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Effect of Natural Adhesive Tapioca Meal on the Quality of Urea Molasses Multinutrient Block

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ABSTRACT

To ensure safe consumption and substitution in the production of urea multi-nutrient molasses block (UMMB), adhesives must be used to bond the raw materials. While cement is one of the primary adhesive materials used, its inorganic material means that its use in feed should be restricted. To address this issue, a study was conducted to evaluate the quality and shelf life of UMMB with tapioca meal as an adhesive substitute for cement. The study used a completely randomized design (CRD) with two factors. The first factor, A, involved substituting cement with tapioca meal., i.e., cement 100% (T0); cement 75% and tapioca meal 25% (T1); cement 50% and tapioca meal 50% (T2); cement 25% and tapioca meal 75% (T3); and tapioca meal 100% (T4), respectively. The second factor, B, is the shelf life, e.g., 0 days (as H0), 15 days (H15), and 30 days (H30), respectively. The study found that tapioca meal as a natural adhesive substitute for cement in the production of UMMB should be limited to a maximum of 50%. The study also revealed that the interaction between the substitution of cement with tapioca meal and the shelf life significantly affected water absorption and total plate count (TPC) but not the density of UMMB. This information could be used to help ensure the safe and effective production of UMMB.
Keywords: Cement, Tapioca Meal, UMMB

INTRODUCTION

On a dairy farm, it's essential to understand the factors related to cow body weight gain. Feeding is a big one, as it plays a role in natural tissue formation. However, the nutritional content in the feed is only sometimes optimally fulfilled, which can lead to low milk yield. To overcome this, provide feed with various options, including sufficient forage, concentrate, and feed supplements. One supplement found to be particularly helpful is the urea molasses multi-nutrient block (UMMB).

At UMMB, various nutritious feed options are available for dairy cows, including minerals and vitamins. These feeds have the potential to significantly improve the nutrition of ruminant livestock by promoting microbial growth in the rumen. This allows the livestock to absorb the nutrients in their feed better [1]. Apart from that, UMMB can also improve the reproductive performance of Bali cattle [2] and enhance the performance of dairy cows and buffalo [3] [4].

UMMB is made up of both fillers and adhesives. Adhesives are essential in the production of UMMB as they bond the raw materials together. Cement is one of the primary adhesive materials used, and it contains calcium (Ca) minerals [5]. Feeding cement should be restricted due to its inorganic material [6]. Excessive consumption of cement can be harmful to livestock as it can poison them and negatively impact their reproduction and performance, according to Chuzaemi *et al*. [7]. The cement used in UMMB production contains calcium oxide (CaO), which is responsible for bonding.

In contrast, silica oxide (SiO_2) acts as a filler and determines the strength of the cement. Aluminum oxide (Al_2O_3) helps in accelerating the hardening process, while iron oxide (Fe_2O_3) has a low melting temperature, as mentioned by Wiryasa and Sudarsana [8]. Cement is an essential component of UMMB production as it works as an adhesive to bind all materials together. Typically, only 10–15% of cement produces UMMB. However, according to Natsir *et al*. [9], using cement at high levels and for an extended period might have adverse effects on livestock, such as negative impacts on their health and meat quality when fed for longer. A natural adhesive is necessary to ensure safe consumption and substitution in UMMB production. Tapioca meal is a viable alternative adhesive due to its high starch content and easy gelatinization when heated [10].

This study aims to enhance the quality and safety of UMMB for dairy cow consumption by substituting cement with tapioca meal as a natural adhesive. The main focus of this study is evaluating the substitution's effects on the quality and shelf life of UMMB.

MATERIALS AND METHODS

The equipment utilized in this study comprised scales, hand mixers, basins, plastic buckets (to mix all the feedstuff), UMMB mold (to produce UMMB), dehydrators (to obtain dry matter of UMMB), and assessments of the physical quality and shelf life/storage capacity of UMMB. These assessments included tests for density, water absorption, and Total Plate Count (TPC).

The UMMB feed supplement comprises urea, lime, coconut cake meal, salt, rice bran, molasses, cement, tapioca meal, commercial minerals, and vitamins. All the feedstuff is obtained from commercial factories. Distilled water is required to test water absorption.

