kg DM					
Ash	200	102	86.3	97.5	94.4
Crude protein	30.8	149	148	138	144
Ether extract	13.9	74.6	66.3	78.0	74.1
Neutral detergent fiber	716	586	495	531	565
Acid detergent fiber	539	338	331	306	294
Ca	0.47	0.81	0.94	0.80	0.88
P	7.01	7.72	6.77	7.92	7.60
GE (kcal/kg DM)	3518	4439	4441	4458	4444

Notes: DM, dried matter; Ca, calcium; P, phosphorus; GE, gross energy; Control, basal diet; L20gC5mg, diet containing 20 g lysolecithin + 5 mg Cr; L30gC5mg, diet containing 30 g lysolecithin + 5 mg Cr; L50C5mg, diet containing 50 g lysolecithin + 5 mg Cr.

A completely randomized design was used on 24 bulls, separated by four different doses (six bulls allocated in each treatment) to compare the effect of lysolecithin (0, 20, 30, and 50 g) combined with Cr (5 mg), each animal received similar dietary ration, 30% paddy straw, and 70% concentrate on a dry matter (DM) basis. The treatments were: (1) control: without lysolecithin and Cr; (2) L20gC5mg: 20 g lysolecithin and 5 mg Cr; (3) L30gC5mg: 30 g lysolecithin and 5 mg Cr; and (4) L50gC5mg: 50 g lysolecithin and 5 mg Cr. Each bull was fed paddy straw and concentrate in the morning (7 am) and evening (4 pm) at a similar proportion, in which the daily ration intake was recorded during the 120-day experimental period. The observed parameters in the current study were the bull's performance, such as dry matter intake, average daily gain (ADG), feed conversion ratio (FCR) on days 31, 59, 90, and 120, and blood profiles on day 90. All animals were slaughtered at 120 days to determine their carcass characteristics.

Parameter measurements

Performance, dietary intake, and nutrient digestibility measurements

All dietary intake was recorded daily during the experimental trials. The animal's initial body weight at day zero (d 0) was directly determined by weighing (Avery Berkel L122, accuracy of 0.1 kg) before morning feeding after the adaptation period and repeatedly measured at days 31, 59, 90, and 120 during the feeding trial to measure the ADG (kg/head/day). Dry matter intake (DMI; kg/head/day), paddy straw, concentrate, and total consumption were measured on a dry matter basis. The FCR was calculated by dividing the DMI by ADG.

Nutrient digestibility was assessed using a modified version of the total feces collection method described by Ramdani et al. (2020), spanning five consecutive days. The process began with cleaning the pen floors before the morning feeding. Throughout the day (08.00–17.00 pm), each fresh fecal drop was immediately collected and placed in a labeled bag. During the evening, fecal samples were collected every 3 hours at 08.00 pm, 11.00 pm, 02.00 am, 05.00 am, and 08.00 am. The feces from each animal were weighed and mixed thoroughly, and a 300 g sample was extracted for analysis. Dried samples from each collection day were combined, homogenized, and stored in sealed plastic pouches for nutrient analysis. Protein analysis was done by taking approximately 50 g of feces treated with 5% boric acid to prevent protein evaporation, then homogenized. Briefly, the samples were dried at 60°C for three days. Following the 5-day collection period, all corresponding dried samples were mixed, homogenized, and stored in sealed plastic bags for crude protein analysis.

Sample analysis

Chemical analysis

All ground mash (1 mm size or mash no. 18) of feed and feces samples were analyzed following the AOAC guidelines (2005) to determine dry matter (method 934.01), ash (method 942.05), and ether extract (method 920.39), whereas total nitrogen (N) (N×6.25=crude protein, CP) was analyzed using the Kjeldahl procedure (method 976.06). The neutral detergent fiber (NDF) content was determined according to Van Soest et al. (1991) without using amylase, sodium sulfite, or decalin (Ramdani et al. 2013), whereas the acid detergent fiber (ADF) content was determined as reported by Van Soest (1973). The NDF, ADF, and other nutrient contents were calculated on a dry matter basis. A similar method from AOAC (2005) was used to determine the Ca and phosphorous (P) of the experimental diets based on spectrophotometer analysis, as previously described by Ramdani et al. (2020).

