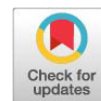


Research Article



Investigating the Impact of Supplementation with Urea Molasses Multi-Nutrient Block (UMMB) Containing Organic Adhesives on the Performance, Milk Quality and Blood Metabolic Profile of Holstein Friesian Cows

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Abstract | Urea molasses multi-nutrient block (UMMB) supplementation is a method employed to enhance the performance of Holstein Friesian dairy cows. However, many UMMBs use cement adhesive as a key component. Some concerns are that using cement as an adhesive could adversely affect the health of dairy cows if consumed over an extended period. Therefore, it is necessary to find organic materials to replace cement as an adhesive component for UMMBs. One potential organic alternative for adhesive feed material is tapioca meal. Tapioca meal possesses gelatinization properties, making it suitable as a natural adhesive for UMMBs. This study investigated the impact of substituting tapioca meal as a natural organic for UMMBs on Holstein Friesian dairy cows' production performance, milk quality, and blood metabolic profile. The study involved 20 Holstein Friesian dairy cows, which were divided into five groups: 0% tapioca meal, 100% cement (T0); 25% tapioca meal, 75% cement (T1); 50% tapioca meal, 50% cement (T2); 75% tapioca meal, 25% cement (T3); and 100% tapioca meal, 0% cement (T4). The results indicated that substituting tapioca meal as a natural adhesive significantly affected ($p < 0.01$) the calcium and iron mineral content of milk. However, the treatment did not significantly ($p > 0.05$) impact milk production, feed consumption, feed consumption efficiency, physical quality of milk, phosphorus mineral content, hematological values, and blood metabolic profile. The substitution of 50% cement with tapioca meal as an organic adhesive showed the most positive results regarding milk quality and performance. Nevertheless, tapioca meal as a substitute for cement can be considered up to the 100% level, as it exhibited normal blood metabolically.

Keywords | Cement, Dairy cows, *Holstein friesian*, Organic adhesive, Tapioca meal, UMMB

Received | July 29, 2024; **Accepted** | December 14, 2024; **Published** | February 13, 2025

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Citation | Utamy RF, Ako A, Hasbi H, Ramadan Z, Muflaha R, Mutfaidah A, Nurbina AF, Mahayani IDA, Hakim AAR (2025). Investigating the impact of supplementation with urea molasses multi-nutrient block (UMMB) containing organic adhesives on the performance, milk quality, and blood metabolic profile of Holstein Friesian Cows J. Anim. Health Prod. 13(1): 78-87.

DOI | <https://dx.doi.org/10.17582/journal.jahp/2025/13.1.78.87>

ISSN (Online) | 2308-2801

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Holstein Friesian dairy cows are known for their high milk yield and are considered the predominant dairy cow breed worldwide (Hazel *et al.*, 2020). However, in Indonesia, the milk production of Holstein Friesian dairy cows remains low due to various factors such as feed nutrition, reproduction, and livestock health. To address the nutritional needs of the livestock, it is necessary to supplement their diet with additional feed/concentrates. The ingredients and composition of these concentrates significantly impact milk yield and composition (Oba and Wertz-lutz, 2011). One such beneficial feed supplement for Holstein Friesian dairy cow is the urea molasses multi-nutrient block (UMMB), which contains essential nutrients such as protein, vitamins, and minerals (Hatungimana and Ndolisha, 2015). The UMMB comprises molasses as filler material and cement as an adhesive substance (Sukri *et al.*, 2024). However, the cement adhesive material is inorganic and process challenges for digestion in dairy cows. Therefore, it is necessary to explore organic alternatives to replace cement as the adhesive material in UMMB production.

Tapioca meal, an alternative organic adhesive feed ingredient derived from cassava, boasts a high starch content that significantly affects gelatinization properties. Furthermore, its nutritional content, including moisture, protein, fat, ash, fiber, and carbohydrates, underscores its potential as a valuable dietary component for dairy cows. Research has demonstrated that supplementing UMMB with 50% tapioca meal can enhance the reproductive performance of dairy cows (Hasbi *et al.*, 2024), highlighting the need to further explore its potential as a natural adhesive to replace cement. As such, this study aims to comprehensively investigate the impact of tapioca meal substitution as a natural adhesive for UMMB on Holstein Friesian dairy cows' performance, milk quality, and blood metabolic profile.

