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Effect of dietary substitution of dried *Moringa oleifera* leaves on haematological parameters of Badri cattle of different age groups

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Abstract
India is an agrarian economy where animal husbandry goes hand in hand with agriculture. Presently, there are 50 registered breeds of cattle in India. Badri is the indigenous cattle breed of Uttarakhand which is used as for milk and draught purposes. The experiment was done to study the effect of feeding *Moringa oleifera* leaves on hematological parameters of Badri cattle. A total of 45 experimental Badri cattle of age groups 6-12 months, 12-18 months and in lactation were selected and the treatment group animals were fed with dried leaves of *Moringa oleifera* substituted in their concentrate feed twice a day @ 10% and 20% substitution rate for a period of 1 year. Blood samples collected and analysed periodically in the beginning and then at every 3-month interval till 1 year period showed an overall significant increase in the total erythrocyte count in T_2 sub-group in all the three groups with respective values of 5.90±.06, 6.09±.06 and 7.15±.06 million/ µL along with increase in haemoglobin concentration in T_2 sub-group for all the three groups with respective values of 13.11±.06, 12.18±.13 and 12.01±.12 gm %. The observations of treatment animals for total leucocyte count, packed cell volume and clotting time were also positively significant than control sub-group. Hence, *Moringa oleifera* leaves can be used for substitution in the concentrate feed of Badri cattle in hilly areas, where there is scarcity of traditional fodder crops, to improve the health status of animals.

Keywords: Badri, *moringa* leaves, concentrate, haematological parameters

Introduction
The role of livestock is significant in India's agricultural economy as it provides a means of subsistence and stimulation to the economy by helping the farmers to raise their earnings using it as an alternative source of income **(**Sati, 2016) [10]. Livestock are raised for meat, eggs, wool, leather, and fur with their use as draught animals in the areas where mechanization of agriculture has not taken place due to monetary or topographic limitations. Badri, a recently registered cattle breed of Uttarakhand, has long been reared by the hill households for its milk and draught value in the slopy hilly terrain of the state (Kumar and Gaur, 2016) [6]. *Moringa oleifera*, also called as miracle tree, is famous worldwide for its immense therapeutic and prophylactic properties which are utilized by human beings all over the world (Chuang *et al*., 2007; Oluduro, 2012) [2, 9]. The hilly and tarai regions of Uttarakhand are blessed with an immense population of *Moringa oleifera* trees which are used as a feed source (green fodder) for the livestock reared locally. The following study was done to evaluate the effect of feeding dried *Moringa* leaves as a dietary substitution to concentrate feed at two levels on the hematological parameters of Badri cattle divided into 3 different groups.

Materials and methods
The present study was undertaken to study the effect of feeding dried *Moringa oleifera* leaves on the performance of Badri cattle after its dietary substitution in their concentrate feed under farm conditions of Uttarakhand from April, 2021 to April, 2022 at Badri cattle unit of Instructional Dairy Farm, Nagla, College of Veterinary and Animal Sciences, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. The experimental trial was be conducted on 45 animals already present at Badri cattle unit of Instructional Dairy Farm, Nagla, GBPUAT, Pantnagar. The animals selected were in the range of 6-12 months, >12-18 months and lactation age-groups and were divided as per Table 1.

Table 1: Division of experimental Badri cattle in groups and sub-groups

Age groups	Control (t_0)	Treatment 1 (t_1)	Treatment 2 (t_2)
6-12 months	5	5	5
>12-18 months	5	5	5
In lactation	5	5	5
Total	15	15	15

The selected experimental animals were dewormed as per the standard schedule at least 10 days before the beginning of the experimental feeding trial. The trial was conducted for a period of 1 year where the animals were fed on green fodder, dry fodder and concentrate feed (both sole and mixed with dried *Moringa oleifera* leaves at two levels) as per the requirements of NRC 2001. The selection and feeding of experimental animals during the feeding trial was conducted as per Table 2.