Blood plasma analysis

Blood sampling was carried out on day 90, in which approximately 5 mL of blood plasma from each bull was collected from the vena cava that was placed in an EDTA tube and centrifuged for 10 min at 3000 rpm to segregate the plasma serum and pelleted particles. Each plasma sample was then placed in an Eppendorf tube and stored at -20°C. Furthermore, the plasma was analyzed for total protein (Biuret method), albumin (Bromcresol green method, BCG), and globulins (globulin=total protein value − albumin value) following the procedures of Asrar et al (2023). Blood lipase was measured using the Lipase Kinetic method (Biolabo, Les Hautes rives, Maizy, France), following the procedures of Imamura and Misaki (1984).

Carcass characteristics evaluation

Fresh carcasses of slaughtered bulls were evaluated in a local abattoir (Bandung Barat, West Java, Indonesia) following the standards of the exporter supply chain assurance system (ESCAS) regulation of Australia (Puradireja et al., 2023). Each experimental bull was weighed to determine the final body weight before being transported to the abattoir. Furthermore, each bull was weighed to measure weight loss during transportation after arriving at the abattoir and placed in a colony pen for 24 h before being slaughtered. After slaughter, the carcass weight of each bull was measured, and meat and fat samples were collected for further analysis. The meat and fat from each carcass sample grade were evaluated following the AUS-MEAT standard (Meat and Livestock Australia, 2011), whereas meat color chips were graded from the range of 1A (very pale) to 7 (very dark purple) and AUS-MEAT standard fat color chips were graded from 0 (white) to 9 (yellow).

Statistical analysis

Data were analyzed by one-way ANOVA using MINITAB 16 software (Minitab LLC., USA). Before analysis, the residual data of each observed variable were analyzed for normality by passing the Anderson–Darling normality test at $p>0.05$. Moreover, all data were statistically analyzed, in which a significant difference was assumed at $p<0.05$ and tended to be different at $0.05<p<0.1$. Moreover, the significant differences analysis was then continued by Duncan's post-hoc test to identify the mean pool between treatments.

Results

All treatments had similar ADG, DMI, and FCR responses at 59, 90, and 120 days of the feeding trial (Table 2). However, a combination of lysolecithin (50 g) and Cr propionate 0.04% (5 mg) per head per day tended to increase the ADG ($p=0.063$) and significantly reduce the FCR ($p=0.043$) of the bull compared with those fed the control diet during the 31days feeding trial.

Moreover, combined lysolecithin and Cr supplementation did not affect the digestibility of DM, organic matter (OM), ADF, and CP. However, EE and NDF digestibility were significantly influenced by the supplementation of lysolecithin and Cr ($p<0.05$; Table 3). Although the EE digestibility from the control diet did not differ with the highest level of supplementation of combined lysolecithin and Cr, the NDF digestibility of the highest dose treatment (L50gC5mg) was higher than that of the others.

In the present study, lysolecithin and Cr supplementation had no significant effect (p>0.05) on glucose, cholesterol, albumin, bilirubin, urea, creatinine, or triglyceride levels (p>0.05). However, cattle supplemented with 50 mg lysolecithin and 5 mg Cr (0.04%) tended to have lower albumin concentrations (p=0.076) than those fed the control diet (Figure 1). In addition, cattle supplemented with a combination of 50 g lysolecithin and 5 mg Cr (0.04%) in the diet had higher (p<0.01) lipase concentrations in the blood plasma than those receiving the control or other diets (L20gC5mg and L30gC5mg) (Table 4). The results of the current study showed that dietary 50 mg lysolecithin and 5 mg Cr (0.04%) significantly increased the trimmed fat percentage (p<0.05) of cattle during the 120 days of the feeding trial (Figure 2).

