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Behavioral activity budget of grower Beetal kids offered total mixed ration under stall-fed system

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Abstract: This study investigates the behavioral activities of grower Beetal kids fed in a conventional method-control group manner or given total mixed ration (TMR) (i.e. hay-based - T_1 and green fodder-based - T_2). Twenty-four weaned Beetal kids were enrolled and randomly distributed into 3 groups based on their body weight, sex, and age. Behavioral observations were recorded 30 min after giving experimental ration to the kids using the scan sampling method for 1 h, which inferred time spent eating normally, eating with forelegs on the cage, and eating with forelegs on the feeders; standing idle and urination were significantly higher in the control group than in the T_1 and T_2 groups ($p < 0.01$). Agonistic activities like bunting were numerically higher for Beetal kids fed with hay-based TMR, followed by the T_2 and control groups (not significantly affected). Grooming using other inanimate objects in the pen ($p < 0.01$) and pawing the ground ($p < 0.05$) were found to be significantly higher in the T_1 group than in the other groups. Animals in the hay-based TMR-fed group also spent significantly ($p < 0.01$) more time ruminating while standing compared to the control and T_2 groups. During normal sitting activity, the variations were statistically higher ($p < 0.05$) for the green fodder-based TMR group than the other groups. The hay-based TMR-fed group consumed the offered feed with more relish, ate more quickly, and showed agonistic activities among mates in their cages or pens.

Key words: Goats, behavior, activity, total mixed ration, stall-feeding

1. Introduction

Globally, the goat population has more than doubled during the last 4 decades; currently, a population of approximately 1 billion goats exists worldwide, an increase of over 34% since 2000 [1]. In terms of international distribution, over 90% of goats are found in developing countries; Asia has the largest proportion of goats, followed by Africa.[1] India has the second-largest population of goats in the world, with 148.88 million animals, according to a recent livestock census conducted in the country.[2] Goat rearing is an important occupation, mostly in developing countries like India, for the livelihood security of small and marginal farmers.[3]

Goats are kept under different rearing systems depending on the agroclimatic region, breed, and farming profile [2]. In urban and periurban areas, intensive system/confinement is the only option because of spatial limitations and the scarcity of feed; as a result, in these areas, goats are exclusively stall-fed (zero-grazed). A stall-fed system is adopted to improve feed intake, average daily gain, and feed efficiency and reduce the fattening period [3]. When animals are offered forage and concentrate in separate feed bunks, forage intake is low because the animals prefer concentrate [4]. The average proportion of dry fodder intake with high dry matter and fiber content by the animals was very low when offered on an ad libitum basis

1 FAO (2019). FAOSTAT Agricultural Data [online]. Website: www.faostat.org [accessed 21/08/2021].

2 DAHDF (2019). Annual Report 2019–2020. Department of Animal Husbandry, Dairying & Fisheries, Ministry of Agriculture, Government of India, New Delhi, India [online]. Website: https://dahd.nic.in/sites/default/files/Annual%20Report%202019-20.pdf [accessed 20/06/2021].

3 BAHFS (Basic Animal Husbandry and Fisheries Statistics) Report (2018). Ministry of Agriculture, Department of Animal Husbandry, Dairying and Fisheries, Krishi Bhawan, New Delhi, India [online]. Website: http://dadf.gov.in/sites/default/files/BAH%20%26%20 [accessed 12/08/2021].

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[5–7]. However, when feed was provided after blending it with concentrate in the form of total mixed ration (TMR) using the appropriate proportions, the intake of dry fodder increased [8–9]. A TMR is a homogenized mixture that promotes rumination and different feed components [9–10]. Moreover, results linked to a greater intake of roughage components, which reduces the sorting behavior of the animals, showed that a dietary plan based on hay-based TMR not only enhanced the feed intake and growth rate of the developing animals [11–12] but allowed for a balanced supply of forage to concentrate ratio according to standard practices [13–14].

