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Evaluation Characteristics of Animal Complete Feed Block, Made Based on Alhagi, Reed Grass and Sorghum Forages

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ABSTRACT

The purpose of this project was to produce complete feed blocks using common forage sources in the Sistan region. The treatments involved different ratios of concentrate to forage, with a ratio of 30:70. The adhesive composition varied among the treatments, included 1) 10% molasses, 2) 10% molasses and 4% bentonite, 3) 4% bentonite, 5% wheat flour, and 5% barley flour, 4) 4% bentonite and 10% wheat flour, 5) 4% bentonite and 10% barley flour, and 6) 10% barley flour and 5% wheat flour. The proportions of common reed, sorghum, alhagi, and straw were 10%, 10%, 5%, and 5% respectively, totaling 30%. To assess the strength of the feed blocks, a durability test was conducted. The blocks were thrown from a height of 1.8 meters, and the ratio of the weight of the largest remaining piece to the initial weight was used as a measure of durability. Treatment 2 exhibited the highest durability at 56.03%, while treatment 6 had the lowest durability at 42.75% ($P < 0.05$). There were no significant differences observed between treatments in terms of post-compression expansion and density at different time points after block construction. The most significant changes in volume and density occurred within the first 24 hours. Based on the findings of this study, the use of 10% molasses or 4% bentonite in the feed composition as an adhesive, can create favorable feed blocks in terms of physical characteristics.

Key words: Alhagi, Bentonite, Complete feed block, Molasses, Sorghum

INTRODUCTION

In the realm of livestock breeding, inadequate nutrition stands out as a key factor leading to suboptimal animal performance (Karangiya *et al.* 2016). The primary reason for low productivity in ruminant livestock, particularly in tropical regions, is the improper handling of feed resources, specifically bulky and fibrous crop residues due to their high fiber and lignin content (Amole *et al.*, 2022). Leveraging locally available feed resources can significantly reduce feeding expenses. Employing suitable techniques for processing these feed resources can substantially assist farmers in enhancing feed efficiency and animal productivity (Karangiya *et al.* 2016; Akram and Yaman Fırıncıoğlu, 2019).

Pastoralists in arid regions encounter a significant challenge in maintaining livestock body condition during extended drought periods due to feed scarcity (Ibrahim and Jayathileka, 2000). To ensure adequate nutrient supply, fodder should be supplemented with energy and protein additives (concentrates) as well as minerals (McGrath *et al.*, 2018).

The technology of producing complete feed blocks can serve as an effective crisis management strategy during natural disasters and droughts to safeguard animals from losses (FAO, 2012; Padilla *et al.*, 2020). This system is among the most efficient ways to provide nutrients to livestock, allowing for customization of forage and

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concentrate proportions in block production based on production levels, lactation stages, animal physiology, and available resources (Padilla *et al.*, 2020). The blocks typically consist of forage fractions, which are primarily crop residues that could be fermented to enhance their nutritional value. Concentrate components, and some bioactive compounds and feed additives like transit nutrients and non-ionic surfactants are incorporated into the blocks as carriers (FAO, 2012). However, a typical composition of straw blocks includes 86% straw, 10% molasses, 2% mineral supplements, 1% urea, and salt, which can adequately fulfill the animals' nutritional requirements (Sharma *et al.*, 2014). Blocked straw has a specific weight that occupies approximately one third of the space compared to unblocked straw, thereby minimizing wastage (Sharma *et al.*, 2014). This method also simplifies feeding, reduces feeding time, and eliminates the need for animals to select feed ingredients (Sharma, 2006).

Feed blocks can be manufactured manually or using machinery. In economically disadvantaged regions, particularly in countries like India and Sri Lanka, significant efforts are being made to produce and expand small-scale block production devices (Silva, 2017).

The Sistan pastures, face challenges due to water fluctuations and extreme instability, leading to variable and fragile coverage (Fayaz, 2017). As a result, accurately estimating the forage supply becomes a difficult task. Furthermore, livestock farmers may not be effectively utilizing the available resources, possibly due to a lack of knowledge or insufficient facilities for feed processing.

Thus, the aim of this study was to investigate the possibility of producing an animal complete feed block, based on common forages in the Sistan region.

