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Intake and growth performance of Brahman and Boran crossbred heifers fed on optimized ash-based vitamin-mineral winter block with bentonitic clay binders

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ABSTRACT

Though use of cement as a binder has produced acceptable results in the manufacture of feed blocks, there are questions on the possible negative health effects and high cost associated with the use of building cement in the production of feed blocks. The objective of the study was to compare supplementation effect of cement and bentonite + cement as binders in optimised ash-based winter blocks on feed intake, weekly weight gain and hair characteristics of beef cattle. Sixteen Brahman x Boran crossbred heifers with initial body weight of 250 ± 5kg were allocated to four treatments in a completely randomized design. Treatments based on the binder used in fabricating the optimized ash-based vitamin-mineral winter block were: cement agglutinated block, bentonite + cement agglutinated block, negative control (no supplement), and positive control (commercially available winter block). Animals were penned and fed on Rhodes grass (Chloris gayana) hay constituting 11% crude protein (CP); 8 MJ/kg DM for seventy days (dry season). Feed and supplement blocks were weighed daily, animal weights were collected on weekly basis. Hair samples were measured at the beginning and end of the experiment. There was no significant difference in voluntary feed intake between bentonite + cement block and the positive control (P<0.05). Block intake was significantly higher (P<0.05) for the commercially available block (0.70±0.05kg/head/day) than in the cement agglutinated block (0.44±0.04 kg/head/day) and the bentonite + cement agglutinated block (0.49±0.04 kg/head/day). All animals that received supplement block had significantly higher weight gains than those that did not receive supplement (P<0.05). There were no significant differences in hair length across all treatments (P<0.05). Ash-based winter block agglutinated by a combination of cement and bentonite clay is a viable supplement which helps trim down amount of cement in feed blocks and improve animal performance. Use of the locally produced optimised ash-based vitamin-mineral block for nourishing ruminant animals is highly recommended.

Introduction

Cattle in Zimbabwe and most parts of Sub-Saharan Africa where feeding is commonly on natural pastures and crop residues require vitamin and mineral supplements(Duguma and Janssens, 2021). It is reported that over 60% of cattle farmers in Southern Africa fail to realize full economic value of their animals due to poor nutrition (Gusha *et al.*, 2016). Resultantly, animals suffer from chronic hunger, poor growth rate, reduced fertility and metabolic disorders (Gasselin *et al.*, 2020). Mineral supplementation has led to increased livestock production as measured by body weight gain and reproductive performance (Arthington, 2006). Use of solid feed supplementation blocks to provide the nitrogen, minerals and vitamins lacking in fibrous feeds offers several advantages: ease of transport, storage and use (EL-Shabrawy and Al-Rajhi, 2020). Toxicity risks associated with practices such as giving a small amount of urea in drinking water, sprinkling of urea solution on fibrous feeds before feeding, or urea-ammonization of crop residues are alleviated (Dove, 2009).

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The binder used in the manufacture of feed supplementation blocks influences block intake (Salman *et al.,* 2017). Vitamin-Mineral supplementation blocks must be hard enough to oblige animals to lick and not to take bites (Rahman *et al.*, 2020). If the block is too hard, intake maybe limited, in contrast, too soft a block maybe consumed too quickly with animals taking bites (Furtado *et al.,* 2018). Hardness can be controlled by changing the proportions of the ingredients, such as adjusting the percentage and type of the gelling agent or binder (Dove, 2009). Preliminary work was done at Chinhoyi University of Technology, Zimbabwe to fabricate a local optimized ash-based vitamin mineral winter block which provides the animal with supplemental energy, protein, vitamins and minerals. Scanty information is available on the performance of animals in response to the particular supplement block locally.

This study was therefore conducted to determine the comparative effect of cement and bentonite + cement as binders in optimised ash-based winter block and commercial winter block lick on block intake, voluntary feed intake (VFI), weekly weight gain and hair length in Rhodes grass (*Chloris guyana*) hay-fed cattle. It was hypothesized that there is no difference in feed intake, weekly weight gain and hair length in beef cattle supplemented with different block licks and those that are not supplemented.

Materials and Methods

Site

The study was conducted at Chinhoyi University of Technology Farm in Mashonaland West Province of Zimbabwe, location 17°20'55.1"S 30°14'06.5"E. The area lies 112m above sea level, average annual temperature is 19.8°C and rainfall is 816mm per year.

Research and animal ethics

Ethics governing the use and conduct of experiments on animals were strictly observed. The experimental protocol was approved by the Chinhoyi University of Technology committee on Animal Research Ethics. Permission was obtained from the farm manager and research officer for the provision of infrastructure and support for carrying out the experiment at the institutional research unit.

Fabrication of experimental optimized ash-based vitamin-mineral winter blocks

Optimized ash-based winter blocks were made through the cold process of block production (Sansoucy, 1986 as cited in Sansoucy *et al.*, 1988). Cement, a combination of cement and bentonite in a ratio of 1:1 were used as binding agents. Ordinary Portland cement was used. The Zimbabwean winter is a dry season. Forage quantity and quality drops in the dry season with low energy, proteins, vitamins and minerals (Ben Salem and Smith, 2008). Apart from vitamins and minerals, the optimized ash-based vitamin-mineral 'winter' block is fabricated to supply the animal with supplementary energy and protein. The ingredients used in the manufacture of the blocks and their respective quantities are shown in Table 1.

