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Intake behaviour of black Bengal kids reared under cafeteria feeding system vis-a-vis total mixed ration

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Abstract
The effect of different feeding systems (cafeteria and total mixed ration/TMR feeding) on the voluntary intake and intake behavior of Black Bengal kids was evaluated in this study. Twelve Black Bengal growing kids were housed indoors and were allocated to two age groups (six kids each): 3-6 months (AGE 1) and 9-12 months (AGE 2) and were fed on four treatments/diets such as T_1(Free choice Paddy straw, Berseem, Oats, Jackfruit leaves, Guinea grass), T_2 (Free choice Paddy straw, Berseem, Oats, Jackfruit leaves, Guinea grass and Concentrate mixture (@ 1.25% of BW)), T_3 (Five fodders offered in T_1 mixed together as TMR) and T_4 (Five fodders and concentrate mixture offered in T_2 were mixed together as TMR). Feeds were offered for two hours during the morning (9 am to 11 am) and during the evening (5 pm to 7 pm). The study lasted 41 days and was conducted in 3 cycles/batches when a representative sample of feeds and residue was collected every day throughout the experimental period. Observations of each animal under each treatment/diet were recorded using CCTV cameras for further analysis of recorded data. The total number of bouts per day taken by kids and total time spent (in minutes) per day was significantly ($p<0.01$) higher in T_4 (TMR with concentrate mixture) than in other treatments. There was a significant ($p<0.01$) increase in total number of bouts per day in AGE 2 (older kids). Kids under T_4 ($p<0.001$) and in AGE 2 ($p<0.01$) had significantly higher voluntary intake in terms of total DMI (g/day/kid). Average DMI/bout, OMI/bout, and CPI/bout of kids of different age groups were significantly ($p<0.01$) higher in T_4. However, NDFI/bout of kids was significantly ($p<0.01$) higher in T_1 and T_4. The average DMI rate, OMI rate, and NDFI rate (g/minute) of kids of different age groups were significantly ($p<0.01$) higher in T_1. However, the average CPI rate (g/minute) of kids under different age groups was significantly highest in T_2. The majority of the macro and micro mineral intake/bout and intake rate (per minute) was higher from concentrate-incorporated diets T_4 and T_2.

Keywords: Bouts, cafeteria, diets, preferential feeding, TMR

Introduction
The rapidly rising goat and sheep population has led to overcrowding in grazing grounds to meet the demand for meat, which has led to a sharp reduction in the quality of grazing resources. In locations where pasture resources are diminishing, goat rearing under an intensive and semi-intensive system may therefore gain popularity in the upcoming years as a potential substitute system for small ruminant rearing on a commercial scale. Traditional methods of enhancing animal welfare have focused on minimizing unpleasant experiences (by, for instance, terminating harsh husbandry practices) and promoting health (by, for example, managing bedding and lowering disease) (Zobel *et al.*, 2019) [27]. The contemporary emphasis on providing animals with "a worthwhile existence" increases hopes for improved care, opportunities for enjoyable experiences, and the manifestation of natural traits by domestic goats in cramped commercial housing. In commercial production systems, goats may lose out on their natural activity due to the absence of cognitive conflicts. This could have a negative impact on their well-being. Therefore, providing cognitive stimulation should be considered as a means to enhance welfare in indoor commercial settings. One way to achieve this is through the free-choice feeding approach, which is popular because it is believed that animals have an inherent ability to regulate their nutrient intake. This allows them to choose a balanced diet that can improve nutrient uptake and animal performance. Despite being frequently housed indoors with access to a mixed-feed diet, the feeding behavior of dairy goats raised in commercial settings has not been studied extensively

(Giger-Reverdin *et al.*, 2020) [8].

Choice/cafe feeding is a type of experiment in which, two or more meals are presented separately at the same time, and the amounts consumed and the animals' preferences for the feeds are recorded (Degen *et al.,* 2010) [6]. In choice feeding experiments, many feed and animal-related aspects that affect an animal's decision to choose its food in a controlled environment are typically investigated. The cafeteria design was a useful tool that can be used for research, under controlled circumstances, to study those elements impacting plant selection/preference and intake (Sitou *et al*., 2023; Torres-Fajardo *et al*., 2018; Meier *et al*., 2012) [23, 25, 12]. This will make it easier for us to comprehend how ruminants eat. The management strategies can be changed to meet the dietary requirements of the particular animal by better understanding the animal's feeding behavior. Cafeteria feeding trials enhance the welfare and health of commercially raised livestock by more effectively coordinating individual needs and lowering stress brought on by unbalanced feeds. Preference and palatability are the two main factors that matter in this type of trial (Alonso-Díaz *et al*., 2009) [1]. Some earlier studies on cafeteria/choice/preference feeding have been conducted in cattle (Gorgulu *et al*., 2012; Bharanidharan *et al*., 2021) [10, 5], sheep (Sitou *et al*., 2023; Berthel *et al*., 2022; Sahin *et al*., 2003) [23, 4, 21] and goat (Priya *et al*., 2020; Serbester *et al*., 2018) [19, 22].

The current study raises the question of whether mixed rations provide an acceptable diet from a welfare standpoint and since goats' preferences for feed appear to be influenced by factors other than its nutritional contents, mixing itself appears to reduce the feed's palatability (Berthel *et al.*, 2022) [4]. With this in consideration, this work aimed to assess the feed preference and intake behavior of Black Bengal kids reared under an intensive cafeteria feeding system. The objective was to identify potential changes in intake behavior as well as voluntary intake of Black Bengal kids for cafeteria and TMR-based diets/treatments. The outcomes here will be very important for a long-term trial and for experimenting with a larger number of animals, wherein growth and production parameters of the Black Bengal kids can also be thoroughly analyzed and recorded.

2. Materials and Methods

2.1 Experimental design

The animal experiment was conducted in the animal farm (Experimental Goat shed) at ERS of NDRI, Kalyani. The animal farm is situated at an altitude of 9.75 meters (31.9 feet) above mean sea level, 22º58'30" N latitude, and 88º26'04" E longitude. The average annual rainfall of this region is 1500 mm, most received during early June to mid-September. The average condition of this region is hot and humid. The present experiment was conducted in the months of January and February when the maximum ambient temperature went up to 80.5ºF and the minimum temperature came down to about 59ºF.

