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Original Article

Effect of dietary incorporation of different proportions of barley silage in total mixed ration on growth performance, nutrients utilization, and blood profile of Sahiwal cross Friesian calves

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Abstract

This study aimed to evaluate the effect of barley silage inclusion in diet at different proportions on growth performance and blood parameters in Sahiwal cross Friesian calves, providing insights into the nutritional benefits and potential recommendations for calf diet formulations. The current investigation employing a Completely Randomized Block Design (CRBD) was conducted with 16 Sahiwal x Friesian calves at the Government Cattle Breeding and Dairy Farm Harichand, district Charsadda, Pakistan. Experimental calves used in this research were selected on the basis of nearly the same body weight and age. They were distributed into four treatment groups, each with four replicates: the control group (routine diet), total mixed ration(TMR)+20% barley silage, total mixed ration (TMR)+40% barley silage, and total mixed ration (TMR)+60% barley silage. The results revealed noteworthy variations ($P<0.05$) in dry matter intake (DMI) among the treatments, and it ranged from 3.8 to 4.7 kg per day by showing a higher DMI (4.7 kg/day) with TMR+60% barley silage. Significant variations ($P<0.05$) were noted in body weight gain (BWG) per animal across different treatments ranging from 0.6 to 0.9 kg/day, depicting greater BWG (0.9 kg/day) with TMR+60% barley silage. The mean feed efficiency for the control was 0.15 kg, total mixed ration (TMR)+20% was 0.17 kg, total mixed ration (TMR)+40% was 0.16 kg, and total mixed ration (TMR)+60% barley silage was 0.18 kg. Nutrient digestibility exhibited significant variations ($P<0.05$) across several groups, with DM (56.8 to 68.5%), CP (70.1 to 78.0%), NDF (61.2 to 67.2%), and ADF (59.5 to 67.3%). Within the blood profile, total protein levels ranged from 59.0-68.7 g/l, blood glucose levels ranged from 60.6-70.6 mg/dl, and blood urea nitrogen (BUN) levels ranged from 14.2-19.2 mg/dl. Better results on nutrients digestibility and blood profile were found with the inclusion of 60% barley silage in TMR. The results concluded that the addition of barley silage in the TMR at 60% attributed to enhanced growth performance, better nutrient digestibility of CP, DM, NDF, and ADF, and elevated profile of blood of Sahiwal x Friesian calves.

Keywords: Barley silage, Blood profile, Growth performance, Total mixed ration, Nutrients digestibility, Sahiwal x Friesian calves

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Introduction

In Pakistan, the Agric. sector plays a main role in the economic growth and contributes 22.9% to GDP, and it employs 37.4% of the labour force (EconomicSurveyofPakistan, 2022). Moreover, livestock contributes 14.0% to the overall GDP and 61.9% to the added value of Agric. (Ahmad et al., 2024) . More than 38 million dairy animals in Pakistan produced 61 million tons of milk in 2020, buffalos and cows the critical drivers in milk production. The share of buffalo and cow milk was 60 percent and 37 percent, respectively, while share of combined dairy animals (goat, sheep and camel milk) were 3 percent (Sattar, 2022).The majority of the 17.29 million animals are raised by small-scale subsistence livestock husbandry in the province of Khyber Pakhtunkhwa (KP), which provides livelihoods to more than 70% of the total population and adds value to 56% of the total economy of the province. A major challenge facing Pakistan's livestock business is the shortage and rising expense of animal feed, coupled with the country's expanding population thus decreasing the affordability of majority of farm owners to feed concentrates to their animals. As a result, feeding cattle with silage helps in the production system while also meeting the animal's nutritional needs.