However, during the last 50 years, with the intensification of animal production, the animals' way of life has become less and less natural [15]; therefore, it is necessary for the mechanisms of animal behavior under different feeding systems to be better explored to optimize animal welfare and production [16]. Whenever a new feeding system is introduced, studying the animals' behavioral response is crucial, in addition to measuring variable intake and growth [17–18]. The behavioral observations of ruminants, such as feed intake, ruminating time, drinking, grooming, agonistic activities, etc., may vary according to the feed type offered, reflecting the physical characteristics of the feed and feeding method. These observations are among the most common and sensitive animal welfare indicators [19]. Moreover, feeding a TMR to goats from a young age has immediate behavioral effects and may lead to longer-term benefits [9].

Recent findings on TMR feeding have been variable concerning the behavior of goats. Little is known about the effects of feeding hay-based TMR to growing-weaned kids. This study aimed to compare the effect of feeding 2 types of TMR, i.e. hay-based and green fodder, based on the behavior profile of local-weaned Beetal kids using the conventional feeding method.

2. Materials and methods

2.1. Location/place of work and climatic conditions

This experimental trial was carried out from November 2018 (the start of winter) to March 2019 (the beginning of spring) at the Goat Research Farm, Department of Livestock Production Management at Guru Angad Dev Veterinary and Animal Sciences University (GADVASU) in Ludhiana, India. The farm is located at a latitude of 30°54'N, longitude of 75°48'E, and 246 meters above sea level. The mean daily air temperature, relative humidity, sunshine, and rainfall outside during the study period were recorded as 15.59 ± 1.27 °C, 68.78 ± 1.72%, 5.77 ± 0.47 h, and 1.16 ± 0.61 mm, respectively. The kids experienced a low Temperature Humidity Index with a mean value of 59.61 ± 1.85, indicating that the environmental conditions were favorable during the entire study period. The research plan was approved by the Institutional Animal Ethics Committee of GADVASU before the start of the experiment.

2.2. Experimental design and management

A total of 24 weaned Beetal kids were randomly placed into 3 treatment groups of 8 animals, each based on mean body weight, sex, and age, after examining for abnormal health conditions (Figure 1). The selected Beetal kids were put in the adaptation trial under stall-fed conditions for approximately 15 days, during which their feeding and housing requirements were standardized. The animals in the 3 groups were further subgrouped for feeding purposes. Two animals of approximately the same mean body age, weight, and sex were placed in a single cage with a wire mesh size of 1 inch and a floor space of 2 m^2. Feeding all kids was done by taking dry matter required for an animal at 4% body weight, and the basal diet was formulated per standard recommendations [20] (Figure 1). The kids were fed a ration containing roughage and concentrate at a ratio of 60:40 on a DM basis. Furthermore, the feed requirement for each pair was calculated for animals in all groups.

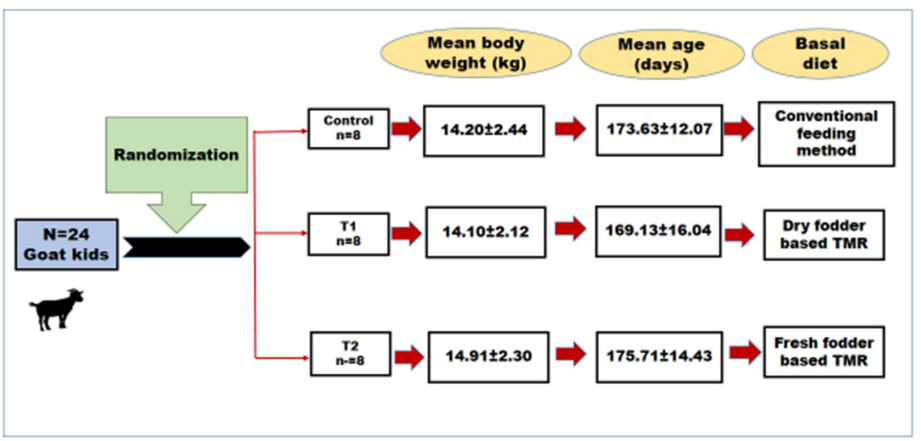

Figure 1. Experimental design and basal diet offered to the animals.
#Behavioral observations were recorded every two weeks.