Table 1. Ingredients respective quantities for experimental winter blocks

Ingredients(kg)	Cement binder	Bentonite + cement binder
Molasses	40	40
Salt	15	15
Wheat Bran	30	30
Cement	15	7.5
Bentonite	0	7.5

Animals

Sixteen animals aged 10 – 12 months, with initial body weight (BW) of 250 ± 5kg, were randomly selected from the Chinhoyi University of Technology Farm Brahman x Boran crossbred heifers. All animals were provided with common salt blocks for three to four hours per day during an acclimatization period of ten days. Thereafter, animals were randomly assigned to four treatments in a completely randomized design. Four treatments were: negative control, cement binder, bentonite + cement binder and positive control (commercially available winter block). The commercial winter block has 30% crude protein as indicated by the manufacturer, however detailed ingredients and respective quantities are considered trade secret and were not provided. Each treatment had four replicates. Animals were penned and fed on Rhodes grass (*Chloris guyana*) hay constituting 11% CP; 8 MJ/kg DM. Hay and drinking water were provided *ad libtum*. Animals were exposed to winter feed blocks through free choice licking for three – four hours per day, between 0700hrs to 1000hrs throughout the experimental period.

Data collection

Hay was weighed using a platform scale (Adam Scales) every morning before placing in feed troughs; refusal hay was also weighed at the end of the day. Blocks were weighed before giving the cattle access to the blocks then weighed again upon removal from the experimental cattle pens. Feed and block intake were obtained by subtracting refusal feed amount

from the initial amount administered to the animal. Animals were weighed once every week. Animals were led to the weighbridge and were made to stand on the platform for 10 to 15 seconds for a constant measurement to be attained before recording the resulting weight (Wangchuk *et al.*, 2018). Hair length was measured at the beginning and end of the experiment as described by Madzimure *et al.* (2012).

Data Analysis

Data was subjected to ANOVA in SPSS version 18.0. Means were separated using least significant difference (LSD).

Results

Table 2 shows the mean values (± standard error) for voluntary feed intake, block intake and weekly weight gain. Voluntary feed intake was highest ($P<0.05$) in cattle supplemented with cement agglutinated winter block and lowest in the negative control animals. Cattle supplemented with bentonite + cement agglutinated block and those that received the commercially available block showed no significant difference in voluntary feed intake ($P<0.05$). Block intake was significantly higher in cattle fed the commercially available block (positive control) than those on the cement and bentonite + cement agglutinated blocks ($P<0.05$). Weekly weight gain was significantly higher in animals that received supplement blocks regardless of block type, than the negative control ($P<0.05$).

Table 2. Effect of block type on mean voluntary basal feed intake, block intake and weekly weight gain

	(Mean ± Standard Error)			
	Cement	**Bentonite + Cement**	**Negative control**	**Positive control**
VFI (kg)	4.86±0.10^{a}	4.63±0.09^{ab}	4.41±0.10^{b}	4.69±0.10^{ab}
Block Intake (kg)	0.44±0.04^{a}	0.49±0.04^{a}	0	0.70±0.05^{b}
Weekly weight gain (kg)	2.78±0.34^{a}	2.75±0.36^{a}	1.93±0.17^{b}	2.78^{a}