A Pakistan meat industry is facing significant challenges due to the increasing demand for meat. To address these challenges, there is a need for an efficient, profitable and effective increase in meat production. While humans don't consume grasses directly, they are an essential source of protein and fat indirectly as they support livestock production. Animals like cows, chickens, sheep and goats convert grasses into nutritious food products such as meat, eggs and milk which are staples of the human diet ((Ahmad et al., 2024) (Chauhan et al., 2017); (Hussain et al., 2012)). Improving both the quality and quantity of feed supplies might increase livestock output from the present breeding population by as much as 50% ((Ahmad et al., 2024) (Hussain et al., 2013); (Tahir et al., 2019);). In Pakistan, particularly in KP province, low fodder production and inadequate feed resource availability present significant complications to livestock production, emphasizing the imperative role of ensuring sufficient quality and quantity of feed ((Khan et al., 2007); (Mahmood et al., 2021); (Shaheen et al., 2020); (Tariq, 2020)). In the diet of feedlot animals major feed ingredient is silage (Queiroz et al., 2018). The main purpose of silage making is to produce a diet that is high in DM, energy and protein as compared to fresh crop ((Kim et al., 2016); (Kung Jr et al., 2018)). Barley emerges as a high-yielding small grain which is well known because of its winter resistance and early maturation compared to wheat or oats ((Elakhdar et al., 2022); (Fricano et al., 2021)). The feasibility of double-cropping maize or sorghum and barley becomes apparent especially if barley is harvested for fodder before it matures in milder climates. Optimum consumption and dietary intake utilization are related to the harvest stage of fodder for silage. The boot stage is identified as the most suitable for barley for good results on lactation and nutrient digestibility ((Martz et al., 1959); (Bikel et al., 2020); (Al-Baadani et al., 2022)). In certain countries, barley serves as the primary energy source in feedlot cattle diets, distinguished by its NDF content of 19-21% (DM basis) and starch content of 52 to 73% ((Waldo, 1973); (Castillo et al., 2014)).

Incorporation of barley into diets has dual advantages as it enhances palatability, leading to increased feed intake and growth performance and having a higher protein content compared to corn (BUSH, 1989); (Blake et al., 2011). Moreover, barley fodder is considered the optimal feed for feedlot cattle when it is harvested to produce silage at the soft dough stage without wilting or during the boot or vegetative period (Polan et al., 1968); (Musa and Mustafa, 2020). Considering the multifaceted benefits of barley silage, the purpose of the current study was to clarify the impacts of different barley silage percentage in the TMR on growth efficiency, utilization of nutrients, and blood profile of Sahiwal cross Frisian calves.

Material and Methods

Study location

The current study was conducted at the Government Cattle Breeding and Dairy Farm (GCB&DF) in Harichand, district Charsadda, Pakistan.

Experimental animals and study design

The research study used a completely randomized block design (RCBD) for its analysis. In this research, a total of 16 Sahiwal cross Friesian calves with a 100 ± 10 kg body weight and an age of about 60 ± 10 days were selected. The data about these variables was taken from the stock register of the farm. All the experimental animals were medicated for ecto and endoparasites before starting the trial. Total mixed ration (TMR) was formulated according to AOAC (AOAC, 2000) and was offered to experimental animals. Animals were then randomly assigned to four treatment groups: A (routine farm diet (TMR), control), B (total mixed ration + 20% barley silage), C (total mixed ration + 40% barley silage), and D (total mixed ration + 60% barley silage). Each group had 4 replicates, and rations were offered morning and night in a day. Water was available to animals a*d libitum*. Trial lasted for 90 days, consisting of 15 days for the adaptation period and 75 days for the collection of data. *Table 1*. lists the chemical composition and content of the experiment diets.

Table 1. Ration formulation for the experimental animals (%/kg)

Nutrients	Barley Silage	Wheat straw	Mustard seed cake	Cotton seed cake	Corn gluten 30%	Wheat bran	Maize grain	Molasses
CP	12.00	3.00	30.90	25.00	21.70	17.00	9.40	6.00
DM	41	88	90	90	80	88	87	75
Ca	0.33	0.2	0.4	0.16	0.03	0.1	0.01	0.8
P	0.26	0.05	0.8	0.5	0.5	1	0.25	0.05
NDF	47	75	25	30	30	40	8	-
ADF	30.5	52	16	22	10	10	4	-
CF	30	35	12	10	8	9	2	-
NE	1.48	0.3	1.3	1.0	1.5	1.3	2.2	1.8
Ash	4.7	5	7	5	5	5	2	9
CEE	3.3	0.5	8	6	2	4	3	0.1

Study parameters

To compute nutrient intake of animals on a regular basis, feed refusal was subtracted from the offered feed as feed intake = (offered feed – refused feed)**.** For determining body weight, initial and final body weights were measured using an electronic floor scale. Body weight gain (BWG) was calculated as:

