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Effect of Replacement of Corn Silage with Orange Peel Silage on Feed Intake, Body Weight Change, and Body Condition Score in Berari Goat During Peripartum Period

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ABSTRACT

A study was conducted to evaluate the effect of partial replacement of Corn silage (CS) with Orange Peel Silage (OPS) in the diet of Berari goats during the Peripartum period on their feed intake, Body weight change, and Body condition score (BCS). A total of eighteen advanced pregnant Berari goats were divided into three groups viz, To, T1, and T2 and offered 0, 25, or 50% orange peel silage in replacement of corn silage. The results revealed that The DMI in group T2 (50% OPS) was lower than in group T1 (25% OPS) and T0 (CS). However, it differed significantly with T0 in all the weeks and with T1 at the Prepartum 2nd week and the Postpartum 3rd week. No significant changes were observed in body weights and BCS among the groups.

HIGHLIGHTS

- Orange peel silage as a potential solution to the feed scarcity problem.
- Significantly reduced their feed intake, without impacting their body weight or body condition score.

Keywords: Berari goats, Corn silage, Orange peel silage, Peripartum period

The availability of feed all year round for livestock is a major challenge to farmers involved in large and small ruminant production, as a result of climate change, deforestation, land shrinkage, increase in production pressure on agricultural land, etc., the grazing resources are depleting globally over some time. In India, the area covered by permanent pastures and other grazing land is 10.34 M ha, Crop residues are expected to provide 54% of total fodder, while rangelands provide 18% and only 28% is met from cultivated fodder crops (Hegde, 2010). There is currently a net deficiency of 35.6% green fodder, 10.95% dry fodder, and 44% concentrate feed materials in the country (IGFRI Vision, 2050), By 2050, the demand for green and dry feed will be 1012 and 631 million tones, respectively.

Agriculture crop residue is India's most crucial feed source for ruminant livestock, which is of low quality. As a result, animals cannot meet their energy and protein needs from the available poor-quality herbage with subsequent marked weight loss and productivity (Ademosum, 1994). Thus, it is the need of the hour to search for alternative

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feedstuffs that are cheaper and available locally. The global orange production for 2022-23 is estimated up to 47.5 million tons (USDA, 2023). Oranges (Mandarin) contribute 44.27% of India's total citrus fruit production, the orange pulp, including peels and seeds, is the primary waste from the orange juice industry. The orange peel has two layers, the outer-colored layer (Epicarp) contains Flavedo (Carotenoids, Flavonoids, Essential oils & Phenols), and the Inner whity spongy layer (Mesocarp) contains Albedo (Pectin, Cellulose, Hemicellulose, lignin & Dietary fibre) (Applied food research, 2022). The orange peel contains 23% sugar, 22% cellulose, 25% pectin, and 11% hemicellulose (Gaind, 2017), Peels are a rich micro-nutrient source; vitamin C contains phytonutrients such as tannins, saponins, limonene, phytate, and oxalate.

The primary constraint in using these wastes as livestock feed is their high moisture content and the presence of contaminants, mainly pesticides and pesticide residues (Wadhwa and Bakshi, 2016). Its wet and sticky nature makes it difficult to store in sheds, bunkers, or silos (Za'za, 2008). Making silage is among the best methods for using by-products as ruminants' feed without harmful effects. Silage-making eliminates pathogens and reduces the effect of drugs and pesticides used locally without profound control or discipline (Azmouti, 2003). Silage made of either certain field crops or agricultural by-products is considered a good feed ingredient. It is used worldwide in livestock operations, especially feedlot operations (Azmouti, 2003). Ensiling Fresh orange peel is a simple procedure, the best option for preservation of the contents, and can be easily performed by the farmer in all weather conditions. The silage produced has an excellent fruity smell, and the animals consume it efficiently. Fresh orange peel has shown potential for producing good-quality silage especially for its high content of soluble carbohydrates and pectin, these are responsible for the improvement in digestibility and degradability of the silages (Ítavo *et al.,* 2000). Orange waste silage has been used in the diets of Goats (El-Zaiat *et al.,* 2022; Mahrous *et al.,* 2019a; Malla *et al*., 2015), Dairy cows (Ítavo *et al*., 2020; Shakweer, 2011), and Sheep (Volanis *et al.*, 2004; de Lima Valença *et al*., 2017; Pagán Riestra *et al*., 2014; Mahrous *et al.*, 2019b).

The aim of this study was to evaluate the effect of replacing of corn silage with varying levels (0, 25, and 50%) of orange peel silage on feed intake, body weight change, and BCS in berari goat during peripartum period.

