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Effect of feeding *Moringa oleifera* stems on milk yield and milk composition of Sahiwal cows

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Abstract
The present experiment was carried out at Bull Mother Farm at Visora, Wadsa and Department of Livestock Production and Management, Nagpur Veterinary College, Nagpur to study the effect of feeding *Moringa oleifera* stems on the performance of Sahiwal cows for a period of 90 days. A total of 12 lactating Sahiwal cows were randomly divided into two groups: Control (T_0) and Treatment (T_1). The animals of T_0 group were fed with a regular diet and T_1 group 20% of concentrate was replaced with Moringa stem meal. The milk yield and milk composition (milk fat, SNF, protein and lactose) were recorded at fortnight interval and it was observed a statistical significant rise in milk yield, milk fat, protein and lactose except SNF in the T_1 treatment group.

Keywords: *Moringa oleifera*, Sahiwal cows, milk yield, milk composition

1. Introduction
The livestock sector is an important sub-sector of Indian Agriculture and the Indian Economy. Milk production during 2023-24 is 239.30 million tones showing annual growth of 3.78% with per capita availability of 471 gm/day (BAHS, 2024) [4].
Sahiwal is popularly known for its high milk production, even under harsh environmental conditions, and also for its excellent tolerance to ticks. Sahiwal is well-known zebu cattle for its superior dairy qualities and is exported to many countries for both cross and pure breeding purposes (Maule, 1990) [16].
Livestock has traditionally held a special role in the lives of Indians and is expected to be continued. The demand for feed and fodder for cattle far surpasses the supply. The number of livestock is growing rapidly, but the grazing lands are gradually declining due to pressure on land for agricultural and non-agricultural uses. Forage source and nutrient composition hold significant importance for dairy production systems due to the cost of concentrates, which is a serious constraint for smallholder farms when the dietary protein sources are restricted or the cost is unaffordable. In the past few decades, many efforts have been made to explore less-expensive ingredients such as agricultural by-products, tree foliage, and plant leaves to supply adequate nutrients. Feed and fodder deficiencies are major limiting factors in raising livestock productivity. Fodder markets are important for communities, which have limited ability to produce their own, but need quality fodder at reasonable prices to produce milk at a competitive cost.
The silvi-pastoral system is a fresh way of improving the grazing system *Moringa oleifera* is attaining popularity as livestock fodder because of its higher levels of nutrient content and lesser anti-nutritional factors. *Moringa oleifera* is the most popularly cultivated tree species among the family Moringaceae (Bellostas *et al.*, 2010) [5]. This plant is native to India and Pakistan (Verdcourt, 1985; Morton, 1991; Duke, 2001) [31, 18, 7] but is widely cultivated, distinctly in dry tropical areas of the Middle East and Africa (Faye, 2011; Palada *et al.*, 2007; Nouman *et al.*, 2014) [9, 24, 20]. It can be grown well in humid tropics or hot dry lands and can exist in less fertile soils with the limited effect of drought conditions (Anwar *et al.*, 2007) [2]. Moringa is a good alternative for substituting commercial rations for livestock. The comparative ease with which Moringa can be propagated through both sexual and asexual means and its low demand for soil nutrients and water later planted, accomplish production and management comparatively easily. Its higher nutritional quality and greater biomass production, especially in dry periods, support its significance as livestock fodder.

One of its main characteristics is its adaptability, since it can be grown as crop or tree fences in alley cropping systems, in agroforestry systems, and even on marginal lands with high temperatures and low water availabilities where cultivation of other crops is challenging.

Many researchers investigated the effect of *Moringa oleifera* leaves on the productive performance of dairy cows, sheep, goats, and laying hens and the growth and carcass characteristics of rabbits, broilers, etc (Sanchez *et al.*, 2006, Khalel *et al.*, 2014) [25, 13]. However, the researches on the use of *Moringa oleifera* leaf and stem in ruminants are scanty and requires further experimentation to evaluate its use as a replacement for protein source in a concentrate mixture. Recently, it has been increasingly considered an alternative ingredient for animal feed because of its high content of protein, vitamins, and minerals (Zeng *et al.*, 2019) [32]. Its different parts are sources of proteins, vitamins, and minerals and present different pharmacological and biotechnological potentials. The leaves of moringa are a good source of antioxidant compounds such as ascorbic acid, flavonoids, phenolics, and carotenoids and also possess medicinal properties. The moringa species have high crude protein with higher nutritive value in terms of energy content and organic matter digestibility. The nutrient profile of Moringa reflects that it has the potential for alternative animal feed resources in tropical countries during scarcity. The stem of *M. oleifera* is willingly consumed by cattle, sheep, goats, pigs, chickens, ducks, and rabbits in their diet. The plant has been used to enhance the health status, growth performance, milk production, and meat quality of several livestock species. However, the reports on the effect of supplementation of *Moringa oleifera* stem in large ruminants are scanty, therefore, the present investigation was planned to study the effect of feeding *Moringa oleifera* on milk yield and milk composition of Sahiwal cows.