Twelve growing Black Bengal goat kids from two different age groups (six each), 3-6 months (AGE 1) and 9-12 months (AGE 2) were selected from the flock of ERS of NDRI, Kalyani for conducting the experiment. Animals were sheltered in tin houses with concrete floors. All the experimental animals were vaccinated against prevailing diseases like PPR, Goat pox, and Enterotoxaemia, and were also dewormed with Ivermectin and Albendazole before starting the experiment. The experiment was conducted in 3 cycles/batches which extended for a period of 41 days. Each cycle comprised 13 days, of which the first 5 days were given as an adaptation period for the animals to get acclimatized/adapted to the new environment and feeds. Each batch comprising four goats (two each from AGE1 and AGE2) was fed individually with 4 treatments/diets such as T_1(Free choice Paddy straw, Berseem, Oats, Jackfruit leaves, Guinea grass), T_2 (Free choice Paddy straw, Berseem, Oats, Jackfruit leaves, Guinea grass and Concentrate mixture (@ 1.25% of BW), T_3 (Five fodders offered in T_1 mixed as total mixed ration/TMR) and T_4 (Five fodders and concentrate mixture offered in T_2 were mixed together as TMR). Feeds were offered for two hours during the morning (9 am to 11 am) and the evening (5 pm to 7 pm). Observations of each animal under each treatment/diet were recorded using CCTV cameras for further analysis of recorded data.

2.3 Observations recorded during Animal Trials

Dry matter intake (DMI) was recorded daily by subtracting the DM of the residue from the DM of the total feed offered, both in the morning and evening. The number of visits to each feed, time spent near each feed, and number of bouts taken from each feed were noted from the videos recorded using CCTV cameras, in the case of Treatments 1 and 2 (both in the morning and evening). Whereas, the total time spent for feeding and total number of bouts were noted in the case of Treatments 3 and 4 (both in the morning and evening).

2.4 Chemical analysis

A representative sample of feeds and residue was collected every day throughout the experimental period and was analyzed as per AOAC (2012) [2] in triplicates in the laboratory of the Animal Nutrition Section for proximate principles viz. Dry Matter (DM), Crude Protein (CP), Ether Extract (EE), Total Ash (TA), and cell wall constituents by Van Soest analysis (Van Soest *et. al*., 1991) [26] i.e., NDF, ADF, and ADL. While Total carbohydrates (TCHO) Hemicelluloses, Cellulose, and Organic Matter were determined by difference.

Minerals such as Ca, Mg, Cu, Zn, Mn, Fe, and Co in feed and fodder samples were analyzed using atomic absorption spectrophotometer (Agilent 240 AA model). For this, 0.5-1 g of feed sample was digested using a triacid mixture of HNO_3:$HClO_4$:H_2SO_4 in the ratio of 3:2:1) in Gerhardt till they became clear, properly digested samples were diluted with distilled water and passed through Whatman filter paper No.1 and the final volume was made to 100 ml by adding double distilled water. 100 ppm stock solution was prepared by diluting 1000 ppm Agilent Technologies standard solution with 1% HNO_3 solution. Different concentrations of working standards in the working range were prepared by diluting the stock solution with 1% HNO_3. The calibration curve for the determination of minerals was prepared using a blank and working standard solution of that mineral. The calibration was periodically verified by analyzing a standard at a frequency of 20 readings. If the recovery was outside the limits, the analysis was stopped, and the system was recalibrated.

Phosphorus was analyzed by volumetric method, where the phosphorus in the sample was converted to phosphor ammonium molybdate by the addition of ammonium molybdate. The precipitate was then dissolved in excess of standard alkali. The quantity of alkali required to dissolve the precipitate was indirectly found by back titration with standard HCL.

2.5 Statistical analysis
The data obtained from the above experiment was statistically analyzed using IBM SPSS 22.0 computer package. The Generalized linear model, ANOVA procedure (Snedecor and Cochran, 1994) [24] was used to compare groups. To compare groups and period effects, a univariate model of the Generalized linear model was used. Data obtained at one point in time were analyzed and compared using one-way ANOVA under compare means of the same SPSS data pack. Duncan's new multiple ranges and F test (Duncan, 1995) [7] with the least significant difference were used for post-hoc comparison. A least square Analysis of variance was used to test the significance of various treatments and the difference between treatment means.

3. Results
3.1 Chemical composition of feeds and fodders offered during animal trials
The chemical composition of the various feeds and fodders offered to the Black Bengal kids during animal trials were analyzed for proximate and fiber fractions and Table 1. depicts the compositional values of the offered feed ingredients.

The Berseem fodder supplied in T_1 and T_2 had the highest average chemical compositional values (% DM basis) in terms of CP (19.73 and 19.83 respectively) while Paddy straw had the lowest (4.57 and 4.59, respectively), contrasted with the concentrate mixture's 20.43% CP level. In T_1 and T_2, Guinea grass had the highest NDF concentration (79.84 and 79.87, respectively), while Berseem had the lowest (45.19 and 45.52, respectively). Jackfruit leaves had the highest EE content (3.32 and 3.33 in T_1 and T_2, respectively), whereas paddy straw had the lowest (1.33 and 1.32 in T_1 and T_2, respectively). On% DM basis, the TMR diet T_3 had CP, EE, TCHO, TA, NDF, ADF, Hemicellulose, Cellulose, and ADL content of 13.01, 2.46, 73.11, 11.42, 58.65, 45.19, 13.46, 40.18, and 5.01, respectively, and T_4 had 15.98, 2.39, 70.89, 11.05, 53.49, 36.04, 17.45, 30. It was noted that T_4 had more crude protein than T_3, whereas, the NDF, ADF, ADL, and EE content in T_3 were higher than that of T_4.

3.2 Macro and micro mineral composition of feeds and fodders offered during animal trials
Table 2. displays the mineral composition of the various diets and fodders presented to the Black Bengal young during animal trials. Berseem exhibited the greatest calcium (1.93% and 1.88%, respectively) and iron (544 ppm and 544.50 ppm, respectively) contents among the T_1 and T_2 fodders. The highest concentrations of zinc (68.84 and 69 ppm in T_1 and T_2, respectively) and phosphorus (0.31 and 0.35% in T_1 and T_2, respectively) were found in jackfruit leaves. The concentrate mixture offered had a Ca (%) and P (%) content of 1.24 and 1.38, respectively.