In the current study, there were no differences (p>0.05) among treatments regarding transportation weight loss, carcass percentage, fat color, and meat color of the cattle after 120 days of the feeding trial. However, the results showed that dietary 30 mg and 50 mg lysolecithin with 5 mg Cr (0.04%) had a higher trimmed fat percentage than the control and other treatments (p=0.045; Table 5).

Table 2: Means of initial body weight, final body weight, average daily gain (ADG), total dry matter intake (DMI), and feed conversion ratio (FCR) of Ongole cross cattle fed with different experimental diets during 120 days of feeding trial.

Measurement	Control	L20gC5mg	L30gC5mg	L50gC5mg	SEM	*p*-value
Initial BW (Kg)	199.8	185.9	206.7	193.7	10.56	0.558
Final BW (Kg)	287.3	279.3	310.2	290.1	16.22	0.589
ADG (Kg/head/day)						
Day 31	0.56	0.92	0.82	1.11	0.135	0.063
Day 59	0.76	0.87	0.84	0.93	0.107	0.756
Day 90	0.83	0.86	0.86	0.91	0.079	0.917
Day 120	0.73	0.78	0.86	0.83	0.07	0.550
DMI Total (Kg/head/day)						
Day 31	6.86	6.77	6.68	6.52	0.200	0.677
Day 59	7.36	7.13	7.17	6.99	0.186	0.590
Day 90	7.52	7.17	7.09	7.00	0.213	0.354
Day 120	7.93	7.45	7.55	7.42	0.29	0.575
DMI Forage (Kg/head/day)						
Day 31	2.13	2.09	2.12	2.09	0.022	0.568
Day 59	2.10	2.10	2.10	2.08	0.012	0.567
Day 90	1.96	1.94	1.95	1.95	0.008	0.567
Day 120	1.68	1.68	1.68	1.68	N/A	N/A
DMI Concentrate (Kg/head/day)						
Day 31	4.73	4.68	4.56	4.43	0.193	0.698
Day 59	5.26	5.05	5.07	4.91	0.179	0.606
Day 90	5.56	5.23	5.14	5.05	0.209	0.354
Day 120	6.25	5.77	5.87	5.74	0.29	0.575
FCR						
Day 31	18.7^{a}	7.84^{ab}	9.79^{ab}	6.44^{b}	3.050	0.043
Day 59	10.4	8.92	9.33	7.81	1.070	0.407
Day 90	9.37	8.84	8.47	7.88	0.663	0.460
Day 120	11.2	9.94	9.89	9.40	0.64	0.108

BW, body weight; ADG, average daily gain; DMI, dried matter intake; FCR, feed conversion ratio; Control, basal diet; L20gC5mg, diet containing 20 g lysolecithin + 5 mg Cr; L30gC5mg, diet containing 30 g lysolecithin + 5 mg Cr; L50C5mg, diet containing 50 g lysolecithin + 5 mg Cr; SEM: Standard Error of the Means**.** Different superscript letters between treatments in the same row are significant difference (p<0.05), n=6/group.

Table 3: Means of nutrient digestibility (g/kg DM) of Ongole cross cattle fed with different experimental diets during 5 days of digestibility trial.

Digestibility	Control	L20gC5mg	L30gC5mg	L50gC5mg	SEM	*p*-value
DM	559	522	502	547	31.9	0.530
Ash	610	583	564	535	33.4	0.456
CP	659	606	586	658	30.3	0.300
EE	935[a]	842[b]	891[ab]	922[a]	20.5	0.013
NDF	476[ab]	359[b]	384[ab]	533[a]	38.1	0.015
ADF	377	332	350	430	46.2	0.450

Notes: DM, dried matter; CP, crude protein; EE, ether extract; NDF, neutral detergent fiber; ADF, acid detergent fiber. Control, basal diet; L20gC5mg, diet containing 20 g lysolecithin + 5 mg Cr; L30gC5mg, diet containing 30 g lysolecithin + 5 mg Cr; L50C5mg, diet containing 50 g lysolecithin + 5 mg Cr; SEM: Standard Error of the Mean. Different superscript letters between treatments in the same row are significant difference ($p<0.05$).