2. Methodology

The present study was conducted at Bull Mother Farm at Visora, Wadsa, District-Gadchiroli (M.S.) and Department of Livestock Production and Management, Nagpur Veterinary College, Nagpur.

2.1 Preparation of *Moringa* Stem Meal (MSM)

The *Moringa oleifera* trees of fodder variety (PKM-1) was grown at Cattle Breeding Farm, NVC, Nagpur. For the experiment, stems (with little leaves) four to five feet in height were harvested and chaffed into one inch with a chaff cutter. The chaffed stems were dried under shade for seven days till the moisture was reduced to 10%, then ground into powder at a Feed Mill, Cattle Breeding Farm, and stored in bags at room temperature.

2.2 Duration of experiment work

The total duration of the experiment work was for 90 days. The experiment was started in the month of September 2022 and lasted up to November 2022.

2.3 Selection of Cows

A total of 12 Sahiwal cows of early stage of lactation were selected for the experiment and were divided into two groups viz. Control (T_0) and Treatment (T_1).

2.4 Housing and Management

Standard management practices were adopted during the research work. The animals were kept in well-ventilated, concrete-floored houses and fed individually. They were provided with fresh, clean water *ad libitum* thrice a day. Sheds were kept clean and in hygienic condition. All the animals selected were dewormed with Albendazole @ 7.5 mg/kg of the body weight before starting the experiment.

2.5 Feeding strategies

To the T_0 group, the standard diet practiced at the farm was offered as per ICAR 2013 [10] standards and in the T_1 group dry fodder, as well as green fodder feeding remains the same as practiced at the farm, but concentrate (20%) was replaced with dried and powdered *Moringa oleifera* stems.

Table 1: Feeding schedules of cows under different groups

Group	No. of Cows	Feeding Diet
T_0	06	66:34:: (green + dry):Concentrates
T_1	06	66:34::(green + dry):Concentrates (80%) + MSM (20%)

2.6 Experimental Design:

Six cows were kept as the control group (T_0) with the Standard diet practiced at the farm and Six cows were kept as the treatment group (T_1). The diet offered for the treatment group (T_1); Dry fodder, as well as green fodder feeding, remained the same as practiced at the farm but concentrate (20%) was replaced with dried *Moringa oleifera* stems.

Table 2: Amount of green fodder, dry roughages and concentrates fed to experimental cows

Treatment group	Ration			
	Green fodder	Dry roughage	Concentrate	MSM (20%)
T_0	8.069 kg	3.636 kg	2.612 kg	---
T_1	8.069 kg	3.636 kg	2.089 kg	0.525

2.7 Proximate Analysis

The feed and fodder offered were analyzed for various proximate principles viz., moisture, crude protein (CP), crude fiber (CF), total ash (TA), and ether extract (EE), according to methods of the Association of Official Analytical Chemists (AOAC, 2000) [3].

Moisture

The method involves drying a sample in an oven and determining moisture content by the weight difference between dry and wet material. About 50-60 g samples of feed and fodder offered were taken in pre-weighed metallic trays and kept in a hot air oven at 100±0.50 °C overnight. The loss in the weight of samples due to evaporation is the moisture content of the sample.

Crude Protein (CP)

Nitrogen present in the samples of feed was estimated by Micro-Kjeldahl's method of AOAC (2000). The nitrogen content was multiplied by a factor of 6.25 to calculate the crude protein content.

Crude Fibre (CF)

About 2 g fat-free dried sample was taken in a spout-less tall beaker. It was boiled with 100 ml of 1.25% sulphuric acid for 30 minutes. Thereafter it was filtered through a muslin cloth and repeatedly washed with hot water till it becomes acid-free. Then it was transferred into the same beaker

containing 100 ml of 1.25% NaOH solution and boiled for 30 minutes. It was then made alkali free through continuous washing with hot water. The residue left was transferred to the previously weighed silica crucible. Then it was dried at 100±0.50 °C in a hot air oven for 12 hrs. The dried material was ignited in the muffle furnace at 600 °C for 2 hours. The loss of weight was considered as the crude fiber content of the sample.