MATERIALS AND METHODS

ETHICAL APPROVAL

This research was conducted following the protocol and did not violate animal welfare, which was approved by the Research Ethics Commission of Hasanuddin University through a certificate with number 591A/UN.6.4.5.31/PP36/2023.

PERIOD AND PLACE OF RESEARCH

The experiment was conducted in Panette Hamlet, Lebang Village, Cendana District, Enrekang Regency. Milk samples were tested at the Feed Chemistry Laboratory of Hasanuddin University, Makassar, South Sulawesi. Blood samples were tested at the Makassar Health Laboratory at

RESEARCH ANIMALS

This study used 20 Holstein Friesian dairy cows aged 4–5 years, with a lactation period of 1–4 months and an average body weight of approximately 500 kg. The cows were fed with 3% dry matter (DM) of their body weight, including 80% elephant grass (*Pennisetum purpureum*) and 20% concentrate. The concentrate used in this study was a rice bran, tofu pulp, oil palm meal, and mineral mix. The concentrate formulation was designed to provide a Crude Protein (CP) content of 16% and a Total Digestible Nutrient (TDN) content of 70%. Additionally, the dairy cows had ad libitum access to drinking water, and each cow was given 500 g of UMMB per day.

RESEARCH DESIGN

This study used a completely randomized design (CRD) with five treatments and four replicates with the following treatments;

T0= Cement 100% substitution tapioca meal 0%.

T1= Cement 75% substitution tapioca meal 25%.

T2= Cement 50% substitution tapioca meal 50%.

T3= Cement 25% substitution tapioca meal 75%.

T4= Cement 0% substitution tapioca meal 100%.

PRODUCTION AND IMPLEMENTATION UMMB

The preparation of UMMB involves a specific process that begins with the weighing of DM such as rice bran, coconut cake meal, commercial minerals, salt, vitamins, lime, and urea (Figure 1). To these ingredients, different levels of cement and tapioca meal are added for each treatment. The weighed feedstuffs are then thoroughly mixed in a bucket. Next, the tapioca meal is gelatinized by heating it with molasses at 70°C. This mixture is then combined with the previously mixed feedstuffs until evenly mixed. The material is put into a UMMB mold, and the molding tool is rotated until the UMMB becomes compact. After molding, the UMMB is placed in a dehydrator at 70°C for a duration of 15 hours. Once this period has elapsed, the UMMB is allowed to cool before being wrapped in clear plastic. Finally, the UMMB is ready to be tested on Holstein Friesian dairy cows. The feedstuff of UMMB is presented in Table 1.

The study spanned 60 days, with a 7-day period for feed adaptation. The dairy cows were housed in group pens, each measuring 6 m × 3 m. Feeding occurred three times daily: at 7:00 am, 11:00 am, and 4:00 pm. The feed given was 3% of the cow's body weight, and UMMB was provided at 500 g per head per day. Dairy cows had ad libitum access to drinking water. Milk and blood samples were col-

lected at the beginning and end of the study. Milk samples were stored in 250 ml bottles placed in an ice pack cooler box, while blood samples (3 ml each) were drawn from the jugular vein using a project needle and project holder and then placed in an Ethylen Diamine Tetra Acetic Acid (EDTA) vacutainer tube in a cooler box. Plasma was obtained by centrifuging the blood sample at 3000 rpm for 10 minutes and transferred into a microtube after standing for 30 minutes.