Table 4: Means of glucose, cholesterol, albumin, bilirubin, urea, creatinine, triglycerides, and lipase of Ongole Cross cattle fed with different experimental diets after 90 days feeding trial.

Measurement	Control	L20gC5mg	L30gC5mg	L50gC5mg	SEM	*p*-value
Glucose (mg/dl)	97.9	88.5	93.4	90.6	6.90	0.791
Cholesterol (mg/dl)	208.3	245.0	251.5	248.2	15.32	0.194
Albumin (mg/dl)	3.91	3.72	3.22	3.63	0.17	0.076
Bilirubin (mg/dl)	0.385	0.338	0.488	0.458	0.062	0.340
Urea (mg/dl)	17.4	19.4	19.1	21.1	1.36	0.318
Creatinine (mg/dl)	1.76	1.67	1.80	1.91	0.19	0.835
Triglycerides (mg/dl)	266.7	264.5	252.3	254.0	20.58	0.945
Lipase (mg/dl)	27.8[b]	22.5[b]	33.2[b]	69.0[a]	5.75	<0.001

Control, basal diet; L20gC5mg, diet containing 20 g lysolecithin + 5 mg Cr; L30gC5mg, diet containing 30 g lysolecithin + 5 mg Cr; L50C5mg, diet containing 50 g lysolecithin + 5 mg Cr; SEM: Standard Error of the Mean. Different superscript letters between treatments in the same row are significant difference ($p<0.05$).

Table 5: Means weight loss during transportation (kg), fat percentage (%), carcass percentage (%), fat, and meat color of Ongole cross cattle fed with different experimental diets after 120 days feeding trial.

Measurement	Control	L20gC5mg	L30gC5mg	L50gC5mg	SEM	*p*-value
Transportation weight loss	9.42	9.25	13.3	8.42	2.09	0.372
Carcass percentage	50.5	49.4	49.2	50.7	0.91	0.559
Trimmed fat percentage	3.2[ab]	3.02[b]	4.22[a]	4.26[a]	0.37	0.045
Fat colour (AusMeat fat color grade)	2.50	2.67	2.50	3.33	0.31	0.217
Meat colour (AusMeat meat color Grade)	4.50	4.33	5.17	4.67	0.44	0.557

Control, basal diet; L20gC5mg, diet containing 20 g lysolecithin + 5 mg Cr; L30gC5mg, diet containing 30 g lysolecithin + 5 mg Cr; L50C5mg, diet containing 50 g lysolecithin + 5 mg Cr; SEM: Standard Error of the Mean. Different superscript letters between treatments in the same row are significant difference ($p<0.05$).

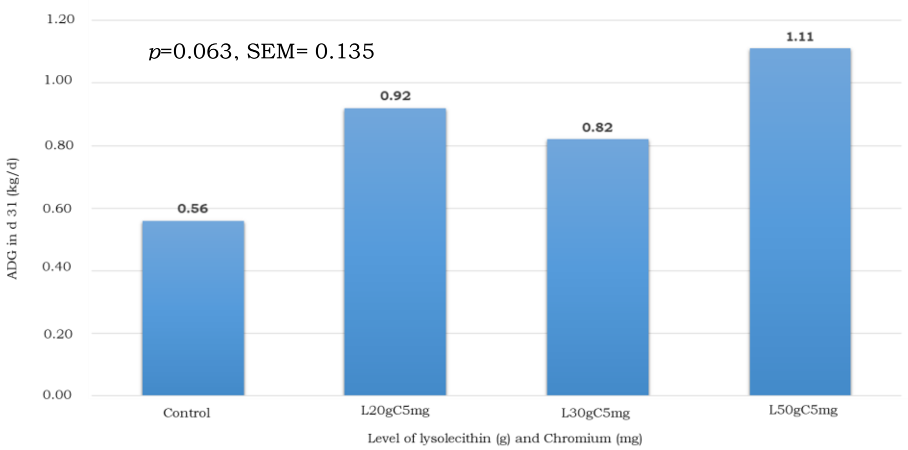

Figure 1: The influence of different levels of lysolecithin (g) incorporated with chromium (mg) on average daily gain (ADG) after 31 d of experimental treatment.