Ether Extract (EE)

About 1 g of dried powdered samples were taken in a readymade thimble. The samples were extracted continuously for 4-6 hours with petroleum ether (400-600 °C boiling point) in a modified Soxhlet extraction apparatus. The ether extract was calculated by the difference in the weight of the oil flask before and after extraction.

2.8 Milk yield and Milk Composition

Milk Yield: Daily morning and evening milk yield was recorded throughout the experimental period.

Milk Composition: The milk composition of each animal was analyzed with an Automatic milk Analyser KURIEN ULTRA SCAN machine at fortnight intervals of the experiment for Fat %, SNF %, Protein % and Lactose %.

2.9 Statistical analysis

The significance of the difference between different groups was estimated by using Snedecor and Cochran, 1994 [28].

3. Results

3.1 Proximate Analysis of feed samples

The results of the Proximate analysis of feed samples include moisture, crude protein (CP), Crude fiber (CF), Ether extract (EE), Nitrogen free extract (NFE), total ash (TA) of Green fodder, Dry roughage, concentrate, and MSM are presented below

The CP of MSM was 20.74 % in the present experiment. The Proximate analysis of feed samples revealed that the CP % of MSM was more than the CP % of the concentrate mixture. This implies that *Moringa oleifera* can be used as a protein source in animal feed.

The CF of MSM (Moringa stem meal) was reported to be 17.5 in contrast and the EE of MSM was 3.2% in the present experiment. The variation of values in the proximate analysis may be due to differences in soil type, stage of plant cultivation, harvest, post-harvesting treatment, climatic condition of the cultivation area, and season of harvesting.

Table 3: Proximate analysis of feed samples

	Green Fodder	Dry Roughage	Concentrate	MSM
Moisture %	80.17	12.00	8.11	10.20
Crude protein %	3.90	4.90	20.00	20.74
Crude fiber %	32.00	44.00	10.00	17.50
Ether extract %	2.70	3.05	3.75	3.20
NFE %	37.67	24.88	45.74	33.76
Ash %	3.90	11.17	12.4	14.6

3.2 Milk yield and milk composition

The average daily milk production in litres of Sahiwal cows of the control group was 4.853±0.104 and the treatment group was 5.047±0.269 at the start of the experiment (Table 4 and Figure 1). The pooled values of control and treatment were 5.440±0.095 and 6.287±0.175 respectively. By the end of the experiment, increase in milk production was observed at 6.355±0.100 of control and 6.972±0.174 of treatment.

Table 4 shows the average fat percentage of the control and treatment groups at fortnight intervals. The average milk fat % of Sahiwal cows of the control group was 3.437±0.196 and the treatment group was 3.772±0.209 at the start of the experiment. By the end of the experiment, an increase in milk fat % was observed at 3.747±0.170 of control and 4.505±0.142 of treatment. The pooled values differ significantly (p<0.05).

The SNF's average percentages at fortnight intervals were summarized in table 5 and figure 2. During the trial, it is observed that the percentage of SNF in the control and treatment groups did not differ significantly. However, the SNF % of T_0 and T_1 at the beginning of the experiment was 8.388±0.146 and 8.480±0.234 respectively. By the end of the experiment SNF % of T_1 was 8.978±0.241and that of the T_0 was 8.655±0.165. The pooled averages of control and treatment groups were 8.528±0.157 and 8.706±0.235 respectively.

The average percentage of milk lactose in the control group was 4.540±0.098 and of treatment was 4.612±0.107 at the start of the experiment. A significant increase (p<0.05) in milk lactose was observed in the group fed with Moringa. By the end of the experiment, the average lactose percentage of the treatment group was 5.068±0.110 and that of the control group was 4.758±0.099. The pooled averages of milk lactose in control and treatment groups by the end of experiment were 4.074±0.113 and 4.821±0.090 respectively.

The average milk protein percentages of the control and treatment groups were 3.158±0.071 and 3.235±0.180 at beginning of the trial respectively. During the experimental trial, there was a significant difference (p<0.05) in milk protein percentages from the Moringa-fed group to that of the control group. By the end of the experiment, the milk protein's average percentage of the treatment group was 3.903±0.199 and that of the control group was 3.370±0.073. however, the pooled averages were 3.261±0.073 and 3.604±0.189 of control and treatment groups respectively.