The available fresh fodder, i.e. berseem (*Trifolium alexandrium*), was dried for haymaking to be later incorporated as dry fodder-based TMR. The concentrate mixture offered to all animals was prepared using conventional feed ingredients that included maize (45%), soybean meal (20%), wheat bran (14%), deoiled rice bran (18%), mineral mixture (2%), and salt (1%). The respective feedstuffs were blended and offered as TMR to all kids at 8:00, 14:00, and 17:00; that is, feeding was done 3 times a day, and the recording of residues was done late at 20:30. The animals were given clean potable water before each feeding and twice during their rest times in the afternoon.

All of the weaned Beetal kids, which were provided with unique identification tags, were housed in a well-ventilated shed made of a concrete floor with a grouped feeding arrangement; the animals were housed in stall-fed conditions in a way that did not enable one group to have access to the manger of the other. During the research period, the health status of the kids was regularly monitored.

2.3. Observations recorded

2.3.1. Behavioral observations

The feeding behavior of the experimental group kids, such as feed-intake time, rumination time, and agonistic activities, was manually recorded every two weeks [21] using a Nikon p530 (Nikon Pvt. Ltd., Japan) camera (Figure 2) for 1 h. The recordings were taken 30 min after offering the animals of each group experimental diets using the scan sampling method; this stage entailed recording the behavior of a group of individuals (scan sample) at sequential, predetermined points in time [22] for a 1-h period. The kids in the control group were first offered concentrate and fresh fodder later, i.e. recordings of the control group were taken while feeding fresh fodder. A standardized ethogram was prepared, as presented in Table 1, based on the behavioral activities observed (Figure 3). A fifteen-day adaptation period was provided to standardize the feeding practice; following this timespan, the animals' behavioral activities were recorded in 2 pens from each group, making a total of 6 pens and 12 animals at a 1-hour duration every two weeks. As previously mentioned, the scan sampling method was employed to estimate behavior during the trial in which, out of a total of 24 experimental animals, the behavioral observations of a group of individuals were only recorded; that is, the same 12 animals (4 kids in each group in which 2 were male and 2 female) were recorded each time. The differentiation between kids in different groups was made easier by tying different color bands around the animals' necks.

2.4. Statistical analysis

Data was initially processed using Microsoft Excel 2010 and further analyzed by two-way ANOVA for variance using the General Linear Model procedure of the SPSS 20.0 software package available at GADVASU's library. Significance between the groups was tested at levels of 1% ($p < 0.01$) and 5% ($p < 0.05$).

3. Results

3.1. Behavioral activities

Behavioral activities were recorded after offering the respective experimental diets, depicted in Table 2 and Figure 4. Time spent eating normally (E_N) and eating with forelegs on the feeders (E_{Ff}) were significantly higher in the control group than in the T_1 group ($p < 0.01$). However, variations in time spent doing activities like eating while putting forelegs on the cage (E_c) or pen did not differ between the control and T_1 groups. In the experiment, treatments did not significantly affect various agonistic activities like bunting and pushing. However, bunting time (performed and received) was numerically higher for Beetal kids fed with hay-based TMR, followed by green fodder-based TMR and the conventional feeding method. Behavioral observations such as changing position at the feeder, standing with forelegs on the cage, standing with forelegs on the feeders, self-grooming, eating from the ground, ruminating while sitting, walking, and defecation