Table 2: Experimental design showing the protocol of treatment on experimental animals

Age-groups		Control (n=15)	Treatment 1 (n=15)	Treatment 2 (n=15)
I	6-12 months (N=5)	Fed with sole concentrate feed as per the schedule of the dairy farm	Fed with concentrate feed substituted with 10% of dried *Moringa oleifera* leaves	Fed with concentrate feed substituted with 20% of dried *Moringa oleifera* leaves
II	>12-18 months (N=5)	Fed with sole concentrate feed as per the schedule of the dairy farm	Fed with concentrate feed substituted with 10% of dried *Moringa oleifera* leaves	Fed with concentrate feed substituted with 20% of dried *Moringa oleifera* leaves
III	In lactation (N=5)	Fed with sole concentrate feed as per the schedule of the dairy farm	Fed with concentrate feed substituted with 10% of dried *Moringa oleifera* leaves	Fed with concentrate feed substituted with 20% of dried *Moringa oleifera* leaves

The sole concentrate feed and *Moringa oleifera* leaves' substituted concentrate feed was fed twice a day (after milking time i.e., at 4 A.M. and 4 P.M.) to control and treatment animals, respectively, according to the body weight of individual experimental animal. *Moringa oleifera* leaves were collected from in and around of the campus of G.B. Pant University of Agriculture and Technology, Pantnagar as Pantnagar and its nearby areas are blessed with an ample number of *moringa* trees. These leaves were then be spread on the floor and dried. Concentrate feed required for preparing experimental *Moringa oleifera* substituted feed were procured from the feed unit of the Instructional Dairy Farm (IDF), GBPUAT, Pantnagar. Green and dry fodder to all the experimental animals was made available from the fodder unit of Instructional Dairy Farm, GBPUAT, Pantnagar in *ad libitum* amount as per the daily schedule of the farm.

Blood samples (10 ml each) were collected from aseptically left jugular veins of 45 Badri cattle of 6-12, >12-18 months and lactating age groups in EDTA vacutainers (Wittgenstein, 1953) [13] in the beginning and after 3rd month, 6th month, 9th month and 12th month of the experimental trial. The collected blood was used for estimation of Haemoglobin (Hb), packed cell volume (PCV), Total Erythrocyte Count (TEC), Total Leucocyte Count (TLC) and clotting time (CT) for all the experimental animals. Standard methods were used for estimation of haematological parameters as mentioned below:

Haemoglobin (Hb)

Haemoglobin (Hb) concentration was estimated following the method described by Sharma and Singh (2000) [11] using Sahli's haemoglobin meter with acid haematin method. Brown colour was matched with standard colour comparator and haemoglobin concentration (gm %) was recorded.

Total Erythrocyte Count (TEC)

Use of Neubauer's counting chamber was used to determine the total erythrocyte count (Jain, 1986) [4]. The Vallarino's solution was used to dilute the blood samples (Iodine 0.3 g, Potassium iodide 0.4 gm, Sodium citrate 2.0 gm and Distilled water 100 ml). Excess blood was cleaned off the pipette's stem after a well-mixed blood sample was sucked up to 0.5 marks in the RBC dilution pipette. To dilute the blood to 1:200, diluting fluid was gently and carefully drawn up to the 101-mark. To mix the blood and diluent, the pipette was rolled between the hands in a horizontal posture. Under a powerful microscope, one haemocytometer secondary square was focussed, and the counting region was covered with a cover slip. One drop of diluted blood was gently put between the cover slip and the haemocytometer slide after the first 2-3 drops of diluted blood were discarded, allowing the fluid to spread beneath the cover slip due to capillary action. Cells were given five minutes to settle down. We tallied the total number of cells at the four corners and the secondary square in the middle, for a total of 80 tertiary squares.

Total erythrocyte numbers were expressed in millions per micro litre (10^6/ µL) calculated as follows:

Total RBCs in 5 secondary squares = n

Volume of diluted blood in 5 secondary squares = (1/250) x 5 =1/50 ml

Since n is the no. of RBCs present in 1/50 ml of diluted blood. Therefore 1 µL of diluted blood had 50 x 200 RBCs (200 dilution factor), therefore, TEC of a sample was 10, 000 n/ µL of blood.