Whereas the Ca (%), P (%), and Mg (%) content in T_3 were 0.81, 0.21, and 0.24, respectively, and those in T_4 were 0.91, 0.41, and 0.36, respectively. According to estimates, T_3 contained 11.04 ppm of Cu, 38.37 ppm of Zn, 103.17 ppm of Mn, and 326.42 ppm of Fe, while T_4 contained 13.56 ppm of Cu, 45.97 ppm of Zn, 112.08 ppm of Mn, and 310.89 ppm of Fe.

3.3 Intake behaviour of kids of different age groups at different diets
The kids were exposed to the feed materials for 4 hours a day: 2 hours in the forenoon and 2 hours in the afternoon. The total number of bouts per day taken and total time spent (in minutes) at different dietary treatments are presented in Table 3.

3.3.1 Total number of bouts per day
The total number of bouts per day of T_1, T_2, T_3, and T_4 were 305.41, 400.04, 391.25, and 442.16, respectively. The trait was significantly ($p<0.01$) higher in T_4, T_3 and T_2, than T_1. But for the total number of bouts each day, the effects of the former three treatments were statistically comparable. The average daily total number of bouts was significantly higher for AGE 2 (429.85) than for AGE 1 (339.58) ($p<0.01$). The interaction effect (T×A), however, was not shown to be significant ($p>0.05$).

3.3.2 Total time spent (in minutes) per day
Black Bengal kids spent a total of 147.18, 188.49, 210.79, and 218.29 minutes every day, each at T_1, T_2, T_3, and T_4, respectively. T_4 had the highest daily average total time spent (measured in minutes), followed by T_3, T_2, and T_1. A slightly greater period was spent on average (in minutes) every day by AGE 2 (194.03) than by AGE 1 (188.34). However, it was discovered that the age effect and the interaction effect (T x A) were statistically insignificant ($p>0.05$).

3.4 Total DMI of kids of different age groups through different diets
The TDMI (g/day/kid) from different dietary treatments is presented in Table 4.

TDMIs (g/day/kid) from T_1, T_2, T_3, and T_4 were 147.01, 184.09, 290.55, and 410.56, respectively. Following T_4, which had a substantially higher TDMI (g/day/kid) than the other three treatment groups ($p<0.001$), was T_3, which had a significantly higher TDMI (g/day/kid) than the T_2 and T_1 groups. But, TDMI (g/day/kid) in T_2 and T_1 was comparable ($p>0.05$). The average TDMI was significantly ($p<0.01$) higher in AGE 2 (220.25) than in AGE 1 (295.85). Treatment and age interaction effect, however, was determined to be insignificant (P=0.751).

3.5 Average intake/bout (g/bout)
The average intake/bout (g/bout) of different dietary treatments is presented in Table 5.

T_1, T_2, T_3, and T_4 had average DMI (g) /bouts of 0.743, 0.591, 0.744, and 0.922, respectively. T_4 had a considerably ($p<0.001$) higher intake/bout than T_3, T_1, and T_2, whereas T_2 had the lowest. There was no statistically significant difference between T_3 and T_1 ($p>0.05$). In terms of DMI (g) /bout, there was no statistically significant difference ($p>0.05$) between AGE 1 (0.734) and AGE 2 (0.766).

T_4 (0.820) had a considerably ($p<0.01$) greater average OMI/bout (g/bout) than T_1 (0.715), T_3 (0.659), and T_2 (0.581). However, in terms of OMI/bout (g/bout), T_4 and T_1 as well as T_1-T_2-T_3 were statistically comparable ($p>0.05$). There was no statistically significant difference ($p>0.05$) between AGE 1 (0.679) and AGE 2 (0.708).

The average CPI/bout (g/bout) was significantly (p<0.01) higher in T_4 (0.147), followed by T_3 (0.0.97), T_2 (0.92), and T_1 (0.72). However, T_2 and T_3 were statistically similar (p>0.05) in terms of CPI/bout (g/bout). Additionally, it was determined that there was no significant difference (p>0.05) between AGE 1 (0.102) and AGE 2 (0.102) in this aspect.

T_1 (0.524) and T_4 (0.493) had considerably greater average NDFI/bout (g/bout) than T_2 (0.346), although T_3 (0.436) did not differ significantly from the other three groups. In terms of NDFI (g) /bout, there was no statistically significant difference (p>0.05) between AGE 1 (0.430) and AGE 2 (0.469).

3.6 Average intake rate (g/min)

The average intake rate (g/min) of different dietary treatments is presented in Table 6.

Black Bengal kids had average DMI rates of 3.866, 2.442, 1.360, and 1.843 g/min from T_1, T_2, T_3, and T_4 respectively. Compared to the statistically similar groups T_2, T_4, and T_3, it was considerably (p<0.01) greater in T_1 and there was no discernible change (p>0.05) between AGE 1 (2.268) and AGE 2 (2.487). It was also determined that the interaction effect (T×A) was not significant (0.755).

T_1, T_2, T_3, and T_4 had average OMI rates of 3.973, 2.618, 1.204, and 1.639 g/min, respectively. It was statistically similar in T_4 and T_3, however, it was considerably (p<0.01) higher in T_1. But T_2 did not differ significantly from the other three groups. OMI rate (g/min) between AGE 1 (2.235) and AGE 2 (2.482) did not differ significantly (p>0.05).

The average CPI rate (g/min) of T_1, T_2, T_3, and T_4 were 0.293, 0.347, 0.178, and 0.294, respectively. In comparison to T_3, it was considerably (p<0.01) greater in T_2, T_4, and T_1. However, the effects of the first three treatments on CPI rate (g/min) were comparable and there was no apparent distinction (p>0.05) between AGE 1 (0.283) and AGE 2 (0.273).

T_1, T_2, T_3, and T_4 had average NDFI rates of 3.016, 1.901, 0.798, and 0.986 g/min, respectively. Compared to T_3 and T_4, it was considerably (p<0.01) greater in T_1. T_2, however, did not differ significantly from the other three groups. In terms of NDFI rate (g/min), there was no significant variation between AGE 1 (1.506) and AGE 2 (1.844) (p>0.05).

3.7 Average mineral intake per bout (mg/bout) by kids of different age groups through different diets

The average mineral intake per bout of Black Bengal kids of different age groups from different treatment diets is depicted in Tables 7 and 8.