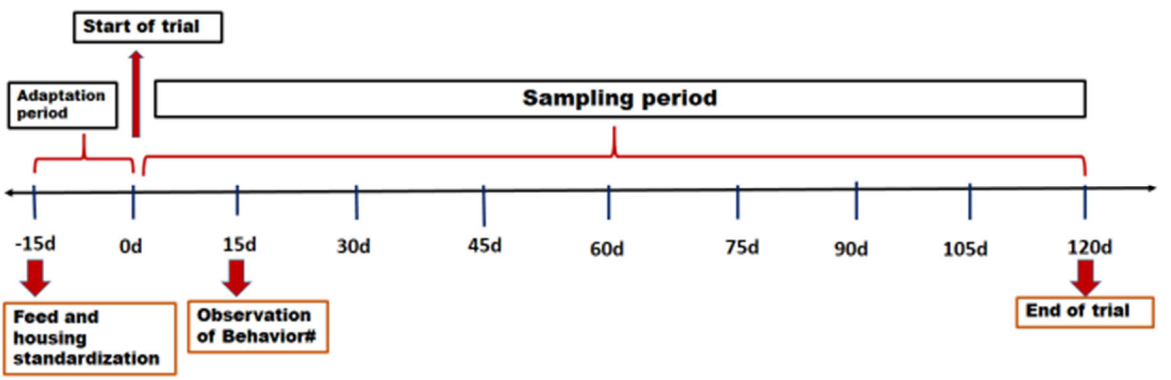

Figure 2. Sampling scheme in the experiment.

Table 1. Description of behaviors recorded after offering feed during the experiment.

Behavioral activities	Description/definition
Feeding activities	
Eating normally (E_N)	Eating with sufficient feeder space in a normal standing position without getting pressed/pushed.
Eating while putting forelegs on the cage or pen (E_c)	Animal touches with its mouth or ingests any edible material while standing with forelegs placed on the cage or pen.
Eating with forelegs on the feeders (E_{Ff})	Animal touches with its mouth or ingests any edible material from the feeder while standing with forelegs placed on feeder.
Changing eating position (C_E)	Animal moves around in a half circle to change its eating position.
Eating from the ground (E_G)	Animal touches with its mouth or ingests any edible material lying on the floor surface of the cage.
Agonistic activities	
Bunting performed (B_p)	Exerting force with the head on other/neighboring animal to move it aside.
Bunting received (B_R)	
Pushing performed (P_p)	Exerting force with a body part other than the head on other/ neighboring animal to move it aside.
Pushing received (P_R)	
Miscellaneous activities	
Standing idle (S_I)	Normal standing position and not displaying any other behavioral activities for more than 5 s.
Sitting (S)	Normal sitting and not displaying any other behavioral activities for more than 5 s.
Standing with forelegs on cage (S_c)	Standing with forelegs placed on the cage.
Standing with forelegs on feeders (S_{Ff})	Standing with forelegs placed on the feeder.
Self-grooming (G)	Licking/scratching its own body parts using the tongue or horns.
Grooming using inanimate objects in the pen (G_R)	Scratching/rubbing its own body parts using inanimate objects such as the cage or feeder in the pen.
Pawing the ground (P_G)	Pawing the ground with forelegs.
Ruminating while standing idle (R_{St})	Ruminating while normally standing.
Ruminating while sitting (R_S)	Ruminating while sitting on the ground.
Walking (W)	Walking normally in the pen and not displaying any other behavioral activities.
Defecation (D)	Voiding feces.
Urination (U)	Voiding urine.

Figure 3. Behavioral activities of kids observed during the trial. a) Animal eating with forelegs on the cage. b) Animal standing with forelegs on the cage. c) Animal eating with forelegs on the feeders. d) Animal standing with forelegs on the feeders. e) Animal self-grooming. f) Animal eating with forelegs on the feeders.

Table 2. Behavioral observations of grower kids recorded after being fed experimental diets.