Total Leucocyte Count (TLC)

Total leucocyte count was performed with Neubauer's counting chamber (Jain, 1986) [4] using Thomas diluting fluid (2 ml glacial acetic acid, 1 ml 1% Gentian violet in 100 ml of distilled water). Excess blood was cleaned out from the pipette's stem after well-mixed blood samples were sucked up to the 0.5 level in the WBC dilution pipette. Blood dilution took place at the 11-second mark thanks to the infusion of diluting fluid. To mix the blood and diluent, the pipette was horizontally rolled between the palms. Under a low power microscope, one principal square (1 mm 2) of the haemocytometer was focused, and the counting region was covered with a cover slip. One drop of diluted blood was gently placed between the cover slip and the haemocytometer slide after the first 2-3 drops of diluted blood were discarded, allowing the fluid to spread beneath the cover slip as a result of capillary action. Cells were given five minutes to calm

down. Total numbers of WBCs were counted in all four primary squares (i.e. total 64 secondary squares). Number of total leucocytes were expressed in thousands per micro litre (10^3/µL) and calculated as follows:

Total WBCs in 4 primary square = n
Volume of 4 primary squares = (1/10) x 4 =0.4 ml
Since 0.4 µl of diluted blood contained n cells, so 1 µL of diluted blood had n/0.4=2.5 n and 1 µL of whole blood had 2.5 n x 20 = 50 n WBC (20 dilution factor), therefore, TLC of a sample was 50 n/ µL of blood.

Packed Cell Volume (PCV)
Packed cell volume was estimated using micro haematocrit method as described by Sharma and Singh (2000) [11]. Fresh anticoagulant blood was drawn into micro capillaries and sealed with wax at one end. Capillaries were centrifuged at 10,000 rpm for 3 minutes. Packed cell volume was directly read by using Citro Cap Micro-haematocrit tube reader and was expressed in percentage.

Clotting time (CT)
About 3 ml of blood in a clean dry hypodermic syringe or a dry test-tube was collected directly. The stop watch was started as soon as blood came out from the vein. Drop/ slide method was used to estimate the clotting time in which few drops of freshly collected blood were placed on a clean dry glass slide. The tip of the needle was passed through blood drop every 15 seconds and was looked for the appearance of fibrin thread. The time was recorded as CT when the first strand of fibrin was seen sticking to the tip of the needle.

Statistical analysis
The experimental data obtained in the present study was analyzed statistically applying one-way ANOVA by using SPSS software version 21 (Snedecor and Cochran, 1994) [12]. The significant mean difference was separated by Tukey post hoc analysis with significance level defined at $p< 0.05$.

Results and Discussion
The results obtained in the following study have been mentioned as follows:

Effect on Haemoglobin (Hb)
The average values of Hb of each group of Badri cattle measured after every 3 months from the beginning till the end of experimental period have been presented in the table 3.