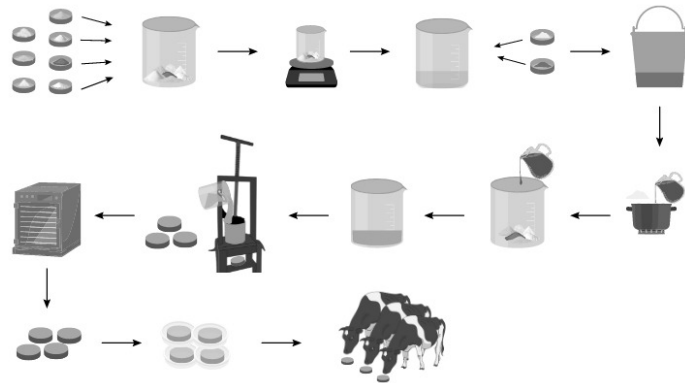


Figure 1: Production and implementation of UMMB.

Table 1: Composition feedstuff of UMMB.

Feedstuff	Percentage (%)	Total (g)
Cement/Tapioca meal	10	50
Urea	5	25
Molasses	30	150
Coconut cake meal	12.5	62.5
Rice bran	38	190
Commercial minerals	1	5
Salt	2	10
Lime	0.5	2.5
Vitamins	1	5
Total	100	500

OBSERVED PARAMETERS

The observed parameters in this study are:

- Milk Yield, milk yield was measured using a measuring cup (liter), adding the milk yield in the morning and afternoon milking.
- Dry Matter Intake (DMI), is measured between the different feed offers and the remaining feed the next day.
- Feed Conversion Efficiency (FCE), is measured by the accumulation between the amount of milk yield divided by the quantity of DMI (Arndt *et al.*, 2014).
- pH, data collection is done by dipping the pH meter in the sample in a glass container, and the value read is the measured pH of the sample (Ibrahim *et al.*, 2023).
- Specific Gravity (SG), measurement of milk SG refers to (NSA, 1992).

- Viscosity, measured using an Ostwald viscometer, the formula used to measure milk viscosity refers to (Rizqati *et al.*, 2021) as follows:

$$Viscosity = \frac{(\rho \text{ milk}) t \text{ milk}}{(\rho \text{ water}) t \text{ water}} \times \eta \text{ water}$$

Description:

η water= viscosity of water (1,0 cP).

ρ milk= specific gravity (g/ml).

t milk= milk flow time (sec).

ρ water= specific gravity water (1 g/ml).

t water= water flow time (sec).

- The milk's calcium (Ca) and phosphorus (P) levels, as well as its iron (Fe) content, were determined using the atomic absorption spectrophotometry (SSA) method. This method accurately measures the concentration of metal atoms in a solution (Mahfudloh and Tirono, 2010).
- Blood glucose levels, urea, alanine aminotransferase (ALT), and aspartate aminotransferase (AST) were accurately measured using advanced methods and state-of-the-art instruments from Thermo Scientific Indiko. These methods include hexokinase, CHOD-PAP, GLDH, and IFCC without pyridoxal phosphate (incubate at 37°C).

DATA ANALYSIS

The data was analyzed using the General Linear Model (GLM) procedure of the Analysis of Variance (ANOVA) in SPSS software for Windows version 16.0, obtained from Chicago, IL, USA, with a confidence level of 95%. In cases where treatment means showed a significant effect ($P < 0.05$), Duncan's test was utilized.

$$Y_{ij} = \mu + U_i + \Sigma_{ij}$$

Description;

Y_{ij} : response variable.

μ : general mean.

U_i : effect of dietary treatments.

Σ_{ij} : random error.

RESULTS AND DISCUSSION

PERFORMANCE OF HOLSTEIN FRIESIAN DAIRY COWS FED UMMB CONTAINING ORGANIC ADHESIVES

The study's results indicated that substituting tapioca meal in producing UMMB did not significantly affect ($P > 0.05$) the performance of Holstein Friesian dairy cows. This includes milk yield, feed consumption, and feed consumption efficiency (FCE), as detailed in Table 2.

Table 2: Performance of Holstein Friesian dairy cows fed UMMB containing tapioca meal as a cement substitute.