The amount of calcium consumed per bout (mg/bout) was considerably (p<0.001) greater from T_4 (8.460) and least from T_1 (4.951). Black Bengal kids had significantly (p<0.001) larger intakes per bout of phosphorus and magnesium from T_2 (3.967 and 3.560, respectively), compared to other treatments, and the least amount from T_3 (1.621 and 1.809, respectively).

Copper intake per bout (mg/bout) was considerably greater from T_2 (0.016) and lowest from T_3 (0.009) (p<0.01). Black Bengal kids' intake (mg/bout) of zinc and manganese was significantly (p<0.01) higher from T_4 (0.043) and T_1 (0.115) (p<0.05), respectively, although it was the least from T_3 (0.029 and 0.077, respectively). While it was least from T_2 (0.179), the intake/bout (mg/bout) of iron was significantly (p<0.001) higher from T_4 (0.287).

The average macro and micro mineral intake/bout (mg/bout) of Black Bengal kids from various diets were similar for AGE 2 and 1.

3.8 Average mineral intake rate (mg/minute) by kids of different age groups through different diets

The average mineral intake rate (mg/min) of Black Bengal kids of different age groups from different treatment diets are represented in Tables 9 and 10.

Similar to the calcium intake per bout, the amount of calcium consumed per minute (mg/min) was considerably (p<0.001) greater from T_4 (16.91) and least from T_1 (9.391). The highest values of the phosphorus and magnesium intake rate (mg/min) by the Black Bengal kids were pronouncedly (p<0.001) recorded in T_4, with 7.591 and 6.786, while the lowest values were found in T_1, with 2.574 and 2.583, respectively.

While the micromineral (Cu, Zn, Mn, Fe) intake rates (mg/min) were markedly greater (p<0.001) from T_4 (0.026, 0.086, 0.207, and 0.574, respectively), and the least values were from T_1 (0.013, 0.045, 0.079, and 0.345, respectively).

The AGE 2 group of Black Bengal kids had a significantly (p<0.001) higher macro and micro mineral intake rate compared to those in the AGE 1 group.

4. Discussion

One of the key elements influencing dietary preference is the chemical makeup of forages (Monllor *et al*., 2020) [14]. For this reason, the chemical composition and nutritive value of the various diets offered were thoroughly analyzed in this study. The higher CP level of Berseem was a result of its leguminous nature, whereas Guinea, a perennial grass, had a higher content of fiber components. When compared to other roughage analogs, the Jackfruit leaf's higher ether extract content is what accounts for the enormous amounts of phytochemicals. As opposed to the concentrate-contained T_4 diet, T_3 had more fiber content because it was a roughage-based diet.

The choice of goat may be influenced by the prehensibility of the meals (Morand-Fehr *et al*., 1991) [17]. The total number of bouts from TMR-based diets was found to be larger than those from Cafeteria diets, suggesting the mixed ration's higher prehensibility and also the lower provision for selection in the case of TMR-based diets. The uniformly chopped and highly blended physical nature of the mixed ration might have had an effect on increased consumption. The kids had a choice in the cafeteria setting, which also might have led to preferential feeding of just a few feed components.

Small ruminants have physiological controls over chewing time, the frequency of eating and ruminating sessions, and the duration of eating bouts (Moyo *et al*., 2019) [18]. According to Baumont *et al*. (2000) [3], sensory aspects of feeds including moisture, smell, taste, and the physical characteristics of the feed (such as particle size, resilience to fracture, and pelleting) also influenced feed preference. The total time spent (in minutes) each day was discovered to be higher from a TMR-based diet than from a cafeteria diet, just like the total number of bouts. The kids preferred to devote more time at a single feed trough offering meal diversity (TMR diet) rather than acquiring satiety by shifting from feed to feed, as in the case of cafeteria settings. In this way, kids wasted less energy by not moving around between different feeds and thus enhanced the voluntary intake. As a result of these behavioral parameters, the kid's intake habits at various diets suggested that they preferred a particular diet/feeding method.

The findings from the study demonstrated that TDMI (g/day/kid) was nearly or more than twice as high in T_3 and T_4 as compared to T_1 and T_2. This meant that, regardless of age, offering identical feed ingredients in the form of TMR to the Black Bengal kids, significantly increased their intake of DM compared to the cafeteria system. Research (Monzon-Gil *et al.*, 2010) [15] has shown that dairy goats fed total mixed ration (TMR) have a higher dry matter intake (DMI) due to the combination of concentrate and roughage. This leads to better utilization of the components of their diet in the rumen. A mixed feed likely encouraged the growth of cellulolytic bacteria, better rumen conditions, and a shorter time for rumen pH<6.0 (Monzon-Gil *et al.*, 2010) [15]. The present outcomes were in line with those of the study by Monzon-Gil *et al.* (2010) [15], which demonstrated that TMR feeding increased goats' feed intake and milk production in comparison to single-component feeding. Priya *et al.* (2020) [19] concluded that TMR feeding of Beetal kids had a positive effect on feed intake and boosted weight gain and feed efficiency in the TMR-fed group in contrast to the usual feeding approach, where feeds were supplied individually. Separate feeding of concentrate and roughage reduced the intake of dry matter ($p<0.01$), but milk production, body weight, total solids, fat, protein, and casein contents were unaffected by feeding methods ($p>0.05$) (Serbester *et al.*, 2018) [22] and seemed to lower the concentration of urea N (P= 0.053). According to the findings by Berthel *et al.* (2022) [4], non-lactating dairy sheep and goats preferred single components over a mixed ration of identical components with comparable nutritional value., which is the opposite of what we had observed. As opposed to the TMR diet, choice feeding increased the milk supply, dry matter intake, and production performance of Damascus goats in early lactation (Gorgulu *et al.*, 2003) [9].

The component or active ingredient present in a mixed concentrate diet, which in turn affects the feed palatability, may also affect the preference of goats (Morand-Fehr *et al.*, 2003) [16]. In addition, dairy goats of different genotypes may react to feeding regimens differently (Mellado *et al.*, 2004) [13].