From the beginning and after 3rd, 6th, 9th and 12th month of the trial respectively, the average values of Hb of T_1 sub-group in 6-12 months group (10.53±.11, 10.67±.12, 10.94±.12, 11.14±.13 and 11.29±.14 gm %) were higher and statistically significant ($p<0.05$) than T_0 sub-group (10.39±.05, 10.40±.05, 10.42±.04, 10.42±.04 and 10.43±.04 gm %). After 9th month of the trial, the average values of Hb of T_2 sub-group (11.46±.03 gm %) was higher and statistically significant ($p<0.05$) than T_1 (11.14±.13 gm %) sub-group while against T_0 sub-group, they were higher and statistically significant ($p<0.05$) from the beginning till the end of feeding trial. The overall observations of Hb of T_2 sub-group were higher and statistically significant ($p<0.05$) than C and T_1 sub-groups.
After 6th, 9th and 12th month of the trial respectively, the average values of Hb of T_2 sub-group in >12-18 months age group (11.19±.13, 11.46±.14 and 11.84±.15 gm %) were higher and statistically significant ($p<0.05$) than T_0 (10.88±.19, 10.89±.19 and 10.90±.19 gm %) and T_1 (10.97±.14, 11.08±.14 and 11.19±.14 gm %) sub-groups. The overall observations of Hb of T_2 sub-group were higher and statistically significant ($p<0.05$) than T_0 and T_1 sub-groups.
After 3rd, 6th, 9th and 12th month of the trial respectively, the average values of Hb of T_1 sub-group (11.55±.05, 11.68±.04, 11.75±.03 and 11.80±.032 gm %) in lactating animals were found to be higher and statistically significant ($p<0.05$) than T_0 sub-group (11.25±.09, 11.26±.08, 11.27±.09 and 11.29±.09 gm %). After 3rd, 6th, 9th and 12th month of the trial respectively, the average values of Hb of T_2 sub-group (11.73±.12, 11.90±.11, 12.29±.12 and 12.77±.13 gm %) were higher and statistically significant ($p<0.05$) than T_0 sub-group (11.25±.09, 11.26±.08, 11.27±.09 and 11.29±.09 gm %), while against T_1 sub-group, the observations were higher and statistically significant ($p<0.05$) after 6th, 9th and 12th month of the feeding trial in lactating animals. The overall observations of Hb of T_1 and T_2 sub-groups were higher and statistically significant ($p<0.05$) than T_0 sub-group.
After feeding *moringa* leaves instead of concentrate, Kumar *et al*. (2020) [7] noticed an increase in haemoglobin levels of female Black Bengal goats. When fed varying levels of *moringa* leaves, Zaher *et al*. (2020) [14] reported a significant ($p<0.05$) increase in haemoglobin levels. An increase in haemoglobin content was seen in Badri cattle fed *moringa* leaves, indicating that feeding them boosts oxygen delivery to the body's numerous tissues. This increase in the haemoglobin content of Badri cattle's blood may be due to the iron-rich *moringa* leaves' substituted diet fed to the treatment animals.

Table 3: Average haemoglobin (gm %) of different groups of Badri cattle during the experimental period

Groups	Beginning	3 months	6 months	9 months	12 months	Overall
6-12 M						
T_0	12.39±.05^a	12.40±.05^a	12.42±.04^a	12.42±.04^a	12.43±.04^a	12.41±.05^a
T_1	12.53±.11^b	12.67±.12^b	12.94±.12^b	13.14±.13^b	13.29±.14^b	12.91±.12^a
T_2	12.49±.07^b	12.76±.07^b	13.24±.05^b	13.46±.03^c	13.61±.03^b	13.11±.06^b
>12-18 M						
T_0	11.87±.20	11.89±.20	11.88±.19^a	11.89±.19^a	11.90±.19^a	11.89±.19^a
T_1	11.53±.12	11.70±.12	11.97±.14^a	12.08±.14^a	12.19±.14^a	11.89±.13^a
T_2	11.57±.11	11.86±.12	12.19±.13^b	12.46±.14^b	12.84±.15^b	12.18±.13^b
Lactation						
T_0	11.26±.09	11.25±.09^a	11.26±.08^a	11.27±.09^a	11.29±.09^a	11.27±.09^a
T_1	11.42±.04	11.55±.05^b	11.68±.04^b	11.75±.03^b	11.80±.03^b	11.64±.04^b
T_2	11.36±.11	11.73±.12^b	11.90±.11^c	12.29±.12^c	12.77±.13^c	12.01±.12^c

Effect on total erythrocyte count (TEC)

The average values of TEC of each group of Badri cattle measured at every 3 months from the beginning till the end of experimental period have been presented in the table 4.