Particulars	C	T_1	T_2	SEM	p-value
Eating normally (E_N)	1268.93^{a} (52.87)	1040.71^{b} (43.36)	1179.64^{ab} (49.15)	52.70	0.01
Eating while putting forelegs on the cage or pen (E_c)	72.86^{a} (3.04)	65.36^{ab} (2.72)	36.25^{b} (1.51)	7.83	0.00
Eating with forelegs on the feeders (E_{Ff})	68.75^{a} (2.86)	39.29^{b} (1.64)	42.86^{ab} (1.79)	7.16	0.01
Bunting performed (B_P)	28.75 (1.20)	36.79 (1.53)	31.07 (1.29)	7.04	0.71
Bunting received (B_R)	28.75 (1.20)	36.79 (1.53)	31.07 (1.29)	7.04	0.71
Pushing performed (P_P)	23.39 (0.97)	26.07 (1.09)	35.71 (1.49)	5.97	0.31
Pushing received (P_R)	23.39 (0.97)	26.07 (1.09)	35.71 (1.49)	5.97	0.31
Changing eating position (C_E)	71.61 (2.98)	61.07 (2.54)	76.25 (3.18)	5.44	0.14
Standing with forelegs on the cage (S_c)	82.32 (3.43)	72.86 (3.04)	85.71 (3.57)	8.14	0.51
Standing with forelegs on the feeders (S_{Ff})	64.64 (2.69)	81.79 (3.41)	71.79 (2.99)	6.66	0.19
Self-grooming (G)	61.79 (2.57)	81.43 (3.39)	69.46 (2.89)	5.87	0.06
Grooming using inanimate object in pen (G_R)	26.25^{b} (1.09)	52.14^{a} (2.17)	24.46^{b} (1.02)	4.74	0.00
Standing idle (S_I)	208.04^{a} (8.67)	155.89^{b} (6.50)	133.21^{b} (5.55)	13.96	0.00
Pawing the ground (P_G)	35.36^{b} (1.47)	48.04^{a} (2.00)	36.25^{b} (1.51)	4.01	0.05
Ruminating while standing idle (R_{St})	98.75^{b} (4.11)	245.00^{a} (10.21)	140.54^{b} (5.86)	23.11	0.00
Ruminating while sitting (R_S)	66.25 (2.76)	88.93 (3.71)	129.64 (5.40)	21.70	0.12
Eating from the ground (E_G)	54.64 (2.28)	76.61 (3.19)	55.54 (2.31)	7.35	0.06
Walking (W)	91.43 (3.81)	97.14 (4.05)	111.61 (4.65)	7.39	0.14
Sitting (S)	24.11^{c} (1.00)	68.04^{ab} (2.84)	73.21^{a} (3.05)	11.32	0.01
Defecation (D)	7.86 (0.33)	4.82 (0.20)	4.29 (0.18)	1.75	0.30
Urination (U)	15.54^{a} (0.65)	4.46^{b} (0.19)	8.57^{ab} (0.36)	2.10	0.00

SEM: Standard Error of Means; Means bearing different superscripts in a row differ significantly.
Particulars for the 3 groups are presented as time in seconds; Values written in parentheses indicate proportion of time spent by the animals performing each activity.

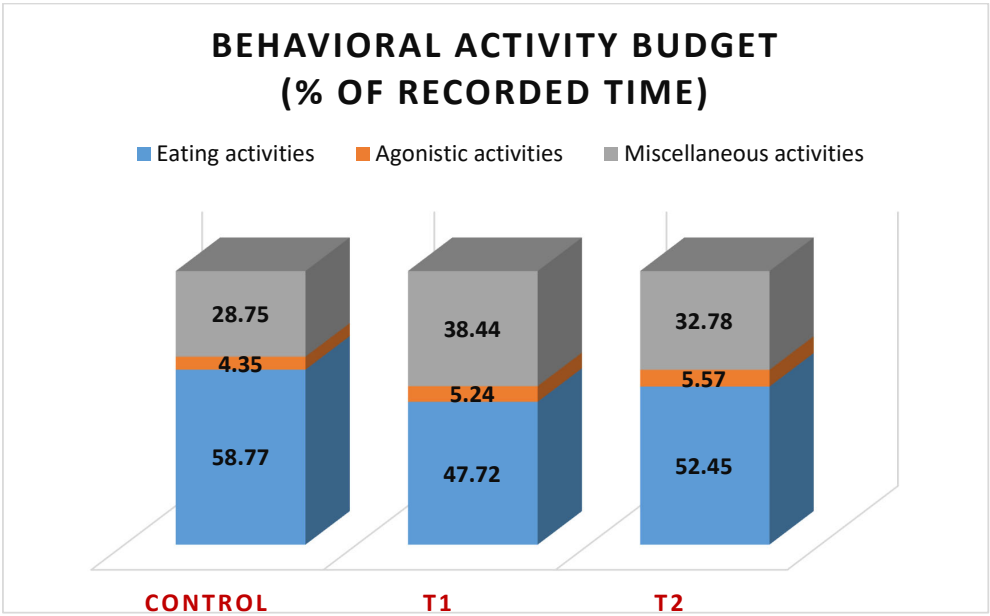

Figure 4. Relative proportion (%) of various activities exhibited by animals fed with respective experimental diets.