MATERIALS AND METHODS

Block ingredients and preparation: Initially, the rations were designed with a concentrate to forage ratio of 70 to 30%, respectively, to meet the requirements of fattening cows. This specific ratio was selected not only to fulfill the nutritional needs of the cows but also due to its ability to compact well into blocks. The forage component of the ration consisted of 10% Reed grass (*Phragmitis communis*), 10% sorghum, 5% sorghum, and 5% straw (as dried form), while the concentrate part included barley, corn, wheat bran, soybean meal, and mineral and vitamin supplements tailored to the binding type, with varying proportions of these ingredients (Table 1). To ensure proper adhesion between the food components, the dry forage was finely chopped to sizes below 3 cm and manually mixed with the concentrate portion. Four materials - molasses, bentonite, barley flour, and wheat flour - were utilized to enhance adhesion among the feed ingredients, resulting in varied rations based on the binding type employed. Before being poured into the block mold, the feed ingredients were meticulously hand-mixed for 10 minutes. Molasses were preheated to approximately 60°C before being added to the diet. A custom block machine was devised and constructed using farm tools for block formation.

Durability and density test: Given that the primary aim of block production in this study was to explore its feasibility in cattle ranches or existing units in the Sistan region, which are in close proximity to each other and allow for rapid block production, the key parameter for evaluation was durability. To assess this, the blocks were exposed to open air for 24 hours post-formation, then dropped from a height of 1.85 meters onto a cement surface, with the ratio of the largest piece's weight after impact to the initial block weight serving as the durability percentage indicator (Santhiralingam and Sinniah, 2018). In addition to the impact test used as a measure of durability, the blocks were also assessed based on post-compression expansion as an indicator of block strength. The dimensions of the blocks were initially measured upon removal from the mold, followed by measurements at 24 hours, one week, one month, and two months intervals. The percentage increase in dimensions compared to the original dimensions (change in volume) was calculated as the Post-compression expansion at various time points (Berwal *et al.*, 1993).

Density measurement of the constructed blocks served as another key indicator. The dimensions (length, width, height) of the blocks under different treatments were measured immediately and at intervals of 24 hours, one week, one month, and two months. The dimensions and weight of the blocks were recorded, and the weight-to-volume ratio was utilized to determine density. The dry matter content of the samples was also measured, with the weight of the dry matter being consistent throughout. As the weight of the dry matter remains constant while only the volume changes, the block weight was assumed to be constant at all stages.

Mold growth test: Furthermore, mold growth condition was examined as an additional factor to assess block durability. The condition of mold growth was inspected 48 hours post-production, followed by weekly checks for 5 weeks. Alongside other assessments, 6 blocks were crushed at specified intervals, and various sections were

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inspected using a magnifying glass. The time taken for the first signs of mold to appear within the 5-week period was recorded.

Table 1 Components and chemical composition[1] of the experimental rations combined to create complete feed blocks for fattening cows

Feed ingredients(%)	Treatments*					
	1	2	3	4	5	6
Sorghum	10.0	10.0	10.0	10.0	10.0	10.0
Reed grass	10.0	10.0	10.0	10.0	10.0	10.0
Alhagi	5.0	5.0	5.0	5.0	5.0	5.0
Wheat Straw	5.0	5.0	5.0	5.0	5.0	5.0
Barley	38.0	38.0	35.0	35.0	35.0	30.0
Corn	6.0	6.0	7.0	7.0	7.0	7.0
Wheat bran	12.3	12.3	9.0	9.0	9.0	9.0
Soybean meal	6.0	6.0	6.3	6.3	6.3	6.3
Barley flour	0.0	0.0	5.0	0.0	10.0	10.0
Wheat flour	0.0	0.0	5.0	10.0	0.0	5.0
Molasses	10.0	10.0	0.0	0.0	0.0	0.0
Bentonite	0.0	4.0	4.0	4.0	4.0	0.0
Calcium carbonate	0.1	0.1	0.1	0.1	0.1	0.1
Vit-Min supplement	0.5	0.5	0.5	0.5	0.5	0.5
Salt	0.5	0.5	0.5	0.5	0.5	0.5
Magnesium oxide	0.1	0.1	0.1	0.1	0.1	0.1
baking soda	0.5	0.5	0.5	0.5	0.5	0.5
DM (%)**	87.5	84.5	89.6	89.4	89.1	75.1
ME(Mcal/KgDM)	2.6	2.4	2.5	2.4	2.4	2.5
OM (%)	90.2	90.1	90.2	90.2	90.2	90.3
CP(%)	13	13	13	13	13	13
NDF(%)	36	36	35	35	35	35
ADF(%)	19	19	18	18	18	18
Ash(%)	9.5	9.7	9.7	9.7	9.7	9.5