After 3rd, 6th, 9th and 12th month of the trial respectively, the average values of TEC of T_1 sub-group (5.64±.081, 5.76±.08, 5.84±.08 and 5.91±.09 million/ µL) in 6-12 months group were higher and statistically significant (p<0.05) than T_0 sub-group (5.47±.07, 5.48±.07, 5.49±.08 and 5.49±.08 million/ µL). After 6th, 9th and 12th month of the trial respectively, the average values of TEC of T_2 sub-group of 6-12 months group (6.02±.06, 6.11±.06 and 6.18±.06 million/ µL) were higher and statistically significant (p<0.05) than both T_0 and T_1 sub-groups, respectively. The overall observations of TEC of T_1 and T_2 sub-groups were higher and statistically significant (p<0.05) than C sub-group.

After 3rd, 6th, 9th and 12th month of the trial respectively, the average values of TEC of T_1 sub-group (5.90±.03, 6.10±.04, 6.18±.03 and 6.26±.04 million/ µL) in >12-18 months age group were higher and statistically significant (p<0.05) than T_0 sub-group (5.66±.10, 5.66±.11, 5.67±.10 and 5.65±.10 million/ µL). After 3rd, 6th, 9th and 12th month of the trial respectively, the average values of TEC of T_2 sub-group (5.79±.08, 5.93±.06, 6.14±.05, 6.25±.03 and 6.32±.03 million/ µL) in the same group were higher and statistically significant (p<0.05) than respective observations of T_0 sub-group. The overall observations of TEC of T_1 and T_2 sub-groups were higher and statistically significant (p<0.05) than T_0 sub-group.

After 3rd, 6th, 9th and 12th month of the trial respectively, the average values of TEC of T_1 sub-group (6.96±.01, 7.16±.06, 7.28±.10 and 7.37±.12 million/ µL) in lactating animals were higher and statistically significant (p<0.05) than T_0 group (6.47±.34, 6.48±.34, 6.48±.34 and 6.49±.34 million/ µL). After 3rd, 6th, 9th and 12th month of the trial respectively, the average values of TEC of T_2 sub-group (5.79±.08, 5.93±.06, 6.14±.05, 6.25±.03 and 6.32±.03 million/ µL) in the same group were higher and statistically significant (p<0.05) than T_0 sub-group. The overall observations of TEC of T_1 and T_2 sub-groups were higher and statistically significant (p<0.05) than T_0 sub-group.

Babeker and Abdalbagi (2015) [1] found that feeding *moringa* leaves at varied levels resulted in significant (p<0.05) differences in TEC in Sundan Nubian goats. The amount of oxygen the tissues receive is often correlated with the overall erythrocyte count (TEC). Glycine, which enhances oxygen availability and is important for cell formation, is found in *moringa* leaves which may be a reason in the increase of erythrocytes in the treatment animals.

Table 4: Average Total Erythrocyte Count (million/ µL) of different groups of Badri cattle during the experimental period

Groups	Beginning	3 months	6 months	9 months	12 months	Overall
6-12 M						
T_0	5.48±.09	5.47±.07^a	5.48±.07^a	5.49±.08^a	5.49±.08^a	5.48±.08^a
T_1	5.52±.08	5.64±.08^b	5.76±.08^b	5.84±.08^b	5.91±.09^b	5.73±.09^b
T_2	5.43±.06	5.76±.05^b	6.02±.06^c	6.11±.06^c	6.18±.06^c	5.90±.06^c
>12-18 M						
T_0	5.65±.10	5.66±.10^a	5.66±.11^a	5.67±.10^a	5.65±.10^a	5.66±.10^a
T_1	5.75±.03	5.90±.03^b	6.10±.04^b	6.18±.03^b	6.26±.04^b	6.04±.04^b
T_2	5.79±.08	5.93±.06^b	6.14±.05^b	6.25±.03^b	6.32±.03^b	6.09±.06^b
Lactation						
T_0	6.47±.33	6.47±.34^a	6.48±.34^a	6.48±.34^a	6.49±.34^a	6.48±.34^a
T_1	6.51±.03	6.96±.01^b	7.16±.06^b	7.28±.10^b	7.37±.12^b	7.12±.04^b
T_2	6.44±.07	6.95±.06^b	7.22±.06^b	7.36±.06^b	7.52±.07^b	7.15±.06^b

Effect on total leucocyte count (TLC)

The average values of TLC of each group of Badri cattle measured at every 3 months from the beginning till the end of experimental period have been presented in the table 5.