The average intake of T_4 (TMR diet supplemented with concentrate) was found to be highest for DM, OM, and CP (g/bout). Due to its high fiber content, T_1 (cafeteria diet without concentrate), which consisted primarily of roughage-based feed ingredients, had the greatest NDFI (g/bout). The difference in NDFI (g/bout) between T_4 and T_1 was, however, statistically insignificant ($p>0.05$). In an experiment conducted by Rao *et al.* (2002) [20] to determine the feed preferences of adult Barbari goats kept in stalls and fed a variety of feed ingredients, including concentrate pellets, Lobia hay, Neem leaves, Berseem fodder, and Arhar straw, it was found that the goats' preferences varied depending on the nutritional composition in terms of DMI and short meals per minute. Additionally, it was acknowledged that the forage's physical characteristics, such as particle size and resistance to fracture, would affect the ease of prehension and, as a result, intake rate (Inoué, 1994).

The cafeteria-based diet T_1, where the kids spent a lot of time selecting from the variety of meals given, had the greatest average DMI rate (g/min) and OMI rate (g/min), according to the current study. T_1 had a high average NDFI rate (g/min) due to the fact that it was solely a roughage-based cafeteria diet. However, T_2, followed by T_4, both of which contained concentrate as a source of protein, had the highest average CPI rate (g/min).

The macro and micro mineral intake/bout and intake rate (per minute) was higher from concentrate-incorporated diets T_4 and T_2, regardless of the feeding systems followed, except for Manganese intake/bout, which was highest from completely roughage-based diet T_1. This can be attributed to the high Manganese-containing roughages (Guinea grass and Paddy straw) included in the formulation of T_1.

Table 1: Chemical composition of different feeds and fodders offered during animal trials (%DM Basis)

Treatments	Feeds	DM%	OM	CP	EE	TCHO	TA	NDF	ADF	HC	Cellulose	ADL
T_1	Oats	13.85	89.05	10.29	2.61	76.14	10.95	54.27	33.78	20.48	29.88	3.90
	Berseem	12.06	84.38	19.73	2.74	61.91	15.62	45.19	31.54	13.65	27.38	4.16
	Guinea Grass	32.30	89.19	9.14	1.92	78.13	10.81	79.84	49.47	30.37	42.71	6.76
	Jackfruit leaves	41.09	87.63	13.92	3.32	70.39	12.37	40.71	29.57	11.14	21.33	8.24
	Paddy Straw	88.65	89.42	4.57	1.33	83.53	10.58	71.22	41.33	29.89	36.33	5.00
T_2	Oats	13.83	89.04	10.28	2.60	76.16	10.96	54.22	33.77	20.45	29.86	3.91
	Berseem	12.09	84.40	19.83	2.73	61.85	15.60	45.52	31.55	13.97	27.38	4.17
	Guinea Grass	32.33	89.20	9.26	1.91	78.03	10.80	79.87	49.48	30.39	42.74	6.74
	Jackfruit leaves	41.12	87.62	13.90	3.33	70.39	12.38	40.70	29.56	11.14	21.31	8.25
	Paddy Straw	88.68	89.59	4.59	1.32	83.68	10.41	71.42	41.38	30.04	36.38	5.01
	Concentrate	91.31	93.78	20.43	1.84	71.51	6.22	27.42	16.91	10.52	16.47	0.44
T_3	TMR 1	37.59	88.58	13.01	2.46	73.11	11.42	58.65	45.19	13.46	40.18	5.01
T_4	TMR 2	46.54	88.95	15.98	2.39	70.89	11.05	53.49	36.04	17.45	30.09	4.95

Each Value is a mean of three replications

T_1: Free choice Paddy straw, Berseem, Oats, Jackfruit leaves, Guinea grass

T_2: Free choice Paddy straw, Berseem, Oats, Jackfruit leaves, Guinea grass and Concentrate mixture (@ 1.25% of BW).

T_3: Five fodders offered in T_1 were mixed together as TMR

T_4: Five fodders and concentrate mixture offered in T_2 were mixed together as TMR

AGE 1: Kids of 3-6 months AGE 2: Kids of 9-12 months

Table 2: Macro and micro mineral composition of different feeds and fodders offered

Treatments	Feeds	Ca% DM	P%DM	Mg% DM	Cu (mg/kg DM)	Zn (mg/kg DM)	Mn (mg/kg DM)	Fe (mg/kg DM)
T_1	Oats	0.39	0.17	0.26	19.21	50.35	81.07	251.43
	Berseem	1.93	0.27	0.21	5.00	17.00	34.00	544.00
	Guinea Grass	0.49	0.24	0.34	6.00	30.00	127.00	279.00
	Jackfruit leaves	0.92	0.31	0.21	14.15	68.84	41.13	301.47
	Paddy Straw	0.29	0.07	0.16	10.86	25.64	232.63	256.21
T_2	Oats	0.35	0.20	0.30	19.52	50.50	81.15	251.81
	Berseem	1.88	0.28	0.26	5.08	17.11	34.51	544.50
	Guinea Grass	0.51	0.25	0.39	6.10	30.15	127.13	279.44
	Jackfruit leaves	0.90	0.35	0.28	14.23	69.00	41.53	302.01
	Paddy Straw	0.30	0.10	0.19	11.00	25.88	232.94	257.00
	Concentrate	1.24	1.38	1.00	26.17	84.00	156.68	233.23
T_3	TMR 1	0.81	0.21	0.24	11.04	38.37	103.17	326.42
T_4	TMR 2	0.91	0.41	0.36	13.56	45.97	112.08	310.89

Each Value is a mean of three replications
T_1: Free choice Paddy straw, Berseem, Oats, Jackfruit leaves, Guinea grass
T_2: Free choice Paddy straw, Berseem, Oats, Jackfruit leaves, Guinea grass and Concentrate mixture (@ 1.25% of BW).
T_3: Five fodders offered in T_1 were mixed together as TMR
T_4: Five fodders and concentrate mixture offered in T_2 were mixed together as TMR
AGE 1: Kids of 3-6 months AGE 2: Kids of 9-12 months

Table 3: Intake behaviour of kids of different age groups at different diets

Treatment	Total number of bouts per day			Total time spent (in minutes) per day		
	Age 1	Age 2	Mean ± S.E.M.	Age 1	Age 2	Mean ± S.E.M.
T_1	269.50	341.33	$305.41^a \pm 20.16$	146.80	147.55	$147.18^a \pm 7.01$
T_2	351.16	448.91	$400.04^b \pm 35.96$	202.80	174.18	$188.49^b \pm 8.71$
T_3	344.16	438.33	$391.25^b \pm 27.45$	199.91	221.66	$210.79^c \pm 6.29$
T_4	393.50	490.83	$442.16^b \pm 31.15$	203.83	232.75	$218.29^d \pm 7.03$
MEAN ± S.E.M.	339.58±20.87	429.85±20.50	384.71±15.90	188.34±7.30	194.03±7.99	191.18±5.37
Age Effect (A)	P=0.002			P=0.403		
Treatment Effect (T)	P=0.008			$p<0.001$		
T×A	P=0.984			P=0.020		