Research Design and Treatments

The process of producing UMMB through the heating method was outlined in a study by [9]. The production involves two steps. Firstly, tapioca meal is mixed with molasses and heated to 70°C. The mixture is then immediately poured into a filler and homogenized using a hand mixer. Secondly, the UMMB is molded, and each unit weighs 1 kg. The molded UMMB is then placed in a dehydrator at 70℃ for 15 minutes for drying. The composition of each material is presented in Table 1.

Table 1. Composition of UMMB using adhesives and fillers

No.	Feedstuff	%	Amount (gr)				
			P1	P2	P3	P4	P5
Adhesives							
1.	Cement	10	100	75	50	25	0
2.	Tapioca Flour		0	25	50	75	100
	Filllers						
1.	Urea	5	50	50	50	50	50
2.	Molasses	30	300	300	300	300	300
3.	Coconut cake meal	12.5	125	125	125	125	125
4.	Rice bran	38	380	380	380	380	380
5.	Commercial Mineral	1	10	10	10	10	10
6.	Salt	2	20	20	20	20	20
7.	Vitamin	0.5	5	5	5	5	5
8.	Chalk	1	10	10	10	10	10
	Total	100	1000	1000	1000	1000	1000

Parameters

Parameters observed in the study were density, water absorption, TPC, and shelf-life formula below [11] can calculate density:

$$Density\ gram/cm^3) = \frac{W}{\pi r^2 x\ T}$$

Descriptions:
W = Sample weight (gram)
π = 3.14 cm
r = Radius (cm)
T = Sample thickness

The absorption value can be calculated using the following formula [12]:

$$Water\ Absorption\ (100\%) = \frac{BB - BA}{BA} x\ 100\%$$

Descriptions:
BB = Weight after immersion (gram)
BA = weight before immersion (gram)

TPC. The procedure of preparation of TPC. First, prepare 5 test tubes and fill each with 9 ml of sterile distilled water. Then, using a dropper, add 1 ml of sample to one of the test tubes to create a 10^{-1} dilution. Secondly, transfer 1 ml of the 10^{-1} dilution to another test tube containing 9 ml of sterile distilled water to make a 10^{-2} dilution. Repeat this process for the remaining test tubes, creating dilutions of 10^{-3}, 10^{-4}, and 10^{-5}, respectively.

Pour 15 or 20 ml of Mueller Hinton Agar (MHA) media into a cooled petri dish to prepare the jelly plates. Then, using a sterile pipette, take 1 ml of each dilution ranging from 10^{-1} to 10^{-5} and place it in a sterile petri dish. To ensure even distribution of the suspension in the dish, shake the petri dish in a figure-of-eight shape as quickly as possible. Duplo should be carried out for each dilution. The next step is to incubate the plate for 24–48 hours at a temperature of 37℃. After that, turn the petri dish upside down and observe and count the number of colonies growing on the media [13].

The TPC calculation using the formula [8] below**:**

$$N = \frac{\sum C}{([(1\ x\ n1) + \ (0{,}1\ x\ n2)]\ x\ (d))}$$

Descriptions:

N = Number of sample colonies (Kol/ml)
∑C = Number of colonies counted on all plates
n1 = The number of plates in the first dilution was counted
n2 = number of plates in the second dilution was counted
d = The first dilution counted

Data Analysis

The data obtained will be statistically processed using the variance in a completely randomized design (CRD) factorial pattern with two factors: factor A is a substitute for adhesive, consists of five treatments, and factor B is the length of time of storage, consists of three treatments and each treatment is repeated three times so that the total treatment is 5 × 3 × 3 = 45 UMMB units. If there is a significant effect, proceed with the Duncan test (Duncan's Multiple Random Tests = DMRT) according to [14].

RESULTS AND DISCUSSIONS

Effect of Cement Substitution with Tapioca Flour on UMMB Density

The density of a feed refers to how tightly packed the particles are. This is primarily influenced by the raw materials' density and the pressure applied during production [15]. The effect of cement substitution to tapioca meal on the density of UMMB was presented in Table 2 as follows:

The study found that Factors A, B, and their interaction did not significantly impact the density of UMMB (as shown in Table 2 with P>0.05). Despite Factor A not having a significant effect, using 100% tapioca meal as a substitute for cement in UMMB production was a viable option. This formulation produced a denser and harder final product compared to other treatments. The type and amount of filler used, as explained by Yanuartono *et al*. [16].