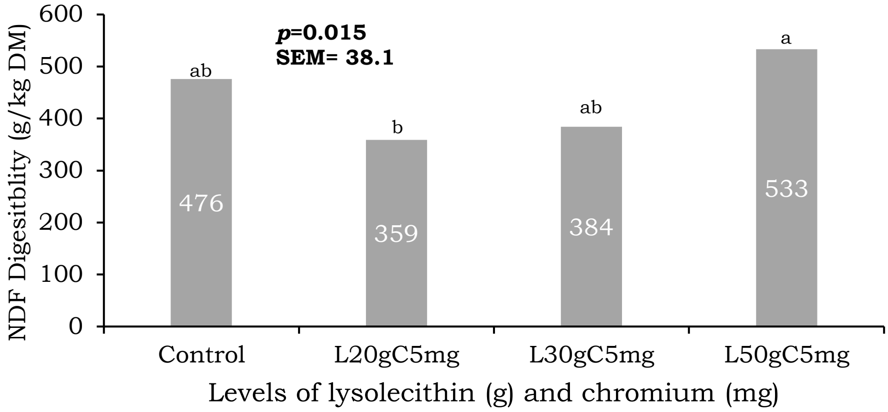

Figure 2: The influence of different levels of lysolecithin (g) incorporated with chromium (mg) on neutral detergent fiber (NDF) digestibility. The neutral detergent fiber (NDF) content was determined according to Van Soest et al. (1991).

Discussion

In Southeast Asia, the annual temperature ranges from 23°C to 32°C, the average humidity is above 70% in a year, and the animals are likely more susceptible to heat stress conditions. It is well known that heat stress conditions can result in reduced dry matter intake, leading to impaired body weight gains and feedlot cattle performance (NRC, 2000). Nutritional strategies are needed to maximize performance and mitigate heat stress in Southeast Asia. To the best of our knowledge, this is the first study to evaluate beef cattle performance when fed with a combination of lysolecithin and Cr propionate.

Cr (III) (Cr^{3+}) is an essential nutrient for protein, fat, and carbohydrate metabolisms (NASEM, 2021). It helps convert glucose into energy, promotes healthy blood glucose and blood pressure levels, and enhances lean body mass by suppressing appetite (Swaroop et al., 2019). Like other micronutrients, chromium is more effectively absorbed in its organic form, such as chromium picolinate, chromium citrate, chromium polynicotinate, chromium gluconate, chromium propionate compared to its inorganic form (Pechova and Pavlata, 2007). Cr increases the number of insulin receptors and activates them through phosphorylation, thereby increasing glucose tolerance in ruminants (Khan et al., 2014; Vincent, 2004). Several studies have evaluated the effects of Cr supplementation on animal performance (NASEM, 2021). As reported by Baggerman et al. (2020), feedlot cattle fed Cr propionate for 150 days showed improved ADG, gain-to-feed ratio, and hot carcass weight. Bernhard et al. (2012) also reported positive effects on performance, health, and BW loss in newly received beef steers fed Cr propionate. In addition, these authors conducted a metabolic study to evaluate the response of Cr propionate to a lipopolysaccharide (LPS) challenge and concluded that Cr supplementation enhanced the glucose and NEFA responses to an endotoxin challenge, suggesting faster recovery in beef steers.

Ongole cross cattle are among Indonesia's most popular cattle breeds (Lestari et al., 2011; Ngadiyono et al., 2019). As a local breed, these cattle are highly adapted to a tropical country's typical feed ingredients and environment. It was previously reported that fattening tropical Ongole cross cattle had an ADG ranging from 0.57 to 0.78 kg/head/day (Lestari et al. 2011; Ngadiyono et al. 2019). However, the ADG of the Ongole cross cattle in the present study ranged from 0.72 to 0.98 kg/head/day. The ADG of ascertained cattle in the control group was within the range of previous studies by Lestari et al. (2011) and Ngadiyono et al. (2019), whereas the ADG of tropical cattle supplemented with lysolecithin and Cr in the current study tended to be higher, particularly at the early stage of the feeding regime.