BWG (kg)=Final body weight (FBWG) −Initial body weight (IBWG)

Feed Efficiency (FE) was calculated by using the following formula:

FE (kg) = gain in body weight (kg)/feed intake (kg)

To calculate nutrient digestibility, the total collection method of feed samples was used. Feed samples were collected from all animals in each treatment group, including both the feed given to the experimental animals and any remaining feed. All the feed samples were taken at the end of the trial and were mixed. 5% of the representative sample from mixed samples of feeds was placed in polythene bags and stored till proximate/chemical analysis. Similarly, fecal samples were collected from all experimental animals in all the treatment groups and were mixed. 10% of the representative fecal sample was taken into polythene bags and was stored at - 20 °C till chemical analysis. Proximate analysis of feeds and faeces was done in the laboratory of the department of animal nutrition of the University of Agric. Peshawar (UAP). Samples of feed were obtained and dried at 60 °C in the oven. Then the dried samples were crushed through a Thomas Willy miller in a 1 mm sieve. The ground samples were then further analyzed according to the method of AOAC (AOAC, 2000) for proximate analysis (Ash, DM, CP contents, EE and CF) while NDF, ADF and ADL were examined using van soest method (Van Soest et al., 1991). To find the digestibility proportion. Nutrients extracted from faeces were deducted from nutrients obtained from feed. It is a standard method that is commonly used in digestibility studies with large animals. To calculate the percentage of digestibility the difference between the nutrients present in the offered feed and the nutrients present in the faeces was calculated.

$$\text{Digestibility \%} = \frac{\text{Nutrient Intake in Feed} - \text{Nutrient Excreted in Faeces}}{\text{Nutrient Intake in Feed}} \times 100$$

Blood profile was analyzed according to the modified method of Direkvandi and Kamyab Kalantari (Direkvandi and Kamyab Kalantari, 2018). Approximately 10 ml of blood were collected aseptically from jugular veins prior to 2 to 3 hours of morning feeding using EDTA tubes containing an anticoagulant. The blood samples were left for coagulation at 4°C for an entire day and centrifuged at 4000 rpm for 10 min to separate plasma serum. Then serum was frozen at −20°C and analyzed for total proteins, total cholesterol, glucose and blood urea nitrogen (BUN) at the National Veterinary Laboratory Islamabad.

Statistical analysis

Data were inserted in an excel sheet and analyzed using RCBD design in the SPSS statistical program, version 20 (Pallant, 2020). Significant differences among treatments were determined using the Tukey multiple comparison test. Mean values will be compared in *LSD* at the 0.05 level of significance.

Results

Results on mean values of growth performance parameters per day/animal across different nutritional treatments are described in *Table 2*. DMI/day/animal exhibited significant ($P < 0.05$) variations across the dietary treatments. The average DMI at proportions of 20%, 40% and 60% of barley silage was 4.9, 5.5 and 5.8 kg/day, respectively (*Table 2).* The average body weight growth per animal following different dietary interventions showed non-significant differences ($P > 0.05$) and ranged from 600 to 900 g. The mean values of body weight gain for barley silage at 20, 40 and 60% proportions were 0.7 kg, 0.6 kg and 0.8 kg, respectively. Notably, gain in body weight was higher (0.8 kg/day/animal) with 60% barley silage in contrast to alternative treatments. Feed efficiency per animal showed statistical differences ($P < 0.05$) with a value (0.18 kg) obtained from 60% barley silage proportion (*Table 2).*

Results on nutrient digestibility percent are shown in *Table 3*. Nutrient digestibility across the different groups showed statistical differences ($P<0.05$). Dry matter digestibility ranged from (56.8 to 68.5%), crude protein digestibility (70.1 to 78.0%), neutral detergent fiber digestibility (61.2 to 67.2%), while acid detergent fiber digestibility was (59.5 to 67.3%).

Results for percent blood profile are shown in *Table 4*. The parameters analyzed showed differences statistically ($P < 0.05$) with blood glucose ranging from 60.6 to 70.6 mg/dl, total protein from 59.0 to 68.7 g/l and blood urea nitrogen from 14.2 to 19.2 mg/dl.