Table 2. Average UMMB Density with Tapioca Flour Substitute Cement Adhesive

Treatments (Factor A)	Factor B			Mean
	H0	H15	H30	
P0	1.20 ± 0.04	1.20 ± 0.01	1.25 ± 0.08	1.21 ± 0.05
P1	1.21 ± 0.05	1.21 ± 0.02	1.20 ± 0.15	1.20 ± 0.08
P2	1.20 ± 0.03	1.22 ± 0.02	1.20 ± 0.05	1.20 ± 0.03
P3	1.20 ± 0.02	1.21 ± 0.02	1.21 ± 0.02	1.20 ± 0.02
P4	1.13 ± 0.01	1.17 ± 0.09	1.17 ± 0.04	1.15 ± 0.05
Mean	1.18 ± 0.04	1.20 ± 0.05	1.21 ± 0.06	

P0 = cement 100%; P1 = cement 75% tapioca flour 25%; P2 = cement 50% tapioca flour 50%; P3 = cement 25% tapioca flour 75%; and P4 = 100% tapioca flour; H0 = 0 days; H15 = 15 days; and H30 = 30 days

The density level of UMMB is affected by several factors, including composition, particle size, and storage conditions/shell life. According to Table 2, the mean density value of UMMB decreases as the life shell becomes longer. A high-density level produces a hard texture, high-density, and has a long shelf life. On the other hand, a low-density level creates the opposite texture. Although the particle size of cement, which is 24 µm, is smaller than tapioca meal, which is 35 µm [17, 18], it is still tolerable to substitute cement for tapioca meal, but not more than 75%.

According to Table 2, it was found that the P0H30 treatment had the highest density and longer shelf life, while the P4H0 treatment had the lowest. In the P0H30 treatment, the density decreased with increased tapioca meal substitution. The P4H0 treatment had the lowest density due to the high starch content in tapioca meals, as stated by Retnani [15]. Additionally, the density in UMMB decreased upon heating as the starch granules elongated and turned brittle upon drying, according to Dwi *et al*. [19]. It is important to note that a high density of cement can restrict air circulation during storage, as stated by Fuadi *et al*. [20].

In this study, the density value was higher than in Rahayu [21], which was only 0.21% by the adhesive of sago flour. This difference is believed to be due to the high amylopectin content in the adhesive used in this study. As we know, amylopectin has a higher water-absorbing character than tapioca meal, resulting in decreased density, as found in Saripuddin [22].

The utilization of tapioca meal as an adhesive in feed or UMMB shows a stronger bond or level of density compared to commercial adhesives such as cement. This is because tapioca meal undergoes a gelatinization process and forms a dense bond when it loses water content [23, 24, 25]. It's an exciting alternative for a farmer who wants to improve the shelf life of their UMMB.

The Effect of Substitution of Cement with Tapioca Flour on the Water Absorbency of UMMB

Water absorption refers to the capacity of a material to soak up water from the environment and attach it to its particles [15]. The effect of cement substitution to tapioca meal on the water absorption of UMMB is presented in Table 3.

According to the findings in Table 3, Factors A and B had a significant impact ($P<0.05$) on water absorption. In contrast, the interaction between the two factors did not have a significant effect ($P>0.05$). The P4 treatment differed from the other treatments in terms of water absorption. The more tapioca meal was added, the higher the absorption rate. High density leads to empty spaces and decreased water absorption [26]. However, high water absorption in UMMB can cause it to break easily, which is not ideal for licking candy meant for dairy cows. It's better if UMMB is not easily crushed when the cow licks it.

Table 3. Average Water Absorbency of UMMB with Tapioca Flour Substitute Cement Adhesive

Treatments (Factor A)	**Factor B**			**Mean**
	H0	**H15**	**H30**	
P0	5.93 ± 3.46	3.80 ± 1.50	8.11 ± 4.36	5.94 ± 3.44^{ab}
P1	6.16 ± 2.31	7.30 ± 1.76	2.21 ± 0.39	5.23 ± 2.74^{a}
P2	8.31 ± 6.60	8.09 ± 2.94	3.20 ± 0.50	10.25± 6.30^{bc}
P3	14.06 ± 10.11	11.12 ± 0.87	5.56 ± 0.20	10.25 ± 6.30^{bc}
P4	25.66 ± 8.47	8.34 ± 4.55	8.08 ± 1.20	14.03 ± 9.98^{c}
Mean	12.02^{a} ± 9.62	7.73^{b} ± 3.31	5.43^{b} ± 3.05	

^{abc} Different superscripts in the same column show significant differences (P<0.01); P0 = cement 100%; P1 = cement 75% tapioca flour 25%; P2 = cement 50% tapioca flour 50%; P3 = cement 25% tapioca flour 75%; and P4 = 100% tapioca flour; H0 = 0 days; H15 = 15 days; and H30 = 30 days.