*1) 10% molasses, 2) 10% molasses and 4% bentonite, 3) 4% bentonite, 5% wheat flour, and 5% barley flour, 4) 4% bentonite and 10% wheat flour, 5) 4% bentonite and 10% barley flour, and 6) 10% barley flour and 5% wheat flour.

**DM: Dry matter, ME:Metabolizable energy, OM: Organic matter. CP: Crude protein, NDF: Neutral detergent fiber, ADF: Acid detergent fiber

Design and build the device: In the absence of a feed block production machine in the region, a machine was custom-designed and constructed on the farm. The innovative design featured a block mold positioned at the bottom, with pressure applied by a hydraulic jack (Bonwan 475 two-way jack, made in Iran) from above. To minimize costs, the decision was made to use the tractor gearbox to power the hydraulic jack.

Figure 1 feed block production machine, designed and built by the researcher

The frame of the machine was crafted using iron No. 14 waste material, while a hydraulic jack from an excavator, capable of handling 5 tons of load, was incorporated into the device. This jack was mounted vertically within the frame and connected to the tractor gearbox via high-pressure hoses to supply the necessary oil pumping power (figure 1). A critical aspect of the machine was the design and fabrication of the mold, which underwent numerous iterations before achieving success. Ultimately, the mold was perfected to produce feed blocks measuring 10x30x20 cm and weighing between 4 to 5 kg DM.

Statistical analysis: The experiment was conducted using a completely randomized design with 6 treatments and 10 replications. Consistency of the block's physical structure, durability, post-compression expansion, and density were analyzed through a using PROC GLM of SAS (Version 9.4, SAS Institute Inc., Cary, NC, USA). The Tukey test

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was utilized to identify specific locations where differences in means were observed. The data was summarized as (Mean ± SEM), and significance was determined at $P \leq 0.05$.

RESULTS AND DISCUSSION

Physical evaluation of blocks: Table 2 presents the findings pertaining to three durability indices, variations in density, and alterations in block volume (Post-Compression Expansion) over different time intervals: 24 hours, one week, one month, and two months.

Durability: The durability index, defined as the ratio of the weight of the largest remaining piece to the initial weight of the block after being dropped from a height of 1.8 meters onto a cement surface, exhibited a notable disparity among the treatments ($P<0.05$).The durability index of treatments 1 to 6 ranged from 42.75 to 56.03, with treatment 2 (a mixture of molasses and bentonite) exhibiting the highest durability at a rate of 56.03, and treatment 6 (wheat and barley flour) showing the lowest durability at a rate of 42.75. The persistence index between treatments 1 (molasses) and 2 (combination of molasses and bentonite) was not statistically significant. Similarly, there was no significant difference in durability index between treatments 1 (molasses), 3 (bentonite + wheat and barley flour), and 4 (bentonite + wheat flour). Additionally, the durability index was not significantly different between treatments 3, 4, 5 (bentonite + barley flour), and 6 (wheat and barley flour). However, there was a significant difference between treatment 2 and treatments 3, 4, 5, and 6. Various studies have reported a range of durability percentages in different researches, such as 73.99-99.82 (Kaushalya *et al.*, 2020), 78.70-83.52 (Pankaj *et al.*, 2015), 91.32-84.63 (Santhiralingam and Sinniah, 2018), and 20.08-100 (Farasti *et al.*, 2016). The durability of blocks is influenced by several factors, including the mixing process of forage and concentrate, compression techniques, humidity, temperature, particle size, material quality, adhesive materials, and the duration of pressure application (Ben Salem *et al.*, 2003; Theerarattananoon *et al.*, 2011; Tabil, 1996; Kaushalya, 2020). A higher durability index indicates better resistance to handling and storage challenges.