Parameters	Treatments					P-Value
	T0	T1	T2	T3	T4	
Milk yield (Kg/head/day)	11.12 ±0.40	12.90 ±3.02	13.48 ±1.48	12.90 ±0.41	11.45 ±0.64	0.33
DMI (Kg)	13.85 ±0.01	13.85 ±0.00	13.78 ±0.04	13.81 ±0.04	13.79 ±0.00	0.61
FCE	0.80 ±0.02	0.92 ±0.21	0.97 ±0.10	0.93 ±0.02	0.89 ±0.11	0.31

Treatment: 100% cement substituted for 0% tapioca meal (as T0); 75% cement substituted, 25% tapioca meal (T1); Cement 50% substituted, 50% tapioca meal (T2); 25% cement substituted, 75% tapioca meal (T3); and 0% cement substituted for 100% tapioca meal (T4). **DMI:** dry matter intake; **FCE:** feed conversion efficiency; Data is presented mean ± standard deviation.

Milk yield ranged between 11.12 and 13.48, with the highest levels observed in the treatment with 50% tapioca meal substitution (T2). Treatments using tapioca meal substitutes resulted in higher milk yield than 100% cement. As the level of cement substitution with tapioca meal increased to 50%, milk yield also increased. Adequate UMMB nutrition, which includes Ca minerals from cement and carbohydrates from tapioca meal, can optimize milk yield. Meeting the Ca needs of the dairy cow will increase milk yield, as Ca is essential for nutrient absorption and a precursor for milk formation. The consumption of Ca by dairy cows will bind with propionic acid to form propionic Ca, and increasing calcium propionate will significantly increase milk yield as it is a precursor for the main milk component, lactose. However, excessive Ca consumption by dairy cows can increase kidney function and reduce protein and energy digestibility.

Additionally, UMMB T2 contains carbohydrates, which optimizes production. Carbohydrates are the primary energy source in diets fed to dairy cows and typically comprise 60 to 70 percent of the diet. Apart from being the main energy source, carbohydrates are also the main precursor for the formation of milk. A carbohydrate deficiency during lactation can lead to low milk production and ketosis.

Dry matter intake plays a crucial role in the performance of dairy cows. High-quality feed is essential to optimize dairy cows' performance. Dairy cows will consume feed based on their physiological needs (NRC, 2001). In this study, feed intake varied from 13.78–13.85 with the lowest intake observed in T2. Despite the lowest feed intake in T2, milk yield was the highest. This suggests that the T2 treatment offers better nutrition than other treatments (D'Mello, 2000). The supplementation of UMMB, which contains Ca minerals, can enhance the digestibility of feed nutrients. The mineral Ca can increase the buffering capacity of the rumen,

leading to higher production of acetic and butyric acids due to fiber fermentation (Wondater and Ayanie, 2023).

Furthermore, the energy obtained from carbohydrates in tapioca meal can have a calorogenic effect when consumed excessively. This calorogenic effect can lead to heat stress in livestock due to energy metabolism, causing excess heat production in the body. Consequently, dairy cows may reduce feed intake to mitigate severe calorogenic effects (Beigi and Edelman, 1971).

Feed efficiency is measured by dividing milk yield by feed consumption. The goal of enhancing feed efficiency is to drive profitability. Increasing milk yield leads to more efficient feed consumption by cows, resulting in higher milk yields. Effective nutrition and feed management play a crucial role in improving feed efficiency. Incorporating UMMB supplements can be a successful approach to fulfilling the nutritional needs of dairy cows while requiring relatively minimal DMI (VandeHaar et al., 2016). In a study, the FCE values ranged from 0.80 to 0.97, with the highest value observed in T2. The nutritional composition in T2 surpasses all other treatments, leading to a more balanced and efficient feed conversion ratio (FCE), significantly influenced by nutrition and feed digestibility (Lovendahl et al., 2018). UMMB can enhance the utilization of low-quality fiber by supporting rumen microorganisms, promoting improved fermentation of fibrous materials, and increasing the production of microbial proteins and fatty acids, thereby enhancing FCE (Wongnen, 2002).