MATERIALS AND METHODS

Study location

The study carried out at the Sheep and Goat unit of the Post Graduate Institute of Veterinary and Animal Sciences in Akola, India. Akola is located between latitude 20.7°N and longitude 77.07˚E. Area is tropical savanna climate with maximum temperature range of 48˚C and minimum temperature range of 6-8˚C. The relative humidity is 20 to 30% in summer, 84.2 to 92.2% in monsoon, and 43 to 63% in winter and rainfall is between 500 to 800 mm (Metrological Observatory, Dr. PDKV, Akola).

Ensiling

The corn silage was prepared from the available crop cultivated purposively on the institute fodder field and the ready-made concentrates were procured from the local market. About 1500 kg of non-marketable ripe orange (*Citrus reticulata*) peels were collected in September 2022 from the orange growing area located near Akola. The peels were too moist; about 1.5-ton peels were wilted for 48 h in shadows to reduce the moisture content to 70-75%. Orange peels were coarsely sliced using a modified machine meant for chopping. Inoculant solution prepared by using Jaggery 1 kg, salt 1 kg, and a pro-biotic mixture of lactic acid bacteria, 40 g in 10 lit of water. The silage was made in 10 white polypropylene plain silage bags (capacity 100 kg, Dimension 2.5 × 2.5 × 4.5 ft.) with having plastic liner sheet inside to avoid any leakage; its top and bottom were covered with soybean straw for proper compaction and to prevent air pockets. The bag was filled with the ensiling material; orange peels layer by layer sprayed with the inoculant solution and pressed/trampled manually by experienced working men at the farm, then sealed properly and allowed to ferment for 30 days under anaerobic conditions before feeding to the goats. About 1 kg, sample was taken from the 15 cm depth, one from the Centre and two parallel on each side. Then the samples were pooled together and mixed thoroughly, and divided into three sub-samples of fresh silage, approximately 300 g each, one sub-sample was analyzed on the same day

for the determination of the physical properties, viz., pH, moisture, Odor, Structure, Color, and a quality class of the silages by using the DLG scoring system (DLG, 1997). The other two sub-samples were stored at −18 °C for the subsequent analysis of chemical composition as per AOAC (2007).

Experimental animals

Eighteen healthy advance-pregnant Berari Goats were selected after scanning through Ultrasonography. Based on parity and body weights, animals were divided into three equal groups, T0, T1, and T2 (Table 1). All the animals under experiments were fed individually with a total mixed ration to fulfill their nutrient requirement as per ICAR (2013) feeding recommendations. The silage was mixed properly with the concentrate before being it to experimental animals and offered twice daily at 08:30 h in the morning and 16:30 h in the evening, and provided with fresh tap water for drinking ad libitum for 24 hr. The treatment was started 21 days before kidding and ended up 21 days postpartum, for a period of 42 days.

Table 1: Diets fed to the experiment's goats

Group	Treatments	No. of animals
T0 (Control)	100% Corn silage + Concentrates @1% Body Weight	6
T1	75% Corn silage + 25% Orange Peel Silage + Concentrates@ 1% Body weight	6
T2	50% Corn silage + 50% Orange Peel Silage + Concentrates @1% Body Weight	6

Management

All the animals were housed in a well-ventilated goat shed and kept in three different compartments of the same shade. Each compartment was of 10 × 12 ft size covered space with concrete floor and asbestos roof, and open space 12 × 16 ft with concrete floor. The animal shed was washed twice daily and cleaned thoroughly to remove feces and dirt. All the animals were maintained under clean and hygienic conditions, disinfectant solution was applied at regular intervals on the floor of the shed. Before the commencement of the feeding trial, all the animals were dewormed and given two weeks adaptation period.

Ethical clearance for this study was obtained the research was performed by the Institutional Ethics Committee for Veterinary Clinical Research (IEC-VCR) of Post Graduate Institute of Veterinary & Animal Sciences, Akola (IEC-VCR (2) 2022 (9).

Performance evaluation

The feed intake of the experimental goats was taken as Dry Matter Intake. Feed offered and refusals were recorded daily before the addition of fresh feed, the average feed consumption was calculated from the difference between the total feed offered and the feed left over on the next day morning. The sample was processed daily for estimating its dry matter content and intake of dry matter was calculated from the aforesaid two values. The quantity of feed and fodders offered was adjusted weekly as per changes in the body weight and consequent changes in nutrient requirement of experimental animals. Goats were weighed accurately using electronic balance at weekly intervals during the morning hours before feeding and watering. The body condition scoring was performed by using the hand to feel muscle and fat cover over and around the vertebrae. Scoring was performed in goats using a BCS ranging from 1.0 to 5.0, with 0.5 increments (Villaquiran *et al*., 2004).