The durability achieved in this study was found to be lower compared to previous research findings. This could be attributed to the compression power of the device used. While factors such as particle composition, size, adhesive materials, and duration under pressure did not vary significantly from other studies, the maximum power was utilized to apply pressure. Increasing the machine's power by adjusting the jack or tractor power could potentially lead to the production of stronger blocks. It is important to note that the blocks are typically packed in nylon for transportation and storage, making them easily movable.

Table 2 Physical indexes of complete feed blocks

Item	Treatments*						Standard Error
	1	2	3	4	5	6	
Durability**	52.22^{ab}	56.03^{a}	46.87^{bc}	46.78^{bc}	45.05^{c}	42.75^{c}	1.98
Density 1***	484.11	486.42	479.15	477.8	477.4	473.85	5.96
Density 2	450.82	451.8	446.9	445.16	443.85	439.72	7.95
Density 3	442.17	443.83	439.94	443.54	442.25	436.33	8.74
Density4	440.54	440.39	436.53	442.78	440.47	434.74	9.18
PCE1****	8.06	7.4	7.28	7.44	7.41	7.7	1.66
PCE 2	8.94	7.82	9.03	7.88	9.56	9.66	1.96
PCE 3	9.37	8.25	9.92	8.04	10.02	10.5	2.11
PCE 4	9.37	8.25	9.92	8.04	10.02	10.5	2.11

-Different letters in each row indicate the tendency of the averages to be significant at the $P<0.05$ level

* 1) 10% molasses 2) 10% molasses + 4% bentonite 3) 4% bentonite + 5% wheat flour + 5% barley flour 4) 4% bentonite + 10% wheat flour 5) 4% bentonite + 10% barley flour 6) 10% barley flour + 5% wheat flour

** index of throwing from a height

*** Kg of DM per cubic meter in 24 hours, one week, one month and two months

**** Post-Compression Expansion (%) at 24 hours (PCE1), one week (PCE2), one month (PCE3) and two months' (PCE4) intervals after block construction

Despite the lower durability observed in this study, these blocks can still meet the requirements for transportation and storage on the farm. The results suggest that a combination of 10% molasses and 4% bentonite, or 10% molasses alone, in diets with a 30:70 forage to concentrate ratio can enhance endurance. Additionally, using 4% bentonite alone can provide similar endurance levels as 10% molasses. While the quality of bentonite may vary in the market, its cost-effectiveness makes it a viable option, especially if high-quality bentonite is readily available and dietary energy requirements

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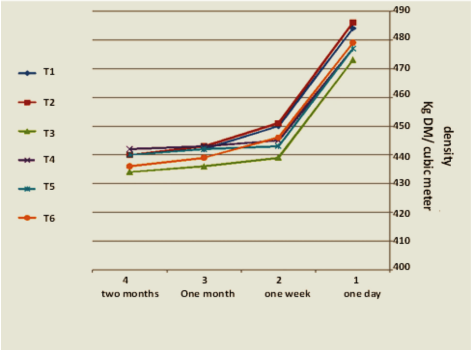
are met. Employing more powerful devices can further improve results. Overall, producing blocks with endurance similar to those in this project can effectively meet block production objectives on the farm and enable the benefits of complete feed blocks to be realized.

Density: There were no significant variations in the density or weight of dry matter per cubic meter during different time intervals among the treatments. However, treatment two exhibited numerically higher values compared to the other treatments during three specific periods (24 hours, one week, and one month). The density of the blocks in the current study ranged from a minimum of 434/74 to a maximum of 486/42. According to FAO (2012), the density of straw-based feed blocks is approximately 450 kg/m3, while for pellets, it is around 600 kg/m3. Previous reports have indicated densities ranging from 418 to 533 kg/m3 for treatments with different part sizes and pressures (Ferasati *et al.*, 2016). The compression level has been found to vary significantly in different reports, depending on factors such as compound type and size, device pressure, and forage-to-concentrate ratio. The suitable density for livestock feeding falls within the range of 300 to 500 kg/m3 (Yadav *et al.*, 1990). This range reflects the animal's ability to separate feed pieces from the block. The density obtained in the present study falls within this range, indicating favorable block production based on this index. In terms of post-compression expansion, there were no significant differences observed among the treatments during different time intervals. A higher expansion after compression suggests a greater tendency for the forage particles to regain their original shape. Therefore, a lower value for this index indicates that the block particles have a better ability to maintain their structure after compression, resulting in improved block production (Pankaj *et al.*, 2015). Various studies have reported this index to range from 18 to 22 percent (Kaushalya, 2020), 28 to 37 percent (Singh *et al.*, 2016), and 1 to 3.5 percent (Ferasati *et al.*, 2016).