PHYSICAL QUALITY OF MILK OF HOLSTEIN FRIESIAN DAIRY COWS FED UMMB CONTAINING ORGANIC ADHESIVES

The utilization of UMMB substitute containing tapioca meal did not produce a significant effect (P>0.05) on milk pH, SG, and milk viscosity, as detailed in Table 3. The average pH value of Holstein Friesian dairy milk ranged from 6.72 to 6.77, which falls within the acceptable range for fresh milk according to NSA (2011) standards, set at between 6.3 and 6.8. The pH value observed in this study corresponds to the averages reported in previous studies: 6.6–6.7 (Alrhoun et al., 2024), 6.40–6.60 (Kandeel et al., 2019), 6.50–6.60 (Ako et al., 2024) and 6.43–6.69 (Ahmad et al., 2023). Furthermore, Aydogdu et al. (2023) highlighted that various factors, including microorganisms, can influence the quality of milk pH. Christi et al. (2022) also acknowledged that milk pH is impacted by environmental factors, milking duration, sanitation, and measurement accuracy.

In this study, the average SG value of Holstein Friesian dairy milk ranges from 1.030 to 1.036. The minimum value for SG, as per NSA (2011), is approximately 1,0270 g/

mL, which aligns with other research findings indicating an average SG of fresh cow's milk to be 1.028 (Yenew *et al.*, 2020), with a range from 1.027–1.035 (Gemechu *et al.*, 2015), 1.070 (Erdem *et al.*, 2022), and 1.025–1.035 (Mudgil and Barak, 2013). Milk SG positively correlates with lactose and DM/milk density (Ahmad *et al.*, 2005; Arief *et al.*, 2021; Rahmawati and Juwitaningtyas, 2024). Lactose is produced from glucose derived from carbohydrates in feed, with tapioca meal high in carbohydrates.

Table 3: Physical quality of milk of Holstein Friesian dairy cows fed UMMB containing tapioca meal as a cement substitute.

Parameters	Treatment					P-Value
	T0	T1	T2	T3	T4	
pH	6.72 ±0.65	6.73 ±0.23	6.73 ±0.32	6.72 ±0.00	6.77 ±0.80	0.59
SG (g/ml)	1.034 ±0.00	1.033 ±0.00	1.031± 0.00	1.034 ±0.00	1.032 ±0.00	0.40
Viscosity (cP)	1.55 ±0.10	1.55 ±0.06	1.58 ±0.12	1.59 ±0.11	1.62 ±0.09	0.83

Treatment: 100% cement substituted for 0% tapioca meal (as T0); 75% cement substituted, 25% tapioca meal (T1); Cement 50% substituted, 50% tapioca meal (T2); 25% cement substituted, 75% tapioca meal (T3); and 0% cement substituted for 100% tapioca meal (T4). **SG:** specific gravity. Data is presented mean±standard deviation.

The treatment did not yield a significant effect ($P>0.05$) on viscosity. However, the viscosity values in this study, ranging from 1.55 to 1.62 cP, are within the normal range as defined by Purwantiningrum *et al.* (2015). The viscosity of the milk increased with the level of tapioca meal substitution in UMMB, attributed to the high carbohydrate content of tapioca meal, which can enhance the production of energy, fat, and lactose in milk (Annisa *et al.*, 2024). The increase in viscosity is associated with forming a more substantial and rigid protein network, leading to a slower flow of the liquid (Dobozi *et al.*, 2023). The milk fat globules are a binding or connecting agent for casein micelles, contributing to the observed high viscosity values (Garavand *et al.*, 2023).

MACRO- AND MICRO-MINERAL MILK QUALITY OF HOLSTEIN FRIESIAN DAIRY COWS FED UMMB CONTAINING ORGANIC ADHESIVES

The feeding of UMMB in the feed had a significant impact ($P<0.01$) on the levels of Ca and Fe, but it did not have a significant effect ($P>0.05$) on P levels (Table 4). The levels of milk Ca increased as the substitution of cement with tapioca meal increased, but only up to a 50% substitution level. According to Mohammad *et al.* (2007), cement contains 25% CaCO_3 , which is difficult for the body

to absorb. In contrast, tapioca meal contains Ca ions more readily absorbed by dairy cows. This aligns with the findings of Shkembi and Huppertz (2022), who suggested that Ca in the dairy cows' body can only be absorbed in ion form, whereas CaCO_3 has low solubility, making it challenging to absorb in the intestine. Additionally, Vega and Stein (2014) noted that the low absorption of CaCO_3 in dairy cows can be improved by supplementing with other easily absorbable forms of Ca.