After 3rd, 6th, 9th and 12th month of the trial respectively, the average values of TLC of T_1 sub-group (7.38±.02, 7.44±.02, 7.46±.02 and 7.49±.03 thousands/ µL) in 6-12 months group were higher and statistically significant (p<0.05) than T_0 sub-group (7.27±.02, 7.28±.02, 7.28±.03 and 7.29±.03 thousands/ µL). After 3rd, 6th, 9th and 12th month of the trial respectively, the average values of TLC of T_2 sub-group of 6-12 months group (7.43±.06, 7.47±.07, 7.48±.07 and 7.50±.07 thousands/ µL) were higher and statistically significant (p<0.05) than T_0 sub-group. The overall observations of TLC of T_1 and T_2 sub-groups were higher and statistically significant (p<0.05) than T_0 sub-group.

After 12th month of the trial, the average values of TLC of T_1 sub-group (7.48±.02 thousands/ µL) in >12-18 months age group was higher and statistically significant (p<0.05) than T_0 group (7.40±.03 thousands/ µL). After the 3rd, 6th, 9th and 12th month of the trial respectively, the average values of TLC of T_2 sub-group (7.50±.02, 7.53±.02, 7.54±.02 and 7.55±.023 thousands/ µL) in the same group was higher and statistically significant (p<0.05) than T_0 group (7.38±.02, 7.40±.02, 7.40±.02 and 7.40±.03 thousands/ µL). The overall observations of TLC of T_2 sub-group were higher and statistically significant (p<0.05) than T_0 and T_1 sub-groups.

In the lactating animals after 3rd, 6th, 9th and 12th month of the trial respectively, the average values of TLC of T_2 sub-group (8.64±.15, 8.80±.15, 8.83±.14 and 8.85±.14 thousands/ µL) were higher and statistically significant (p<0.05) than T_0 group (8.03±.23, 8.04±.24, 8.09±.25, 8.10±.26 and 8.12±.27 thousands/ µL). The overall observations of TLC of T_2 sub-group were higher and statistically significant (p<0.05) than C and T_1 sub-groups.

Supplementing *moringa* leaves did not result in significant (p>0.05) difference in TLC levels of Sirohi goat kids, according to Meel *et al*. (2018) [8]. Jiwuba *et al*. (2017) [5] discovered that feeding varying levels of *moringa* leaves in the diet resulted in a significant (p<0.05) variation in TLC count in West African dwarf goats.

TLC helps animals fight off a variety of bacterial and viral infections, as well as toxins (Das *et al*., 1957) [3]. The potent antibacterial and antifungal effects of *moringa* leaves are due to its pterygospermin content. The animal did not have any active illnesses when the increase in TLC was seen in the current experiment because it was within the usual range. Hence, feeding of *moringa* leaves was not harmful for the Badri cattle.

Table 5: Average Total Leucocyte count (thousands/ µL) of different groups of Badri cattle during the experimental period

Groups	Beginning	3 months	6 months	9 months	12 months	Overall
6-12 M						
T_0	7.27±.03	7.27±.02^a	7.28±.02^a	7.28±.03^a	7.29±.03^a	7.28±.03^a
T_1	7.25±.02	7.38±.02^b	7.44±.02^b	7.46±.02^b	7.49±.03^b	7.42±.03^b
T_2	7.34±.05	7.43±.06^b	7.47±.07^b	7.48±.07^b	7.50±.07^b	7.45±.06^b
>12-18 M						
T_0	7.38±.03	7.38±.02^a	7.40±.02^a	7.40±.02^a	7.40±.03^a	7.39±.02^a
T_1	7.37±.02	7.45±.01^{ab}	7.47±.02^{ab}	7.47±.01^{ab}	7.48±.02^b	7.45±.02^a
T_2	7.41±.03	7.50±.02^b	7.53±.02^b	7.54±.02^b	7.55±.02^b	7.51±.03^b
Lactation						
T_0	8.43±.23	8.44±.24^a	8.45±.25^a	8.45±.26^a	8.45±.27^a	8.44±.25^a
T_1	8.37±.02	8.45±.02^a	8.49±.03^a	8.52±.04^a	8.54±.04^a	8.47±.03^a
T_2	8.45±.14	8.64±.15^b	8.80±.15^b	8.83±.14^b	8.85±.14^b	8.77±.14^b