Post-Compression Expansion (PCE): In the present study, Post-Compression Expansion ranged from 7.4 to 10.5, which falls within an acceptable range when compared to previous research findings. The PCE can be influenced by several factors, including the type of forage, particle size, machine pressure, and binder material.

Previous studies have reported that in blocks made from wheat and rice straw, higher pressing pressures result in greater PCE (Das *et al.*, 2004). This suggests that different forages possess varying levels of compressibility and elasticity, and that increased pressure leads to a greater change in the tolerable level of the forage, resulting in higher expansion rates after compression. following block production, which is a significant aspect in all treatments. The figure 2 and 3 clearly indicate that the most substantial alterations in volume and density occur within the initial 24 hours, followed by a gradual decrease in these changes during the first week, and eventually reaching nearly zero after a month.

Figure 2 Changing the density of blocks at different times



The process of volume increase and density decrease at different time points exhibits a similar pattern, as these two variables are inversely correlated. This can be attributed to the definition of density, which is the amount of weight in a given volume. With an increase in expansion, the volume of the block expands, subsequently leading to a decrease in its density.

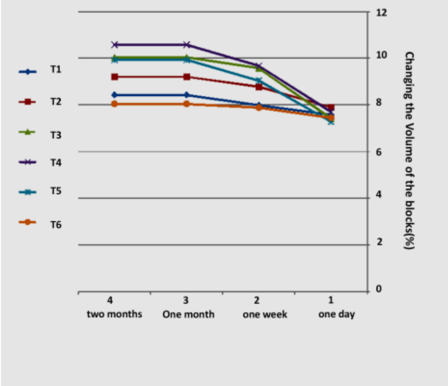


Figure 3 Changing the volume of the blocks at different times

Check for mold growth: Examining the mold growth in the blocks at different time intervals was done with a magnifying glass. Apart from treatment six (barley and wheat flour), mold presence was not detected in the other treatments during different time periods. It is important to note that the moisture content of the blocks in the first five treatments was maintained between 14 to 16%, a common level in feeds that does not promote mold

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growth. However, in the sixth treatment, the moisture level was increased to 25% due to insufficient adhesion, aiming to create adequate adhesion and form the block structure. Consequently, the elevated humidity in this particular group appears to have facilitated mold growth. Therefore, edible blocks should not contain more than 16% moisture, because due to exposure to air, there is a risk of mold growth.

CONCLUSION

Based on the findings of this study, it appears feasible to manufacture complete feed blocks at a low cost in the livestock farming sector and rural communities, thereby reaping the benefits associated with this practice. To enhance the structural integrity of the feed block, it is advisable to enhance the device's power capacity. When minimal movement is required and ample dietary energy sources are present, bentonite can serve as an adhesive at a rate of 4% of the dry matter in the ration, resulting in reduced overall costs. Conversely, in situations where energy sources are scarce (such as cereals), incorporating 10% molasses can serve dual purposes as an energy source and binding agent.

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CONFLICT OF INTEREST

There were no discernible conflicts of interest present.

AUTHOR CONTRIBUTIONS

Dr. Mortaza Keykhasaber was entrusted with the oversight and execution of this project, while Dr. Mohammad Farhad Vahidi contributed significantly to the analytical processing of the data.

DATA AVAILABILITY

The datasets generated and analysed in the current study are not publicly accessible; however, they may be acquired from the corresponding author upon a reasonable request.

ETHICAL CONSIDERATIONS

Ethical approval is deemed inapplicable for the present study.

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