The Mean values with different superscripts (a, b, c) among treatments differ significantly
T_1: Free choice Paddy straw, Berseem, Oats, Jackfruit leaves, Guinea grass
T_2: Free choice Paddy straw, Berseem, Oats, Jackfruit leaves, Guinea grass and Concentrate mixture (@ 1.25% of BW).
T_3: Five fodders offered in T_1 were mixed together as TMR
T_4: Five fodders and concentrate mixture offered in T_2 were mixed together as TMR
AGE 1: Kids of 3-6 months AGE 2: Kids of 9-12 months

Table 4: Total DMI of kids of different age groups through different diets

Treatments	TDMI (g/day/kid)		
	Age 1	Age 2	Mean ± S.E.M.
T_1	125.96	168.05	$147.01^a \pm 11.38$
T_2	147.54	220.64	$184.09^a \pm 18.89$
T_3	250.72	330.39	$290.55^b \pm 20.88$
T_4	356.79	464.32	$410.56^c \pm 35.63$
Mean ± S.E.M.	220.25±27.07	295.85±24.14	258.0±18.77
Treatment Effect (T)	$p<0.001$		
Age Effect (A)	P=0.001		
T×A	P=0.751		

The Mean values with different superscripts (a, b, c) in the same column differ significantly
T_1: Free choice Paddy straw, Berseem, Oats, Jackfruit leaves, Guinea grass; T_2: Free choice Paddy straw, Berseem, Oats, Jackfruit leaves, Guinea grass and Concentrate mixture (@ 1.25% of BW); T_3: Five fodders offered in T_1 were mixed together as TMR; T_4: Five fodders and concentrate mixture offered in T_2 were mixed together as TMR; AGE 1: Kids of 3-6 months; AGE 2: Kids of 9-12 months

Table 5: Average intake / bout (g/bout) of kids of different age groups through different diets

Treatment	Age 1	Age 2	Mean ± S.E.M.
DMI / Bout (g/bout)			
T_1	0.728	0.759	0.743^{b}±0.064
T_2	0.591	0.591	0.591^{a}±0.048
T_3	0.723	0.764	0.744^{b}±0.021
T_4	0.894	0.949	0.922^{c}±0.029
MEAN ± S.E.M.	0.734±0.040	0.766±0.038	0.750±0.027
P value	Treatment effect (T): *p*<0.001 Age effect (A): P=0.488 T×A: P=0.978		
OMI/ Bout (g/bout)			
T_1	0.686	0.744	0.715^{ab}±0.069
T_2	0.592	0.569	0.581^{a}±0.050
T_3	0.641	0.676	0.659^{a}±0.018
T_4	0.795	0.844	0.820^{b}±0.026
MEAN ± S.E.M.	0.679±0.036	0.708±0.036	0.693±0.025
P value	Treatment effect (T): P=0.008 Age effect (A): P=0.536 T×A: P=0.929		
CPI / Bout (g/bout)			
T_1	0.071	0.073	0.072^{a}±0.005
T_2	0.100	0.084	0.092^{b}±0.010
T_3	0.095	0.100	0.097^{b}±0.003
T_4	0.144	0.151	0.147^{c}±0.004
MEAN ± S.E.M.	0.102±0.007	0.102±0.007	0.102±0.005
Statistical Implications P value	Treatment effect (T): *p*<0.001 Age effect (A): P=0.957 T×A: P=0.551		
NDFI / Bout (g/bout)			
T_1	0.469	0.579	0.524^{b}±0.067
T_2	0.351	0.341	0.346^{a}±0.031
T_3	0.423	0.450	0.436^{ab}±0.012
T_4	0.479	0.507	0.493^{b}±0.015
MEAN ± S.E.M.	0.430±0.025	0.469±0.034	0.450±0.021
P value	Treatment effect (T): P=0.013 Age effect (A): P=0.321 T×A: P=0.730		

The Mean values with different superscripts (a, b, c) among treatments differ significantly
T_1: Free choice Paddy straw, Berseem, Oats, Jackfruit leaves, Guinea grass; T_2: Free choice Paddy straw, Berseem, Oats, Jackfruit leaves, Guinea grass and Concentrate mixture (@ 1.25% of BW); T_3: Five fodders offered in T_1 were mixed together as TMR; T_4: Five fodders and concentrate mixture offered in T_2 were mixed together as TMR; AGE 1: Kids of 3-6 months; AGE 2: Kids of 9-12 months

Table 6: Average intake rate (g/minute) of kids of different age groups through different diets

Treatment	Age 1	Age 2	Mean ± S.E.M.
DMI Rate (g/minute)			
T_1	3.445	4.288	3.866^{b}±0.821
T_2	2.709	2.176	2.442^{a}±0.265
T_3	1.230	1.490	1.360^{a}±0.065
T_4	1.690	1.995	1.843^{a}±0.113
MEAN ± S.E.M.	2.268±0.265	2.487±0.433	2.378±0.252
Statistical Implications (P value)	Treatment effect (T): P=0.002 Age effect (A): P=0.630 T×A: P=0.755		
OMI Rate (g/minute)			
T_1	3.391	4.554	3.973^{b}±0.938
T_2	2.954	2.281	2.618^{ab}±0.283
T_3	1.090	1.317	1.204^{a}±0.057
T_4	1.504	1.773	1.639^{a}±0.101
MEAN ± S.E.M.	2.235±0.275	2.482±0.504	2.358±0.285
Statistical Implications (P value)	Treatment effect (T): P=0.002 Age effect (A): P=0.629 T×A: P=0.651		
CPI Rate (g/minute)			
T_1	0.270	0.317	0.293^{b}±0.045
T_2	0.430	0.265	0.347^{b}±0.048
T_3	0.162	0.194	0.178^{a}±0.009
T_4	0.272	0.317	0.294^{b}±0.018
MEAN ± S.E.M.	0.283±0.031	0.273±0.023	0.278±0.019
Statistical Implications (P value)	Treatment effect (T): P=0.008 Age effect (A): P=0.766 T×A: P=0.082		
NDFI Rate (g/minute)			
T_1	2.293	3.739	3.016^{b}±0.855
T_2	2.107	1.694	1.901^{ab}±0.203
T_3	0.719	0.876	0.798^{a}±0.038
T_4	0.905	1.066	0.986^{a}±0.060
MEAN ± S.E.M.	1.506±0.204	1.844±0.457	1.675±0.249
Statistical Implications (P value)	Treatment effect (T): P=0.004 Age effect (A): P=0.454 T×A: P=0.514		