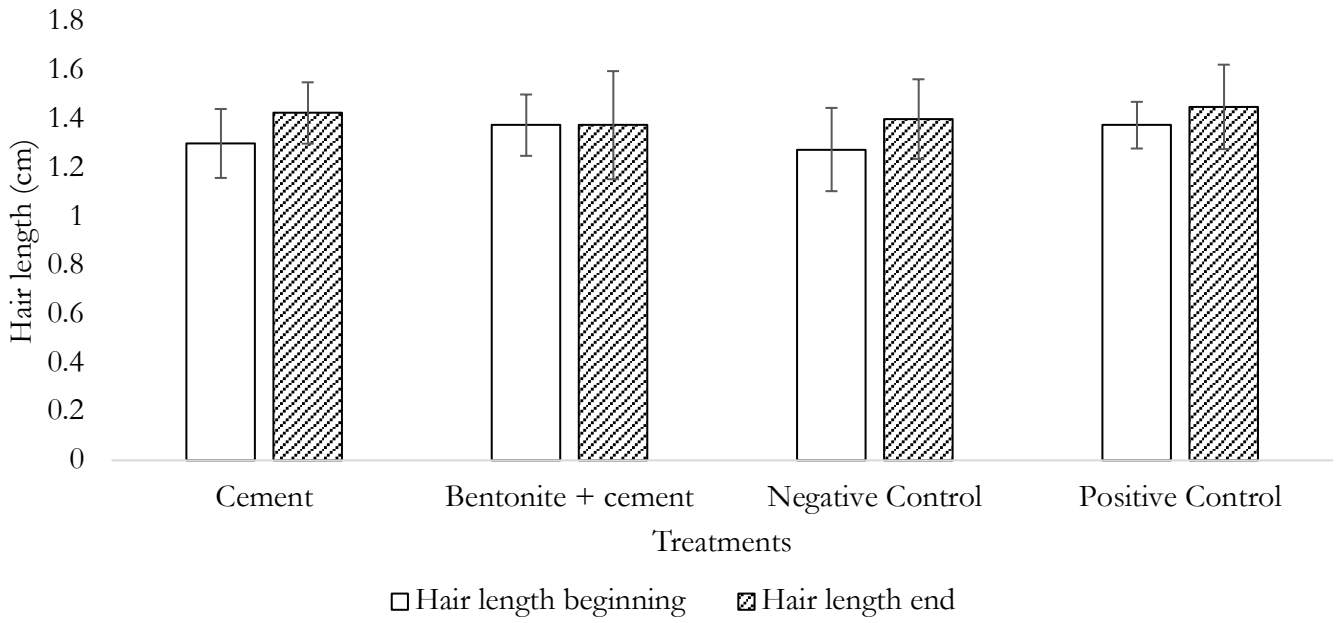

Figure 1. Effect of winter block type on hair length of Brahman x Boran crossbred heifers

Discussion

The significantly higher block intake observed for the commercially available block (positive control) than the test blocks could be attributed to the hardness of the block. Block hardness is a crucial factor determining intake. By pressing in the middle of the commercial block with a thumb, the block could be considered less hard when compared to the test block. The commercial block was also easier to break by hand when compared to the tests blocks. Asaolu (2012), determined hardness in moringa multi-nutrient blocks by having three people independently press in the middle of the block with a thumb. Herrera *et al.* (2017) reported reduced block intake as hardness increases. The type and concentration of the binder in the commercial block

is considered a trade secret, thus making it difficult to ascertain the absolute effect of binder on the hardness and intake of the block. Cement and bentonite + cement binders proved to be equally good binders as they produced blocks whose intake was not significantly different. Mubi *et al.* (2012) supplemented cattle grazing natural pastures with a multi-nutrient block and observed mean block intake of 0.46kg/head/day, which corroborates that of the test blocks in the current study.

The higher weekly weight gain observed in animals that received supplementation blocks confirmed that providing animals with feed blocks absolutely nourishes animals with supplementary nutrients. The availability and adequacy of essential minerals elements is key in the performance of cattle (Cantalapiedra-Hijar *et al.,* 2018). Trace elements are crucial in the maintenance of homeostasis, appropriate micronutrient levels promote healthy growth and development (Żarczyńska *et al.*, 2017). Phosphorus is one of the limiting minerals in cattle nutrition as it is present in adenosine triphosphate (ATP) which is the energy source for most metabolic processes (Ahuja and Parmar, 2017). Phosphorus is a key element included in the optimized ash-based vitamin mineral winter block and its availability and adequacy could likely have promoted an energy balance, hence higher weight gain in animals that received supplement blocks. Similarly, Gasselin *et al.* (2020) observed that supplementation with micronutrients improved body weight and body condition score in dairy cattle. Energy metabolism among other factors is key in feed efficiency (Guinguina *et al.*, 2020). Animals seek to achieve energy equilibrium despite the physiological and environmental conditions using the energy available in the diet and tissue reserves (Mondal *et al.,* 2018). Supplementary energy and protein in the test blocks and the commercial block could have promoted the higher body weight gain in animals that received supplement blocks.

Despite the variation in block intake between the test blocks and the commercial block, animals' performance in terms of weight gain was the same in the present study. Obtaining similar weight gains in cattle that received the test blocks and the commercial lick at a block consumption rate of 0.46kg/head/day and 0.49kg/head/day against 0.70kg/head/day respectively, possess an economic benefit. This implies that a 10kg block from cement and/or bentonite + cement binder can last for approximately 20 days against an approximate 14 days for the commercial block yet realizing similar animal performance from both blocks.

Any differences in hair length in the particular study could possibly be due to the duration of the experiment. Further experiments over a prolonged period are recommended to observe impact of feed supplementation blocks on hair length, hair density and other on coat characteristics.

Conclusions

The study indicated that cement and bentonite+ cement agglutinated winter block is a viable feed supplementation block that compares well with the commercially available winter block for cattle. The tests blocks proved to have desirable hardness as indicated by block intake. The cement and cement + bentonite agglutinated blocks improved basal diet intake and weekly weight gain as observed in cattle that received these tests blocks. It is therefore concluded that bentonite clay which has a documented voluntary intake by farm animals can be used as combined binder, thus trimming down the amount of cement in cattle feed blocks. Farmers and feed manufacturers are recommended to use a combination of cement and bentonite clay as a binder in a ratio of 1:1 when manufacturing feed block supplements. This successfully helps trim down cement inclusion level by 50%, addressing the concerns of cement skeptics raised by farmers without compromising block quality and animal performance. A further investigation on the cost benefit analysis of using the test blocks is recommended.

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