Data analysis

Data of present study was collected, tabulated, and subjected for the statistical analysis on IBM SPSS statistics version 22.00 procedures with interaction as described by Snedecor and Cochran (1980). The mean and standard error for all parameters were calculated. The averages were compared using Duncan's Multiple Range Test (DMRT) for a significant difference.

RESULTS AND DISCUSSION

Silage quality

The Corn and Orange peel silage possessed a similar DLG score for Odor (12.8±0.80), structure (3.6±0.27), and color (1.8±0.13) and were free from any signs of molds (Table 2). Values of pH indicated good preserved silage as it decreased with advancing ensilaging period where it

reached 3.84 and 4.18 for corn silage and orange waste silage, respectively, which seems to be within the normal range for very good quality silage reported by McDonald *et al*. (1995). Limited studies reported the physical properties of the silages made from orange waste (peel, pulp, pomace, and seed). El-Zaiat *et al*. (2022) revealed a fruity Odor, brownish-yellow color, and wet and soft texture in orange waste silage, While Volanis *et al.* (2004) reported orange silage was palatable and had a pleasant odor. Mahrous *et al.* (2019a, b) also revealed that orange silage was mould-free and smelled good.

Chemical composition of Feedstuff presented in Table 3. The values for corn silage in the present study are similar to those reported earlier by El-Zaiat *et al*. (2022). Mahrous *et al*. (2019a, b) reported higher values for DM, CP, CF, and Ash and lower values for OM, EE, and NFE with the present values. The differences in the chemical composition of the corn silage may have been caused by differences in climatic conditions, soil type, harvesting time, etc. Chemical composition of orange peel silage are in line with the results of Itavo *et al.* (2000) for DM, EE, and NFE, and for CP, the present values are in concurrence with the values reported by Grizotto *et al.* (2020) who revealed it 10.38; however, the lower CP values are reported by Itavo *et al.* (2000), Ashbel and Donahaye (1984); Megias *et al*. (1993) and Alnaimy *et al*. (2017), who revealed the CP values in the range of 7.3 to 8.45 vs present value 10.42±0.44. The values for CF are in agreement with Ashbel and Donahaye (1984). The differences in the chemical composition of orange peel silage possibly occurred due to different climatic regions and varieties of oranges.

Table 2: Physical properties of the corn silage and orange peel silage

		DLG Score	
1.	**Physical property**	**Corn silage**	**Orange peel silage**
(i)	Odor	12.8±0.80	12.8±0.80
(ii)	Structure	3.6±0.27	3.6±0.27
(iii)	Color	1.8±0.13	1.8±0.13
2.	Quality class according to the physical properties of silage	18.2±1.20	18.2±1.20
	Class	Very good	Very good

Table 3: Chemical composition of the feedstuff

Item (%)	N	Corn silage	Orange peel silage	Concentrates
Dry Matter (DM)	10	29.63±1.34	25.48±0.56	90.33±0.25
Crude protein (CP)	10	8.83±0.25	10.42±0.44	16.20±0.30
Crude Fiber (CF)	10	19.98±1.11	16.32±0.72	11.34±0.33
Ether extract (EE)	10	3.25±0.43	5.59±0.28	2.81±0.14
Ash	10	9.59±1.17	8.30±0.18	11.84±0.47
NFE (Nitrogen-Free Extract)	10	58.36±2.23	59.38±1.18	58.18±0.78
Organic matter (OM)	10	90.41±1.17	91.70±0.18	88.52±0.47
pH	10	4.18±0.09	3.84±0.02	—

Feed intake

The weekly feed intake in experimental goats is measured as Dry Matter Intake. The DMI in group T2 (50% OPS) was lower than in group T1 (25% OPS) and T0 (CS). Still, it differed significantly with group T0 for all the weeks, and with T1, it differed significantly in 2nd week before and 3rd week after kidding (Table 4). These results are in agreement with those attained by Itavo *et al.* (2020), who reported a linear decrease in the DMI of cows fed orange peel silage replacing whole plant corn silage. However, Oloche *et al.* (2013) reported a nonsignificant effect on goats DMI on replacing maize offal with sweet orange peel meal up to 50% in the diet of growing kids. Similarly, Malla *et al.* (2015) reported nonsignificant differences in buck feed intake when fed with Kinnow silage compared to oat silage. Also, Pagán Riestra *et al.* (2014) reported nonsignificant differences for DMI in crossbred rams fed with 20% citrus silage. A decrease in DMI in the goats under the present study might be associated with a decrease in rumen fill, shown by the reduction in consumption of Neutral Detergent Fiber (NDF) and consequent increase in non-fiber carbohydrates (NFC) consumption from the pectin present in orange peel silage. According to Van Soest (1994), orange peel is particularly rich in pectin, which has a high potential for rumen degradation without excessive ruminal acidification.