The Mean values with different superscripts (a, b, c) among treatments differ significantly
T_1: Free choice Paddy straw, Berseem, Oats, Jackfruit leaves, Guinea grass; T_2: Free choice Paddy straw, Berseem, Oats, Jackfruit leaves, Guinea grass and Concentrate mixture (@ 1.25% of BW); T_3: Five fodders offered in T_1 were mixed together as TMR; T_4: Five fodders and concentrate mixture offered in T_2 were mixed together as TMR; AGE 1: Kids of 3-6 months; AGE 2: Kids of 9-12 months

Table 7: Average intake per bout (mg/bout) of macro minerals by kids of different age groups through different diets

Treatment	Age 1	Age 2	Mean ± S.E.M.
Calcium Intake / Bout (mg/bout)			
T_1	4.718	5.183	$4.951^a \pm 0.358$
T_2	6.445	5.646	$6.045^a \pm 0.604$
T_3	5.863	6.208	$6.035^a \pm 0.169$
T_4	8.200	8.721	$8.460^b \pm 0.262$
MEAN ± S.E.M.	6.306±0.403	6.439±0.349	6.373±0.264
Statistical Implications (P value)	Treatment effect (T): $p<0.001$ Age effect (A): P=0.737 T×A: P=0.598		
Phosphorus Intake / Bout (mg/bout)			
T_1	1.648	1.916	$1.782^a \pm 0.210$
T_2	4.403	3.531	$3.967^b \pm 0.583$
T_3	1.574	1.668	$1.621^a \pm 0.048$
T_4	3.680	3.914	$3.797^b \pm 0.115$
MEAN ± S.E.M.	2.826±0.375	2.757±0.243	2.792±0.221
Statistical Implications (P value)	Treatment effect (T): $p<0.001$ Age effect (A): P=0.832 T×A: P=0.557		
Magnesium Intake / Bout (mg/bout)			
T_1	2.013	2.163	$2.088^a \pm 0.197$
T_2	4.173	2.947	$3.560^b \pm 0.578$
T_3	1.751	1.867	$1.809^a \pm 0.052$
T_4	3.294	3.494	$3.394^b \pm 0.106$
MEAN ± S.E.M.	2.808±0.338	2.618±0.172	2.713±0.188
Statistical Implications (P value)	Treatment effect (T): $p<0.001$ Age effect (A): P=0.544 T×A: P=0.309		

The Mean values with different superscripts (a, b, c) among treatments differ significantly

T_1: Free choice Paddy straw, Berseem, Oats, Jackfruit leaves, Guinea grass; T_2: Free choice Paddy straw, Berseem, Oats, Jackfruit leaves, Guinea grass and Concentrate mixture (@ 1.25% of BW); T_3: Five fodders offered in T_1 were mixed together as TMR; T_4: Five fodders and concentrate mixture offered in T_2 were mixed together as TMR; AGE 1: Kids of 3-6 months; AGE 2: Kids of 9-12 months

Table 8: Average intake per bout (mg/bout) of micro minerals by kids of different age groups through different diets

Treatment	Age 1	Age 2	Mean ± S.E.M.
Copper Intake / Bout (mg/bout)			
T_1	0.015	0.015	$0.015^b \pm 0.002$
T_2	0.019	0.013	$0.016^b \pm 0.002$
T_3	0.008	0.009	$0.009^a \pm 0.001$
T_4	0.013	0.013	$0.013^b \pm 0.001$
MEAN ± S.E.M.	0.014±0.001	0.013±0.001	0.013±0.001
Statistical Implications (P value)	Treatment effect (T): P =0.005 Age effect (A): P=0.349 T×A: P=0.265		
Zinc Intake / Bout (mg/bout)			
T_1	0.030	0.035	$0.033^a \pm 0.003$
T_2	0.037	0.034	$0.036^{ab} \pm 0.004$
T_3	0.028	0.030	$0.029^a \pm 0.001$
T_4	0.042	0.044	$0.043^b \pm 0.001$
MEAN ± S.E.M.	0.034±0.002	0.034±0.002	0.035±0.001
Statistical Implications (P value)	Treatment effect (T): P=0.006 Age effect (A): P=0.575 T×A: P=0.741		
Manganese Intake / Bout (mg/bout)			
T_1	0.114	0.116	$0.115^b \pm 0.015$
T_2	0.089	0.078	$0.083^a \pm 0.008$
T_3	0.075	0.079	$0.077^a \pm 0.002$
T_4	0.101	0.107	$0.104^{ab} \pm 0.003$
MEAN ± S.E.M.	0.095±0.007	0.095±0.007	0.095±0.005
Statistical Implications (P value)	Treatment effect (T): P=0.023Age effect (A): P=0.991 T×A: P=0.903		
Iron Intake / Bout (mg/bout)			
T_1	0.219	0.233	$0.226^b \pm 0.019$
T_2	0.182	0.176	$0.179^a \pm 0.014$
T_3	0.237	0.250	$0.243^b \pm 0.007$
T_4	0.278	0.296	$0.287^c \pm 0.009$
MEAN ± S.E.M.	0.229±0.012	0.239±0.012	0.234±0.008
Statistical Implications (P value)	Treatment effect (T): $p<0.001$ Age effect (A): P=0.467 T×A: P=0.930		

The Mean values with different superscripts (a, b, c) among treatments differ significantly

T_1: Free choice Paddy straw, Berseem, Oats, Jackfruit leaves, Guinea grass; T_2: Free choice Paddy straw, Berseem, Oats, Jackfruit leaves, Guinea grass and Concentrate mixture (@ 1.25% of BW); T_3: Five fodders offered in T_1 were mixed together as TMR; T_4: Five fodders and concentrate mixture offered in T_2 were mixed together as TMR; AGE 1: Kids of 3-6 months; AGE 2: Kids of 9-12 months