Table 4: Mean and S.E. of Milk Yield and Milk Fat in Sahiwal Cows

Groups	0th	15th	30th	45th	60th	75th	90th	Total
Milk Yield (Liters)								
T_0	4.853±0.104	4.940±0.124	5.152±0.078	5.330±0.100	5.503±0.129	5.948±0.116	6.355±0.100	5.440^{b}±0.095
T_1	5.047±0.269	5.928±0.142	6.227±0.190	6.407±0.188	6.575±0.164	6.857±0.169	6.972±0.174	6.287^{a}±0.175
CD								0.296
Pooled	4.950±0.186	5.434±0.133	5.690±0.134	5.869±0.144	6.039±0.147	6.403±0.142	6.667±0.137	5.864±0.135
Milk Fat (%)								
T_0	3.437±0.196	3.598±0.240	3.610±0.189	3.628±0.168	3.657±0.169	3.690±0.170	3.747±0.170	3.620^{b}±0.179
T_1	3.772±0.209	3.908±0.227	3.940±0.197	4.143±0.182	4.247±0.156	4.405±0.142	4.505±0.142	4.131^{a}±0.167
CD								0.213
Pooled	3.603±0.203	3.753±0.234	3.775±0.193	3.886±0.175	3.952±0.163	4.048±0.156	4.126±0.156	3.877±0.173

The pooled averages values within columns bearing superscripts a and b, differ significantly at $p<0.05$.