also did not differ significantly between groups. Although self-grooming was not significantly different for kids in the control, T_1, and T_2 groups, grooming using other inanimate objects in the pen was significantly higher for the hay-based TMR group, followed by the T_2 and control groups. Likewise, pawing the ground was significantly ($p < 0.05$) higher for animals in T_1 compared to the control and T_2 groups. Animals fed the hay-based TMR also spent significantly ($p < 0.01$) more time ruminating while standing compared to the control and T_2 groups. For normal sitting activity, the variations were statistically ($p < 0.01$) higher in the T_1 and T_2 groups than in the control group. However, between both TMR groups (T_1 and T_2), variations in sitting activity were statistically insignificant. The differences in standing idle and urination were significantly ($p < 0.01$) higher for the conventionally fed group than the T_1 and T_2 groups.

4. Discussion

4.1. Behavioral observations of the Beetal kids

Feeding behavior comprises three steps: foraging, feed selection, and intake and its related activity, rumination [23]. In intensive systems, foraging and feed selection are limited to domestic ruminants, but numerous factors other than hunger and satiety can still influence feeding behavior [24]. In this experiment, stall-fed goats provided with two different types of TMR (hay-based and green fodder-based) or forage and concentrate separately showed variations in feeding behavior in their respective groups. The results indicate that time spent eating with different postures (E_N, E_C, and E_{Ff}) by the Beetal kids fed with the conventional method was higher than in the other groups ($p < 0.01$). This finding demonstrates that the T_1 group animals ate faster than the control and T_2 group specimens, further reflecting the higher palatability of hay-based TMR as these animals spent less time engaging in eating activities. This variation in time spent eating with different postures for hay and green-fodder-based TMR can also be accounted for because most feeding occurs soon after fresh food delivery, likely reflecting the higher nutritional value of fresh TMR. Moreover, the shorter eating time or faster-eating rate for the kids fed hay-based TMR can be attributed to the reduced particle size, resulting in a faster gastrointestinal passage of feed. Higher feeding time was also reported in Kacang goats when the animals were offered a bulky diet instead of TMR [25]. This is also justified by the findings in several previous studies [26–28]. In a study involving steers, the authors [29] reported a shorter eating time in animals offered TMR, a trend similarly observed in dairy cows according to [26–28]. Moreover, eating with the forelegs on the cage and forelegs on the feeders for an extended time in the control group reflected their browsing instinct while standing on their rear legs when green fodder was available. However, Pérez-Ruchel et al. showed that lambs spent more time eating and ruminating and less time resting as the TMR level in the diet decreased, demonstrating a higher rate of intake [30]. The high fiber intake of forage by lambs could be why the animals spent more time eating and ruminating. Similarly, Miller-Cushon et al. observed an increased

feeding time when young calves were provided with hay and concentrate as a mixed ration, compared with separate feeding of hay and concentrate [31]. Such results were observed because young calves were chosen for the study, and hay was fed to the control group specimens instead of green fodder.

Goats are social animals that readily form dominance hierarchies, especially at the feed bunk [13]. Competition within a group of animals under intensive conditions is predominantly observed in the feeding area [32], where a large amount of aggression among the goats has been recorded [33]. Agonistic activity, such as bunting, which involves using the head to keep neighboring kids away, was greater for the hay-based TMR-fed group than other groups. However, pushing other kids with body parts besides the head was the other observed agonistic activity; this activity was higher for kids fed green fodder-based TMR, followed by hay-based TMR. Despite variations in animal performance, these activities did not differ significantly among treatments. These agonistic activities demonstrate the competition and preference for hay-based TMR in the manger.