In the first month of adaptation, the experimental cattle were newly arrived and could have stressful conditions after being transported and allocated to a new environment of intensive feedlot conditions, and needed to adapt to a different dietary treatment. Lack of feed and water intake during transportation decreases body weight (Noffsinger et al., 2015). Moreover, livestock transportation is associated with increased morbidity and stress, decreased immune response (Stanger et al., 2005), and reduced body weight and physiological conditions (White et al., 2009). However, the present study confirmed that a proper combination dose of 50 g lysolecithin and 5 mg Cr (0.04%) supplementation per head per day is recommended for the starter period of cattle fattening. Appropriate lysolecithin and Cr supplementation in the bulls' diet consented to the expectation of trialed cattle to adapt to the new environment and gain compensatory growth rapidly, leading to higher ADG and lower FCR than those without supplementation. According to Huo et al. (2019), lysophospholipids can selectively stimulate bacterial growth and emulsify lipids, resulting in optimal fiber digestion and lipid absorption rates. In addition, adding lysophospholipids to the diet of ruminants can improve feed digestibility by modifying the output of rumen volatile fatty acids (VFA) fermentation, particularly to higher propionate and lower acetate profiles, leading to increased nutrient availability for enhancing growth (Huo et al., 2019). Hence, the higher ADG and better FCR values obtained with lysolecithin and Cr supplementation could indicate that the treated cattle had better nutrient absorption and glucose utilization than those without supplementation during the early fattening stage. Cr^{3+} is an essential nutrient (NASEM, 2021) which is required for protein, fat, and carbohydrate metabolism. It helps convert glucose into energy, promotes healthy blood glucose and blood pressure levels, and enhances lean body mass by suppressing appetite (Swaroop et al., 2019).

During the feeding trial, all experimental cattle had similar access to the same quality of basal diet, which was already formulated to meet the nutrient requirements above maintenance for local tropical cattle. However, the cattle observed in the present study only had a short adaptation period (14 days). Nonetheless, it was well maintained similarly to address the limited variability in feed composition across batches during observation.

Commonly, the use of an additive in the diet of ruminants shows 'no effect' or 'no efficacy' under normal conditions, where all nutrients and handling requirements can be met appropriately. In contrast, feed additive utilization mostly shows significant efficacy when animals are subjected to challenging situations. Here, adding 50 g lysolecithin and 5 mg Cr (0.04%) to the diet is highly recommended to obtain improved ADG and FCR, especially in the early phase of fattening, when the cattle are likely stressed during the adaptation period. However, the improved ADG and FCR results can emphasize that trends are corroborated by further study.

Lysolecithin can be obtained through an enzymatic process, in which soy lecithin is converted into lysophospholipids (more hydrophilic and fluid), which can improve the capacity to support the formation of oil-in-water emulsions. Moreover, lysophospholipids have unique physical and chemical properties that enhance nutrient absorption and improve feed efficiency in multiple species. For example, Zhang et al. (2022) reported that bulls supplemented with lysophospholipids could increase their hepatic lipase and antioxidant status. Zhang et al. (2022) have confirmed in their research that lysolecithin can increase lipoprotein lipase activity, indicating that lysolecithin can promote fat catabolism. Moreover, dietary lysophospholipids can affect the expression of lipoprotein-lipase genes involved in lipid metabolism (Dong et al., 2014). In contrast, lipoprotein lipase is a key enzyme that affects the delivery of fatty acids to tissues through the hydrolysis of triglycerides (Wang et al., 2009).