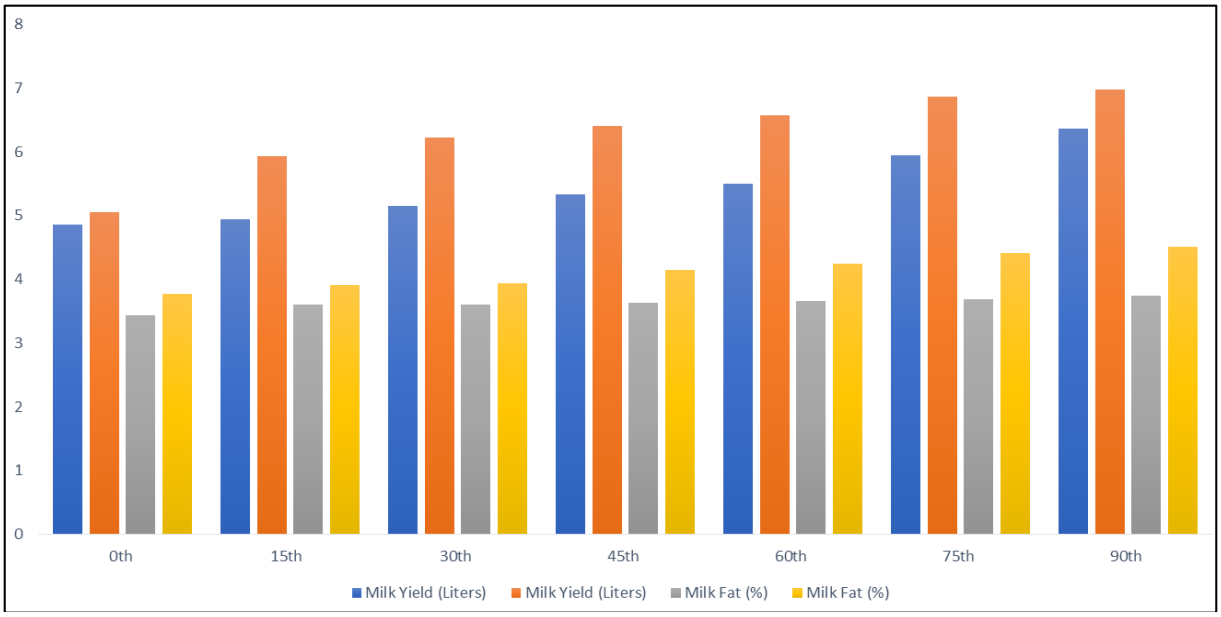

Fig 1: Milk yield and milk fat % at fortnightly interval

Table 5: Mean and S.E. of SNF, Lactose and Protein in Sahiwal Cows

Groups	0th	15th	30th	45th	60th	75th	90th	Total
	SNF (%)							
T_0	8.388±0.146	8.430±0.148	8.487±0.159	8.533±0.162	8.585±0.161	8.620±0.166	8.655±0.165	8.528±0.157
T_1	8.480±0.234	8.558±0.233	8.610±0.238	8.715±0.228	8.758±0.233	8.845±0.241	8.978±0.241	8.706±0.235
CD								NS
Pooled	8.434±0.190	8.494±0.191	8.548±0.198	8.624±0.195	8.672±0.197	8.733±0.203	8.817±0.203	8.617±0.196
	Lactose (%)							
T_0	4.540±0.098	3.598±0.240	3.610±0.189	4.663±0.085	3.657±0.169	3.690±0.170	4.758±0.099	4.074^{b}±0.113
T_1	4.612±0.107	4.663±0.112	4.703±0.107	4.827±0.066	4.873±0.068	5.002±0.097	5.068±0.110	4.821^{a}±0.090
CD								0.218
Pooled	4.576±0.103	4.131±0.176	4.157±0.148	4.745±0.075	4.265±0.119	4.346±0.133	4.913±0.104	4.448±0.102
	Protein (%)							
T_0	3.158±0.071	3.185±0.071	3.240±0.066	3.250±0.090	3.293±0.077	3.328±0.074	3.370±0.073	3.261^{b}±0.073
T_1	3.235±0.180	3.365±0.182	3.535±0.208	3.638±0.208	3.735±0.194	3.817±0.195	3.903±0.199	3.604^{a}±0.189
CD								0.175
Pooled	3.197±0.125	3.275±0.127	3.388±0.137	3.444±0.149	3.514±0.135	3.573±0.134	3.637±0.136	3.432±0.131

The pooled averages values within columns bearing superscripts a and b, differ significantly at $p<0.05$.

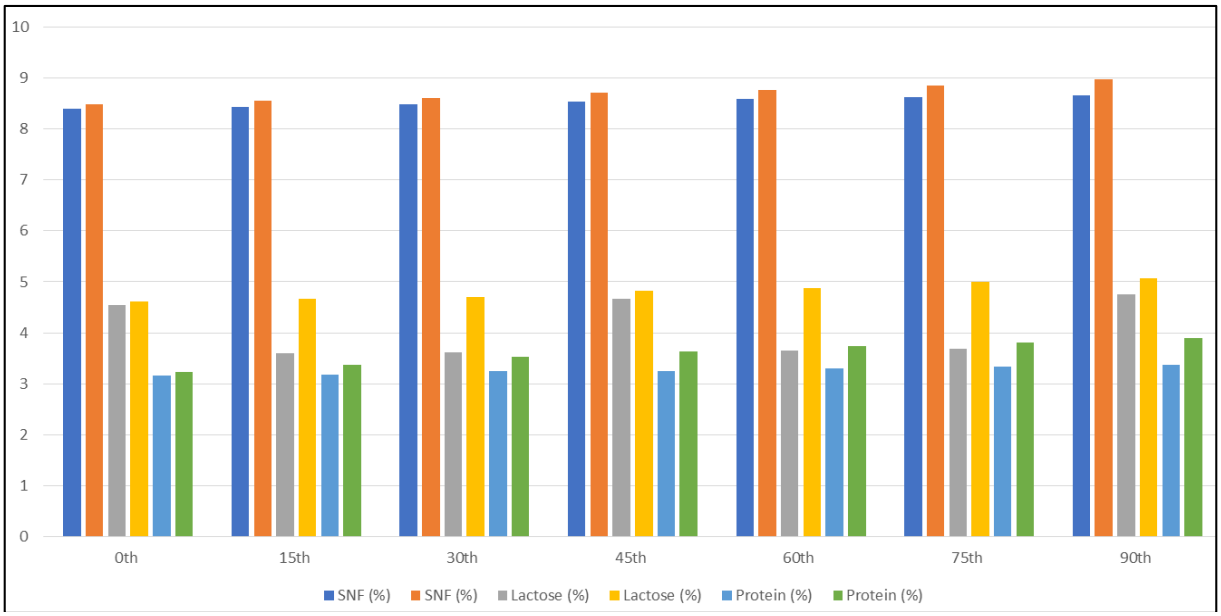

Fig 2: Milk SNF, Lactose and Protein

4. Discussion

4.1 Proximate Analysis of feed samples

The Crude protein of MSM was 20.74% in the present experiment and it was more than the Crude protein % (CP %) of the concentrate mixture. This implies that *Moringa oleifera* can be used as a protein source in animal feed. The results of CP values in the present study are close to Sultana *et.al.* (2015) [29] from *Moringa oleifera* foliage which is 23.91% and Navarro *et al.* (2019) [19] in *Moringa oleifera* meal reported CP of 20.20% from dried stems and leaves. Lanjwani *et al.* (2021) [15] in *Moringa oleifera* stems reported 28.3% of crude protein. However, the percentage of CP values of MSM differ from the trials conducted by Igwilo *et al.* 2011 [11]; Shih *et al.* 2011 [27]; Olaofe *et al.* 2013 [23]; Abdulkadir *et al.* 2016 [1]; Tope *et al.* 2017 [30]; El-Esawy *et al.* 2018 [8] and Setiboma *et al.* 2019 [26].