The phosphorus content averages 698.95–809.09 mg/kg. These findings are consistent with Vorinina *et al.* (2022) research on P mineral content in cow's milk, which found 719.93–1216.55 mg/kg. The high P value in T2 is attributed to the carbohydrate content in tapioca meal, which can enhance P mineral absorption (Permana *et al.*, 2012). Furthermore, calcium phosphate ($\text{Ca}_3(\text{PO}_4)_2$) in cement can degrade into P (Boughanmi *et al.*, 2018). According to the statistical analysis, the T0 treatment differs significantly and has a higher average value of 1.20–2.75 mg/kg compared to the other treatments (Table 4), with a significance level of $P<0.01$. The Fe content decreased as the tapioca meal level increased. This is due to the absence of Fe in tapioca meal (Lekahena, 2016), while cement contains FeO_3 compounds ranging from 0.5–6.0% (Putra, 2021). FeO_3 may degrade into Fe ions and serve as a precursor to milk iron formation.

Table 4: Mineral macro- and micro-milk quality of Holstein Friesian dairy cows fed UMMB containing tapioca meal as a cement substitute.

Parameters, mg/kg	Treatment					P-Value
	T0	T1	T2	T3	T4	
Calcium	609.90 ±34.37 ^a	724.04 ±8.36 ^c	721.24± 56.66 ^c	658.09± 9.19 ^{ab}	684.96± 8.48 ^{bc}	0.00
Phosphorus	779.94 ±5.12	698.95± 22.89	809.09± 97.28	796.10± 17.84	807.77± 82.59	0.19
Iron	2.75± 0.12 ^c	1.56± 0.18 ^b	1.20± 0.09 ^a	1.53± 0.14 ^b	1.22 ±0.10 ^a	0.00

Treatment: 100% cement substituted for 0% tapioca meal (as T0); 75% cement substituted, 25% tapioca meal (T1); Cement 50% substituted, 50% tapioca meal (T2); 25% cement substituted, 75% tapioca meal (T3); and 0% cement substituted for 100% tapioca meal (T4). Data is presented mean±standard deviation.

HEMATOLOGICAL VALUES OF HOLSTEIN FRIESIAN DAIRY COWS FED UMMB CONTAINING ORGANIC ADHESIVES

The provision of UMMB containing cement adhesive and substituted with tapioca meal did not significantly affect ($P>0.05$) the levels of RBC, WBC, and platelets. The average RBC value in this study ranged from $5.18\text{--}6.16\times10^6/\mu\text{L}$, falling within the normal range (Table 2). Previous

studies have reported that dairy cows typically have a total RBC of $5.5\text{--}6.5\times10^6/\mu\text{L}$ (Morar *et al.*, 2018), $5.1\text{--}7.6\times10^6/\mu\text{L}$ (Brink *et al.*, 2023), and $3.92\text{--}6.37\times10^6/\mu\text{L}$ (Nosike *et al.*, 2020). Furthermore, Bali cows fed cocoa pulp-based concentrate as an energy source exhibited RBC values of $4.78\text{--}5.18\times10^6/\mu\text{L}$ (Utamy *et al.*, 2021).

The study found that the average WBC value ranged from $8.80\text{--}11.70\times10^3/\mu\text{L}$, falling within the normal range (Table 5). Previous reports by Divers and Peek (2008) indicated that normal WBC levels for dairy cows are $5.60\text{--}12.70\times10^3/\mu\text{L}$ (Morar *et al.*, 2018); $7.83\text{--}10.71\times10^3/\mu\text{L}$ (Nosike *et al.*, 2020); and $10.02\text{--}10.15\times10^3/\mu\text{L}$ of Balinese cows with cocoa pulp-based concentrate as an energy source exhibited certain SDP values (Utamy *et al.*, 2021).