Table 9: Average intake rate (mg/min) of macro minerals by kids of different age groups through different diets

Treatment	Age 1	Age 2	Mean ± S.E.M.
Calcium Intake / Minute (mg/min)			
T_1	7.906	10.876	$9.391^{a}\pm0.864$
T_2	7.716	13.183	$10.450^{a}\pm1.184$
T_3	9.970	12.091	$11.031^{a}\pm0.520$
T_4	15.499	18.327	$16.913^{b}\pm1.030$
MEAN ± S.E.M.	10.273±0.950	13.619±0.657	11.946±0.621
Statistical Implications (P value)	Treatment effect (T): p<0.001 Age effect (A): p<0.001 T×A: P=0.481		
Phosphorus Intake / Minute (mg/min)			
T_1	2.213	2.935	$2.574^{a}\pm0.233$
T_2	4.605	8.061	$6.333^{b}\pm0.780$
T_3	2.676	3.245	$2.960^{a}\pm0.139$
T_4	6.954	8.227	$7.591^{c}\pm0.461$
MEAN ± S.E.M.	4.112±0.526	5.617±0.537	4.864±0.388
Statistical Implications (P value)	Treatment effect (T): p<0.001 Age effect (A): p<0.001 T×A: P=0.049		
Magnesium Intake / Minute (mg/min)			
T_1	2.221	2.945	$2.583^{a}\pm0.216$
T_2	3.811	6.404	$5.108^{b}\pm0.564$
T_3	2.977	3.634	$3.306^{a}\pm0.156$
T_4	6.229	7.343	$6.786^{c}\pm0.418$
MEAN ± S.E.M.	3.810±0.424	5.082±0.390	4.446±0.300
Statistical Implications (P value)	Treatment effect (T): p<0.001 Age effect (A): p<0.001 T×A: P=0.122		

The Mean values with different superscripts (a, b, c) among treatments differ significantly

T_1: Free choice Paddy straw, Berseem, Oats, Jackfruit leaves, Guinea grass; T_2: Free choice Paddy straw, Berseem, Oats, Jackfruit leaves, Guinea grass and Concentrate mixture (@ 1.25% of BW); T_3: Five fodders offered in T_1 were mixed together as TMR; T_4: Five fodders and concentrate mixture offered in T_2 were mixed together as TMR; AGE 1: Kids of 3-6 months; AGE 2: Kids of 9-12 months

Table 10: Average intake rate (mg/min) of micro minerals by kids of different age groups through different diets

Treatment	Age 1	Age 2	Mean ± S.E.M.
	Copper Intake / Minute (mg/min)		
T_1	0.011	0.014	$0.013^{a}\pm0.001$
T_2	0.013	0.022	$0.018^{b}\pm0.002$
T_3	0.014	0.018	$0.016^{ab}\pm0.001$
T_4	0.024	0.028	$0.026^{c}\pm0.001$
MEAN ± S.E.M.	0.016±0.001	0.020±0.001	0.018±0.001
Statistical Implications (P value)	Treatment effect (T): p<0.001 Age effect (A): p<0.001 T×A: P=0.308		
	Zinc Intake / Minute (mg/min)		
T_1	0.039	0.051	$0.045^{a}\pm0.004$
T_2	0.044	0.075	$0.059^{b}\pm0.007$
T_3	0.048	0.058	$0.053^{ab}\pm0.002$
T_4	0.079	0.093	$0.086^{c}\pm0.005$
MEAN ± S.E.M.	0.052±0.005	.069±0.004	0.061±0.003
Statistical Implications (P value)	Treatment effect (T): p<0.001 Age effect (A): p<0.001 T×A: P=0.281		
	Manganese Intake / Minute (mg/min)		
T_1	0.067	0.090	$0.079^{a}\pm0.006$
T_2	0.071	0.126	$0.099^{a}\pm0.011$
T_3	0.128	0.155	$0.141^{b}\pm0.007$
T_4	0.190	0.225	$0.207^{c}\pm0.013$
MEAN ± S.E.M.	0.114±0.013	0.149±0.010	0.131±0.009
Statistical Implications (P value)	Treatment effect (T): p<0.001 Age effect (A): p<0.001 T×A: P=0.526		
	Iron Intake / Minute (mg/min)		
T_1	0.292	0.398	$0.345^{a}\pm0.030$
T_2	0.225	0.385	$0.305^{a}\pm0.033$
T_3	0.402	0.487	$0.445^{b}\pm0.021$
T_4	0.526	0.621	$0.574^{c}\pm0.035$
MEAN ± S.E.M.	0.361±0.033	0.473±0.021	0.417±0.021
Statistical Implications (P value)	Treatment effect (T): p<0.001 Age effect (A): p<0.001 T×A: P=0.742		

The Mean values with different superscripts (a, b, c) among treatments differ significantly

T_1: Free choice Paddy straw, Berseem, Oats, Jackfruit leaves, Guinea grass; T_2: Free choice Paddy straw, Berseem, Oats, Jackfruit leaves, Guinea grass and Concentrate mixture (@ 1.25% of BW); T_3: Five fodders offered in T_1 were mixed together as TMR; T_4: Five fodders and concentrate mixture offered in T_2 were mixed together as TMR; AGE 1: Kids of 3-6 months; AGE 2: Kids of 9-12 months

5. Conclusion

The present study was a preliminary effort to throw some light on the intake behavior of Black Bengal kids under different dietary treatments and presentations. Our findings suggest that the Voluntary Intake of Black Bengal kids was higher on a TMR-based diet (with or without concentrate mixture) rather than when given multiple feed options as free choice in the cafeteria. TMR diet was preferred over the cafeteria diet, in terms of time spent and number of bouts as well. Older kids had a higher DMI as compared to the younger ones. Moreover, our results suggest that it is possible that growing Black Bengal kids can be fed with a TMR-based ration, contradictory to the conventional feeding system, for better growth and productive performance. Overall, it is likely that the chemical composition of offered feedstuffs, in combination with various physiological and behavioral mechanisms by goats resulted in a preference for a specific diet. The reports on this kind of intake behavior study are very rare in goats in general and Black Bengal kids in particular. In the future, the short-term trial conducted in the present study can be expanded for a longer term and can be experimented with a larger number of animals, where in growth and production parameters of the Black Bengal kids can also be thoroughly analyzed and recorded.

6. Declaration of competing interest
The authors declare that they have no competing interests

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