According to Table 3, the water absorption capacity of P1 was lower than the other treatments, excluding P0, and this difference was significant (P<0.05). The UMMB material is known for maintaining its solid form without being easily crushed due to its low water absorption capacity. However, it is essential to note that high water absorption can lead to physical changes in UMMB, such as changes in thickness and texture, as pointed out by Zainuddin *et al*. [27]. Despite this, tapioca meal as an adhesive in UMMB production can increase water absorption compared to Calcium Carbonate [28]. Overall, UMMB is considered to be a suitable material.

Effect of Cement Substitution with Tapioca Starch on TPC in UMMB

The TPC method calculates the number of microbes/fungi in feed samples. The quantity of microbes/fungi meets the required minimum standards [29]. The effect of cement substitution to tapioca meal on the TPC of UMMB was presented in Table 4.

Table 4. Average UMMB TPC with Tapioca Flour Substitute Cement Adhesive

Treatments (Factor A)	**Factor B**			**Mean**
	H0	**H15**	**H30**	
P0	3.67×10^{4} ± 2.08	8.67×10^{4} ± 1.15	2.33×10^{4} ± 0.57	4.89×10^{4} ± 3.14^{a}
P1	3.33×10^{4} ± 2.95	5.67×10^{4} ± 3.51	5.33×10^{4} ± 3.05	4.68×10^{4} ± 3.02^{a}
P2	9.33×10^{4} ± 1.15	6.67×10^{4} ± 4.16	7.33×10^{4} ± 3.05	7.78×10^{4} ± 2.90^{a}
P3	2.50×10^{4} ± 10.00	8.67×10^{4} ± 9.81	16.67×10^{4} ± 5.77	15.11×10^{4} ± 9.10^{a}
P4	20.00×10^{4} ± 10.00	36.67×10^{4} ± 46.18	23.33×10^{4} ± 5.77	26.67×10^{4} ± 25.00^{b}
Mean	11.27×10^{4} ± 9.54	13.67×10^{4} ± 21.70	11.00×10^{4} ± 8.80	

^{abc} Different superscripts in the same column show significant differences (P<0.01); P0 = cement 100%; P1 = cement 75% tapioca flour 25%; P2 = cement 50% tapioca flour 50%; P3 = cement 25% tapioca flour 75%; and P4 = 100% tapioca flour; H0 = 0 days; H15 = 15 days; and H30 = 30 days.

The results revealed that Factor A had a significant effect ($P<0.05$), but Factor B and its interaction between the two factors had no significant effect ($P>0.05$) on the number of TPC. The level of TPC increases with the increasing level of substitution of tapioca meal. Tapioca meals are organic, meaning they are more resistant to mold growth [30]. Therefore, it's essential to consider this when storing and using tapioca meals in UMMB production. Besides, tapioca meal is known for its high amylopectin content, which gives it unique properties such as high adhesive power, low clotting tendency, and resistance to breakage or damage. Additionally, it has a gelatinization temperature of 70°C. Regarding nutritional content, tapioca meal contains 362 calories, 0.59% protein, 3.39% fat, 12.9% water, and 6.99% carbohydrates per 100 g sample [31].

There was a decrease in the level of TPC in H15, which continued to be lower in H30. This trend is due to the fungal growth lag between days seven and 14. Moreover, it is essential to note that tapioca meal that has been gelatinized contains a high water content. This can create an environment that supports the growth of fungus, which can then further accelerate the damage of UMMB. It is best to store tapioca meal in a cool, dry place to prevent any potential issues. During phases 15–21, the fungal growth remains relatively constant while the number of dead cells is balanced. However, after this period, the fungus enters the last phase of growth, the death phase, resulting in a decrease in its number after the 21st day [32]. This is shown in Table 4. Interestingly, UMMB production by cement can be stored for 30 days due to the lower growth of the fungi. Despite this, the substitution of tapioca meals is still at the threshold [33] and is considered organic material.

CONCLUSIONS

The tapioca meal adhesives can be used as a credible substitute for cement up to 50% without compromising the density, water absorption, and TPC values of UMMB production. Moreover, UMMB's quality and shelf life are relatively high even after 30 days.

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