Based on the WBC value, it can be suggested that UMMB resulting from substituting cement adhesive material with tapioca meal does not pose a toxicity risk to dairy cows. Cows with normal WBC levels demonstrate a high count of neutrophils. According to Wagner *et al.* (2008), healthy cows display normal WBC levels and high neutrophil counts. An increase in WBC count can help prevent severe microbial infections in dairy cows and provide a robust defense against infections (Nosike *et al.*, 2020). Halek *et al.* (2020) suggest that increasing WBC above normal limits is a physiological response to protect the body from toxic compounds and microorganisms.

After being fed UMMB, Holstein Friesian dairy cows showed no significant effect ($P>0.05$) on their blood platelet count, which averaged $366.3\text{--}452\times10^3/\mu\text{L}$ (Table 5). According to Elsayed *et al.* (2024), platelet values in dairy cows ranged from $120.8\text{--}508.5\times10^3/\mu\text{L}$, $400\text{--}480\times10^3/\mu\text{L}$ (Nosike *et al.*, 2020), and $298.5\text{--}379.7\times10^3/\mu\text{L}$ (Indah *et al.*, 2020). Blood platelets are crucial for blood clotting, and a low platelet concentration indicates a longer blood clotting process, leading to increased blood loss (Wagner *et al.*, 2008).

BLOOD BIOCHEMICAL PROFILE OF HOLSTEIN FRIESIAN DAIRY COWS FED UMMB CONTAINING ORGANIC ADHESIVES

The study's results and the statistical analysis showed that the administration of UMMB had no significant effect on blood glucose, ureum, AST, or ALT levels. The study revealed that the glucose levels of dairy cows varied between 58.33 and 64.66 mg/dL. These results align with a study by Iriso *et al.* (2023), which reported that glucose levels ranged from 40.0 to 100.0 mg/dL. The research also indicated that glucose levels increased as tapioca meal, suggesting that the energy needs derived from carbohydrates degraded into glucose in UMMB are adequately met. According to Prathyusha and Nirmala (2024), tapioca meal,

with its high carbohydrate content (83.17%), is suspected to impact the increase in glucose levels. Further support for this comes from Cihan *et al.* (2023), who noted that blood glucose reflects the metabolic rate in dairy cows and serves as an energy source. In lactating dairy cows, the requirement for glucose is mainly driven by the mammary glands' need for milk synthesis.

Table 5: Hematological Values in Holstein Friesian Dairy Cows Fed UMMB containing tapioca meal as a cement substitute.

Parameters	Treatment					P-Value
	T0	T1	T2	T3	T4	
RBC ($\times10^6/\mu\text{L}$)	6.16± 1.63	5.65± 0.26	6.15± 1.04	5.40± 0.18	5.18± 0.44	0.33
WBC ($\times10^3/\mu\text{L}$)	8.80± 1.70	11.36± 1.58	10.56 ±0.89	9.13± 1.15	11.70± 6.43	0.72
PLT ($\times10^3/\mu\text{L}$)	439± 70	366± 97.14	452 ±13	420 ±0	413 ± 54.50	0.48

Treatment: 100% cement substituted for 0% tapioca meal (as T0); 75% cement substituted, 25% tapioca meal (T1); Cement 50% substituted, 50% tapioca meal (T2); 25% cement substituted, 75% tapioca meal (T3); and 0% cement substituted for 100% tapioca meal (T4). **RBC:** red blood cell; **WBC:** white blood cell; **PLT:** platelet. Data is presented mean±standard deviation.

Table 6: Blood Biochemical Profile in Holstein Friesian Dairy Cows Fed UMMB containing tapioca meal as a cement substitute.