Table 2. Effect of different proportions of barley silage on growth performance (kg/day) of Sahiwal x Fresian calves

Groups	Treatment	DMI	BWG	Feed Efficiency
A	Routine diet (control diet)	3.8 ± 0.01^{b}	0.6 ± 0.12^{b}	0.15 ± 0.16^{b}
B	Total Mixed Ration (TMR) + 20% barley silage	3.9 ± 0.06^{b}	0.7 ± 0.09^{b}	0.17 ± 0.11^{ab}
C	Total Mixed Ration (TMR) + 40% barley silage	4.5 ± 0.08^{a}	0.7 ± 0.15^{b}	0.16 ± 0.10^{b}
D	Total Mixed Ration (TMR) + 60% barley silage	4.7 ± 0.11^{a}	0.9 ± 0.11^{a}	0.18 ± 0.13^{a}
	P-value	0.03	0.04	0.05

Mean values with different superscripts within same column are significantly different at 0.05.

Table 3. Effect of different proportions of barley silage in total mixed ration on nutrients digestibility (%) in Sahiwal x Friesian calves

Groups	Treatment	Dry Matter Digestibility(DMD) %	Crude Protein Digestibility(CPD) %	NDF digestibility %	ADF digestibility %
A	Routine diet (control diet)	56.8±0.7^{c}	70.1 ± 1.3^{c}	61.2± 1.9^{c}	59.5± 1.1^{b}
B	TMR+20% barley silage	59.9±1.5^{c}	70.8 ±2.6^{bc}	61.9 ± 1.5^{bc}	61.3 ± 1.5^{b}
C	TMR+40% barley silage	64.3±2.1^{b}	73.8±2.4^{b}	62.6 ± 2.5^{b}	62.4± 2.8^{b}
D	TMR+60% barley silage	68.5±1.5^{a}	78.0 ±0.8^{a}	67.2± 2.1^{a}	67.3 ± 3.1^{a}
	P-value	0.03	0.04	0.04	0.05

Mean values with different superscripts within same column are significantly different at 0.05.

Table 4. Effect of different proportions of barley silage in total mixed ration on blood profile of Sahiwal x Friesian calves

Groups	Treatment	Blood glucose (mg/dl)	Total proteins (mg/dl)	Blood urea nitrogen (mg/dl)
A	Routine diet (control diet)	60.6±0.16^{b}	59.0±0.11^{c}	14.2±0.15^{c}
B	Total mixed ration + 20% barley silage	63.4±0.11^{ab}	64.0±0.09^{b}	15.6±0.23^{b}
C	Total mixed ration + 40% barley silage	67.3±0.10^{b}	66.7±0.22^{ab}	17.6±0.20^{ab}
D	Total mixed ration + 60% barley silage	70.6±0.13^{a}	68.7±0.19^{a}	19.2±0.19^{a}
	P-value	0.05	0.03	0.02

Mean values with different superscripts within same column are significantly different at 0.05.

Discussion

DMI per animal/day differed substantially between groups in the current research and ranged up to 4.7 kg/day. The variation in DMI can be attributed to the palatability of the different proportions of barley silage in the TMR. DMI is a crucial aspect of animal nutrition, influencing the availability of nutrients for health and production (Carey et al., 2023). In the present study, DMI results are in line with the result reported on DMI by feeding animals on a total mixed ration along with barley silage proportions (Koenig and Beauchemin, 2013; Smerchek et al., 2020). Similarly, (Zaman et al., 2002) also found a similar range of DMI in their studies on the feeding proportion of barley silage in total mixed ration in finishing feedlot cattle. The observed differences in DMI between this study and others (Lees et al., 2022; Rajendran et al., 2022; Rombach et al., 2023) could be attributed to the variations in the quality of barley silage including harvesting and management practices (Liebert et al., 2023; Fu et al., 2022; Zhao et al., 2022; Nuraeefar et al., 2024; Koenig and Beauchemin, 2013).