Weekly Body weight Change

The weekly body weights were comparable and there were statistically non-significant differences among groups

Table 4: Weekly DMI (kg/day/goat) of goats under different treatment groups during transition period

Group/Week	Transition period						
	-3rd	**-2nd**	**-1st**	**Kidding**	**+1st**	**+2nd**	**+3rd**
T0	0.574^{b}±0.03	0.634^{C}±0.03	0.642^{B}±0.03	0.550^{b}±0.03	0.519^{b}±0.03	0.541^{B}±0.03	0.562^{B}±0.02
T1	0.486^{ab}±0.05	0.524^{B}±0.05	0.544^{AB}±0.05	0.416^{a}±0.05	0.443^{ab}±0.04	0.463^{AB}±0.05	0.484^{B}±0.05
T2	0.405^{a}±0.01	0.398^{A}±0.02	0.449^{A}±0.02	0.395^{a}±0.01	0.368^{a}±0.02	0.368^{A}±0.02	0.380^{A}±0.01
Overall average	0.488±0.03	0.518±0.03	0.545±0.03	0.454±0.03	0.443±0.02	0.457±0.02	0.475±0.02

The means bearing different superscript $^{A, B, C}$ within the column differ significantly (P<0.01); The means bearing different superscript $^{a, b, c}$ within the column differ significantly (P<0.05).

Table 5: Weekly body weights (kg/goat) of goats under different treatment groups during transition period

Group / Day	-21d	-14d	-7d	Kidding	+7d	+14d	+21d
T0	31.38±1.70	32.65±1.80	33.53±1.76	29.80±1.52	28.28±1.38	28.75±1.36	29.48±1.36
T1	30.90±2.80	32.18±2.90	33.10±3.01	29.43±2.59	27.90±2.30	28.53±2.45	29.28±2.45
T2	30.05±0.59	31.42±0.64	32.27±0.81	28.75±0.71	27.85±0.68	28.55±0.64	29.40±0.64
Overall Average	30.78±1.05	32.08±1.09	32.97±1.13	29.33±0.97	28.01±0.87	28.61±0.90	29.39±0.90

Table 6: Body condition score of goats under different treatment groups during transition period

Group/Day	Transition period						
	-21d	**-14d**	**-7d**	**Kidding**	**+7d**	**+14d**	**+21d**
T0	2.67±0.11	2.92±0.15	3.17±0.11	2.75±0.11	2.33±0.11	2.50±0.00	2.83±0.11
T1	2.67±0.11	3.00±0.13	3.25±0.11	2.83±0.11	2.50±0.00	2.58±0.08	2.92±0.08
T2	2.67±0.11	3.00±0.00	3.42±0.08	2.83±0.11	2.50±0.00	2.67±0.11	2.92±0.08
Overall average	2.67±0.06	2.97±0.06	3.28±0.06	2.81±0.06	2.44±0.04	2.58±0.05	2.89±0.05

throughout the transition period (Table 5). There was a progressive increase in pre-kidding body weights, loss of body weights from kidding to the 7th day post-kidding, and then the progressive gain in body weights from post kidding 14th day till the end of the transition period. The present results are similar to results obtained by Mahrous *et al.* (2019a); Malla *et al*. (2015) and Oloche *et al*. (2019). Volanis *et al.* (2004) and de Lima Valença *et al.* (2017). reported no effect on their body weight in sheep feeding orange waste silage.

Body Condition Score (BCS)

Body condition scores were comparable and did not differ significantly among the groups throughout the transition period (Table 6). There was a common trend of the initial increase in BCS up to kidding and then a sudden decrease on the day of kidding, and then it was found to decrease gradually up to postpartum 7th day and then increased gradually from the postpartum 14th day onward till the 21st day. There is a high correlation between live weight and BCS, stating that one unit of change in BCS equals around 5 kg changes in live body weight (Oregui *et al.,* 1991) and 5.1 kg (Sanson *et al.,* 1993). BCS between lambing to weaning was not significantly affected by feeding grass and maize silage together compared to only maize, grass silage, or concentrates reported by Annette *et al.* (2013).

CONCLUSION

It was concluded that replacing corn silage with orange peel silage up to 50% in the diet of Berari goats during the

transition period significantly ($p<0.05$) lowers their feed intake without affecting body weights and body condition score.

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