Self-grooming was higher in the hay-based TMR group, although this did not differ significantly. Grooming activities with an inanimate object, such as a cage or wall, were mainly self-oriented. Variations in time spent grooming with an inanimate object like a cage or wall showed that the animals in the T_1 group were engaged more in grooming using other inanimate objects than the control and T_2 groups ($p < 0.01$). An increase in self-grooming indicates greater psychological and social stability [34], which may be a substitute for feeding behavior, as the feeding rate was higher in the T_1 group.

Similarly, the animals pawed the ground to show social hierarchy, and this activity was significantly higher in Beetal kids fed with hay-based TMR ($p < 0.05$). In a stall-fed production system, the limiting factor was feed, so during the feeding, pawing the ground showed dominance over the counterpart animal, which shows their preference for this type of feed.

Animals fed the hay-based TMR were also more engaged in ruminating while standing than the control and T_2 groups ($p < 0.01$). This could be because of the high dry matter of feed given to animals in the T_1 group. The animals in the T_2 group spent more time ruminating while sitting, followed by the T_1 and the control group, respectively. However, these variations in ruminating while sitting did not differ significantly. Concerning time spent ruminating, the results show that this activity was linked to a greater hay or dry-fodder intake by kids fed TMR. In contrast, the shorter time spent ruminating in kids fed forage and concentrate separately suggests that a longer time spent eating and standing idle were ways to redirect behavior to other stimuli. This can also be explained by the fact that animals that spend more time ruminating produce more saliva, which buffers rumen pH and helps the TMR-fed kids protect themselves from ruminal acidosis. These findings are consistent with results from previous studies in which the authors found overall time spent ruminating to be longer in TMR-fed groups than in groups fed dietary components separately [4, 29). Lee et al. reported that time spent ruminating while standing was longer than time spent sitting in growing steers fed TMR [29]. In contrast, da Silva Dias et al. indicated that cows fed organic acid-supplemented TMR spent less time idling and tended to exhibit a lower rumination time [35]. Grille et al. observed that cows experiencing a diet change from a system combining TMR and pasture feeding to a confinement system (TMR) showed a decrease in rumination and lying frequency from before to after the change, which could be due to a lack of access to pasture and the resulting emotional response.

Beetal kids in the T_2 group showed more sitting activity, followed by T_1, than the control group. Animals in the T_2 group ate intermediate bulk feed compared to control and T_1 group animals, and this could be a possible reason for their spending more time sitting. Moreover, ruminating and sitting are associated behaviors occurring when animals rest [37]. In this experiment, ruminating while sitting and other sitting activities were higher for the TMR-based groups than the control group, suggesting their synergistic link or correlation.

Animals in the control group showed higher standing idle activity over the T_1 and T_2 groups ($p < 0.01$). Beetal kids in the control group were fed green fodder separately that was higher in bulk density; between the eating periods of this feed, the animals spent some time standing idle. Moreover, the longer time spent ruminating in kids fed TMR can explain the shorter time they spent standing idle because standing idle was recorded when no other activity was being performed. Contrary findings were reported by Iraira et al. [4]. In that study, resting time with no behavioral activities was higher for heifers fed TMR.

A greater frequency of defecation and urination in the animals fed wet TMR was observed compared to separate feeding methods. Variations in urination were observed to be higher in the control group than in the two TMR-based groups ($p < 0.01$). This result could be because of the high moisture content of the fresh fodder given to the animals in the control group compared to the hay-based TMR group, which was offered a feed containing very low moisture content and high dry matter. However, Lee et al. found contradictory results [29].

5. Conclusion

From the findings in this study, it was concluded that grower Beetal kids fed forage and concentrate separately showed more time spent eating, standing idle, and

urinating. The animals given hay-based TMR exhibited increased behavioral activities, such as grooming using inanimate objects in the pen, pawing the ground, time spent ruminating while standing, and less time eating, indicating more of a preference for hay-based TMR.

Declaration of competing interest
The authors report no declarations of interest.

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