Before an animal's diet can be accurately assessed, a component called dry matter intake (DMI) needs to be evaluated. However, the concept of DMI is often misunderstood. The rate at which feed passes through the animal's digestive system, specifically the rumen, has a crucial role in determining the amount of low-energy, high-fiber meals that the animal consumes (Tabler Jr, 2004). In the meantime, the animal's energy requirements and metabolic variables regulate the ingestion of highly digestible, high-energy, low-fiber foods. Although these ideas appear straightforward, there are many other factors that affect DMI that are not fully understood. A mature animal will typically ingest 1-3% of its body weight (BW) depending on the quality of its feed (Herd and Arthur, 2009).According to the previous study shows that green pasture can be consumed at a rate of 2-3% of body weight (BW) while lower-quality feeds may only be consumed at a rate of 1-2% of body weight (Berça et al., 2021;Greenwood, 2021). An animal's intake is influenced by its size, stage of development, production level and body condition. Other factors that influence intake include the type and amount of supplements given, the environment as well as the quality and availability of the forage. In diets high in fiber how quickly the feed moves through the digestive system and how easily it's digested have a big impact on how much an animal will eat. If the feed is easier to digest it passes through the system faster allowing the animal to eat more (Svihus, 2014). On the other side, low-quality roughage like straw will digest more slowly than feed of superior quality. Reduced feed intake results from a protein deficit in the feed (less than 6-8%) and this frequently happens when cattle are fed low-quality roughage such as straw or maize stalks. This is why adding more protein improves the digestibility of roughage and increases how much the animal can eat (DMI). The rumen microorganisms require protein in order to grow and break down cellulose. DMI may also be affected by palatability and highly palatable feeds encourage greater intake. Body weight gain/day/animal reached a standard body weight gain of 0.9 kg. This aligned with similar findings in Sahiwal x Fresian calves reported by (Addah et al., 2016; Preston et al., 2017). Discrepancies in body weight gain among studies (Sutherland et al., 2020; Sun et al., 2021; Keno et al., 2021; Pereira et al., 2021) might be attributed to variations in barley silage treatments affecting fiber fraction and subsequently influencing body weight gain.

Feed efficiency represents the nutrients obtained from a given diet for body weight gain across different dietary treatments of barley silage in TMR and it was 0.18 kg/day/animal in the present study. Similar results were obtained on the feed efficiency of a ration with barley silage (Johnson et al., 2020; Khakbazan et al., 2022; Chibisa et al., 2020) . In contrast to the study, (Addah et al., 2015; Refat et al., 2018) observed no significant difference in feed efficiency with barley silage in a total mixed ration.

The nutrient digestibility of barley silage is generally lower compared to green roughages and concentrates. In the present study the nutrient digestibility showed greater variations amongst the treatments. Results on DM, CPD, NDF and ADF digestibility are in line with findings of (Nair et al., 2016). However the present results are in contrast with those of (Manni et al., 2017) who observed comparatively higher values of nutrient digestibility. These differences can be attributed to factors such as variations in environmental growing conditions, the maturity stage of the barley when harvested for silage, and the use of different barley varieties (Sun et al., 2021).

Variations were observed in blood glucose concentration in the present study, potentially due to the variable metabolic rate of glucose utilization from different proportions of barley silage. This change in glucose level may be regulated by the homeostatic mechanism of the animal body. Tiwari and Yadava (1994) reported similar findings on blood glucose concentration. However, in contrast (Son et al., 1996) observed higher changes in blood glucose. Additionally, no significant differences were observed in plasma glucose, blood urea nitrogen (BUN) and total protein levels in calves fed silage, as reported by (Khan et al., 2007).These diverse results could be linked to variations in the initial feed processing techniques used in these research, such as mashed versus pelleted.

Conclusion

In the present research, improved growth performance, nutrient digestibility and enhanced blood profile were observed with TMR+60% barley silage compared to other treatments. Based on present results, it was recommended that inclusion of 60% barley silage in the total mixed ration is advised to obtain more favorable results on body growth outcomes, nutrient digestibility and blood profile of Sahiwal cross Friesian calves.

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Further research is recommended to explore the impact of barley silage on ruminal fermentation, nutrient profiles and milk yield and composition of dairy cows.

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Contribution of Authors

Naseer Ahmad & Muhammad Mobashar: Planned the study, performed the experiments, wrote the first draft, performed the statistical analysis.
Hao Yuan, Lei Zhang, Niu Chen, Zhongshi Zhu, Tingting Chu, Chu Yujian, Yue Jiang & Jiaxin Liu: Planned and supervised the study, reviewed the literature, analyzed the data, wrote and revised and edited the manuscript.
Yuxuan Song, Hao Yuan & Lei Zhang: Acquired funds for the study.

All authors read and approved the final draft of manuscript.

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