The Crude fibre of MSM was reported to be 17.5 in contrast to the previous work by El-Esawy *et al.* (2018) [8], Albulkadir *et al.* (2016) [1], Navarro *et al.* (2019) [19] had reported CF values of 33.6, 44.2 and 30.02 percentages respectively. The lower CF value added advantage for MSM, might be due to Soil type, plant variety, stage of harvesting and season of harvesting, etc.

The EE of MSM was 3.2% in the present experiment, which was nearer to the experimental values done by the researchers Navarro *et al.* (2019) [19] 3.1%, Ojjako *et al.* (2014) [21] 2.8%, Okiki *et al.* (2015) [22] 3.88%.

The variation of values in the proximate analysis may be due to differences in soil type, stage of plant cultivation, harvest, post-harvesting treatment, climatic condition of the cultivation area, and season of harvesting.

4.2 Milk yield and milk composition

By the end of the experiment, increase in milk production was observed at 6.355±0.100 of control and 6.972±0.174 of treatment. The treatment group differ significantly (p<0.05). Experiments by El-Esaway *et al.* (2018) [8], Kholif *et al.* (2016) [14], Sanchez *et al.* (2006) [25] and Imran *et al.* (2016) [12] were also shown a higher milk yield in groups fed with *Moringa*.

The average milk fat % of Sahiwal cows of the control group was 3.437±0.196 and the treatment group was 3.772±0.209 at the start of the experiment. By the end of the experiment, an increase in milk fat % was observed at 3.747±0.170 of control and 4.505±0.142 of treatment. The pooled values differ significantly (p<0.05). Experiments by El-Esaway *et al.* (2018) [8], Chowdary *et al.* (2018) [6], and Imran *et al.* (2016) [12] were also shown significant difference in fat content in groups fed with *Moringa*. However, Kholif *et al.* (2016) [14] and Sanchez *et al.* (2006) [25] recorded a non-significant difference.

The percentage of SNF in the control and treatment groups did not differ significantly throughout the experiment. El-Esaway *et al.* (2018) [8], Mendieta-Araica *et al.* (2011) [17] and Imran *et al.* (2016) [12] recorded the higher SNF content in groups fed with Moringa. However, Kholif *et al.* (2016) [14] and Chowdary *et al.* (2018) [6] recorded a non-significant difference in milk SNF.

The average percentage of milk lactose in the control group was 4.540±0.098 and of treatment was 4.612±0.107 at the start of the experiment. A significant increase (p<0.05) in milk lactose was observed in the group fed with Moringa, by the end of the experiment. The average lactose percentage of the treatment group was 5.068±0.110 and that of the control group was 4.758±0.099. The pooled averages of milk lactose in control and treatment groups by the end of experiment were 4.074±0.113 and 4.821±0.090 respectively.

The average milk protein percentages of the control and treatment groups were 3.158±0.071 and 3.235±0.180 at beginning of the trial respectively. During the experimental trial, there was a significant difference (p<0.05) in milk protein percentages from the Moringa-fed group to that of the control group. By the end of the experiment, the milk protein's average percentage of the treatment group was 3.903±0.199 and that of the control group was 3.370±0.073. however, the pooled averages were 3.261±0.073 and 3.604±0.189 of control and treatment groups respectively.

In the experiment conducted by El-Esaway *et al.* (2018) [8] in which different levels of Moringa stems were included 10% and 20% showed a rise in milk protein and milk lactose that of the control group. Similar results were recorded by Chowdary *et al.* (2018) [6]; Kholif *et al.* (2016) [14] and Imran *et al.* (2016) [12].

5. Conclusion

The proximate analysis of *Moringa oleifera* revealed that it is rich in proteins and could be used as a protein source in animal diets. The results of the present study revealed that feeding *Moringa oleifera* as in 20% replacement of concentrate is beneficial for improving milk production as it provides better nutrition to Lactating Sahiwal cows. Feeding of *Moringa oleifera* did not show any negative effect on blood and biochemical parameters that means, Moringa can be used as animal feed.

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