However, there were no significant differences in glucose, cholesterol, bilirubin, urea, creatinine, or triglyceride concentrations in bull blood plasma among experimental cattle in the present study. These findings are consistent with a previous study by Zhang et al. (2022), who reported that dietary lysophospholipids did not affect cattle's creatinine, glucose, uric acid, or urea nitrogen concentrations. Nonetheless, a previous study showed that an emulsifier addition to the diet can reduce triglyceride and cholesterol concentrations by stimulating a more efficient use of energy (Upadhaya et al., 2018). Hence, lysophospholipids can remove chylomicrons from the blood and subsequently decrease blood concentration levels (Zhang et al., 2022). Although the concentration of lipase in the serum was high, the administration of 50 mg lysolecithin and 5 mg Cr (0.04%) did not affect triglyceride and cholesterol concentrations in the blood serum of cattle. It seems that the increased high lipase activity can also be influenced by other nutrients in feed, for example, starch, whereas the pancreas activates its exocrine function and is significantly influenced by the amount of starch transiting the rumen and entering the small intestine (Beauchemin et al., 2009).

Moreover, cattle supplemented with 50 mg lysolecithin and 5 mg Cr (0.04%) tended to have lower albumin levels than those fed the control diet. The liver primarily produces albumin and serves as a significant biomarker for measuring the ability of the body to synthesize proteins as well as protein absorption and metabolism (Gao et al., 2021). Hence, the evidence observed in the current study suggests that lysophospholipids can also influence protein metabolism and liver function.

Studies have reported that the performance and carcass characteristics of feedlot cattle fed with dietary Cr and lysolecithin vary (Chang et al., 1992; Song et al., 2015). However, previous findings have revealed a significant increase in trimmed fat percentage in cattle-fed lysolecithin and Cr (Hallmarks et al., 2020; Pacheco et al., 2023). The results of this study also suggest that the inclusion of 50 g lysolecithin with 5 mg Cr in the dietary ration positively influenced fat deposition in the carcasses of experimental bulls. In brief, the increased fiber digestibility and lipid absorption in bulls can be influenced by lysolecithin, which enhances emulsification processes and improves lipid absorption. Current studies primarily focus on other dietary components and their effects on ruminants' fiber digestibility and lipid metabolism (Buonaiuto et al., 2021; Cavallini et al., 2018; Cavallini et al., 2021).

However, their findings did not directly support the claims regarding chromium's influence on ruminants; hence, the specific effects of chromium require further investigation. Nonetheless, current evidence highlights the interconnectedness of fiber and lipid metabolism in ruminants and underscores the potential for targeted nutritional strategies to optimize productivity in livestock systems.

However, no significant differences among the treated bulls regarding transportation weight loss, carcass percentage, fat color, and meat color were found. This indicated that the combined supplementation of lysolecithin and Cr did not noticeably impact these parameters. Nonetheless, cattle fed 50 mg lysolecithin and 5 mg Cr (0.04%) tended to have lower transportation weight loss and higher carcass percentages than those in the control and other treatment groups.

The lack of significant differences in transportation weight loss, carcass percentage, fat color, and meat color among the treatments suggests that other factors might influence these parameters. These factors could include environmental factors, genetic variation, and management practices, contributing to the overall similarity in performance and meat quality among the experimental groups. Hence, current results reveal possible mechanisms by which lysolecithin and Cr affect fat deposition in cattle. Lysolecithin is known to be involved in lipid metabolism, and its supplementation can enhance fat utilization and deposition in animal tissues. Cr has been suggested to play a role in glucose and lipid metabolism, which influences fat metabolism in cattle.

Conclusions

A combination of 50 g lysolecithin and 5 mg chromium propionate 0.04% in an agricultural byproduct-based diet has the potential to increase ADG and reduce FCR of Ongole cross cattle during the early stage period, particularly during the first month of the fattening period of bulls, followed by an increase in NDF digestibility, glucose absorption, and fat deposition in cattle. The increased glucose and fat deposition observed in the current study was also followed by higher fat deposition in the carcass. The current study can offer practical evidence for cattle farmers in tropical regions, such as the cost-effectiveness or scalability of the supplementation strategy.

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