Parameters	Treatment					P-Value
	T0	T1	T2	T3	T4	
Glucose (mg/dL)	58.33 ±1.52	62.33 ±2.51	61.66 ±5.50	60.00 ±2.64	64.66 ±4.50	0.33
Urea (mg/dL)	13.00 ±1.73	10.66 ±4.61	12.33 ±2.51	10.00 ±1.00	10.66 ±4.93	0.78
AST (IU/l)	80.33 ±7.57	68.0± 12.76	67.66 ±8.50	63.66 ±8.02	72.50± 10.50	0.33
ALT (IU/l)	34.00 ±5.29	28.66 ±2.51	32.00 ±5.29	26.66 ±8.50	25.66 ±4.04	0.35

Treatment: 100% cement substituted for 0% tapioca meal (as T0); 75% cement substituted, 25% tapioca meal (T1); Cement 50% substituted, 50% tapioca meal (T2); 25% cement substituted, 75% tapioca meal (T3); and 0% cement substituted for 100% tapioca meal (T4). **AST:** Aspartate aminotransferase; **ALT:** alanine transaminase. Data is presented mean ± standard deviation.

The urea levels observed in this study ranged from 10.00 to 13.00 mg/dL (Table 6), consistent with the findings of Agustina *et al.* (2023), who reported a range of 26.6 to 56.7 mg/dL. According to Peng *et al.* (2021), urea is a by-product of protein metabolism produced in the liver

and excreted by the kidneys. Elevated urea concentrations in the blood generally indicate more efficient amino acid utilization. Tial *et al.* (2023) further explained that urea in UMMB is a non-protein nitrogen source converted into ammonia nitrogen in the rumen through microbial hydrolysis. Additionally, Luan (2020) noted that urea levels are influenced by the composition of the feed, as the majority of urea is derived from the breakdown of dietary protein.

The study indicated that AST and ALT levels were 63.66–80.33 IU/l and 25.66–34.00 IU/l, respectively, as presented in Table 6. The consistent levels between treatments suggest that the liver function of lactating Holstein Friesian dairy cows is normal and healthy. Cui *et al.* (2019) suggested that normal AST levels typically range from 42.5–98 IU/l, and normal ALT levels range from 14–38 IU/l. According to Mobashar *et al.*, (2023), AST and ALT are enzymes in liver tissue, muscle cells, the heart, and kidneys and serve as markers of liver damage in dairy cows. Excessive consumption of free radicals by dairy cows can lead to oxidative stress, causing damage to cells and tissues. Turafelli *et al.* (2023) explained that oxidative stress results from increased oxidants in cattle body cells, which produce free radicals, causing chemical stress in the body. Mohsin *et al.* (2022) added that when liver cells are damaged, AST and ALT are released into the blood, increasing enzyme activity.

CONCLUSIONS AND RECOMMENDATIONS

According to the study findings, it has been established that substituting cement with tapioca meal as an organic adhesive material at 50% yields the highest milk performance and quality. Additionally, tapioca meal as a substitute for cement can be extended up to 100% as it maintains normal blood metabolic profile.

ACKNOWLEDGEMENTS

The research team is grateful to the Sipatuo Farmer Group in Panette Village, Cendana Subdistrict, Enrekang District, for facilitating this research. We also thank the Livestock and Fisheries Service Office of Enrekang District for supporting this research activity. We hope that the results of this research will be valuable and contribute positively to the development of dairy cows practices in the future.

NOVELTY STATEMENTS

The innovation of this research is in the utilization of tapioca meal as a binder in the formulation of UMMB, serving as a replacement for the traditionally used binder, cement. This novel approach seeks to mitigate the limitations as-

sociated with cement, such as potential health risks for livestock and adverse environmental effects. As an organic material, tapioca meal has not been extensively examined or applied in this context. This study offers a more environmentally friendly and safer alternative for livestock while simultaneously enhancing the functional attributes and sustainability of UMMB production. Furthermore, it provides empirical evidence regarding the efficacy of tapioca meal as a binder, its durability, and its acceptance by livestock, signifying a notable advancement in the field of animal feed technology.

AUTHOR'S CONTRIBUTIONS

R. F. Utamy: Conceived and designed the experiments, performed the field experiments, analyzed data, and wrote the paper.

A. Ako and H. Hasbi: Conceived and designed the experiments, performed the field experiments, performed, and analyzed data, and wrote the paper.

Z. Ramadan, R. Mufliha, A. Mutfaidah and A. F. Nurbina: Performed the data tabulation, analyzed data, and wrote the paper.

I. D. A. Mahayani and A. A. R. Hakim: Performed the field experiments and data tabulation.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

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