Effect on packed cell volume (PCV)

The average values of PCV of each group of Badri cattle measured at every 3 months from the beginning till the end of experimental period have been presented in the table 6.

After 3rd, 6th and 9th month of the trial respectively, the average values of PCV of T_1 sub-group (29.01±.32, 30.78±.51, 30.93±.35 and 31.96±.41%) in 6-12 months group were higher and statistically significant (p<0.05) than T_0 sub-group (27.02±.14, 27.20±.26, 27.25±.24 and 27.32±.22%). From the beginning till the end of the trial respectively, the average values of PCV of T_2 sub-group (27.58±.12, 30.00±.62, 32.10±.82, 33.42±.63 and 34.35±.52%) of 6-12 months group were higher and statistically significant (p<0.05) than T_0 sub-group (26.95±.16, 27.02±.14, 27.20±.26, 27.25±.24 and 27.32±.22%), while against T_1 (30.93±.35 and 31.96±.41%), they were higher and statistically significant (p<0.05) after the 9th and 12th month of the trial, respectively. The overall observations of PCV of T_1 and T_2 sub-groups were higher and statistically significant (p<0.05) than T_0 sub-group.

After 6th, 9th and 12th month of the trial respectively, the average values of PCV of T_1 sub-group (32.36±.36, 33.22±.26 and 34.15±.30%) in >12-18 months age group was higher and statistically significant (p<0.05) than T_0 sub-group (28.63±.06, 28.63±.06 and 28.64±.06%). After the 3rd, 6th, 9th and 12th month of the trial respectively, the average values of PCV of T_2 sub-group (33.41±.53, 36.20±.47, 36.34±1.28 and 35.34±2.99%) in the same group were higher and statistically significant (p<0.05) than T_0 sub-group (28.62±.06, 28.63±.06, 28.63±.06 and 28.64±.06%), while against T_1 (32.36±.36%), they were higher and statistically significant (p<0.05) only after the 6th month of the trial. The overall observations of PCV of T_1 and T_2 sub-groups were higher and statistically significant (p<0.05) than T_0 sub-group.

After the 3rd, 6th, 9th and 12th month of the trial respectively, the average values of PCV of T_1 sub-group (35.81±.06, 37.38±.80, 37.82±.67 and 38.16±.57%) in lactating animals were found to be higher and statistically significant (p<0.05) than T_0 (34.02±.40, 34.10±.42, 34.14±.42 and 34.17±.42%) sub-group. After the 3rd, 6th, 9th and 12th month of the trial respectively, the average values of TLC of T_2 sub-group (37.98±.29, 40.72±.28, 42.46±.26 and 44.32±.32%) were higher and statistically significant (p<0.05) than T_0 and T_1 sub-group in lactating animals, respectively. The overall observations of PCV of T_1 and T_2 sub-groups were higher and statistically significant (p<0.05) than T_0 sub-group.

Meel *et al.* (2018) [8] found no significant effect on PCV levels after supplementing diet with different level of *moringa* leaves in Sirohi goat kids. Jiwuba *et al.* (2017) [5] found significant (p<0.05) improvement in the PCV level while feeding *moringa* leaves in West African dwarf goats.

The presence of various amino acids and minerals like iron and magnesium in *moringa* leaves may contribute to increase the volume of blood cells of the experimental Badri cattle. According to the results of the experiment, *moringa* leaves can be added to the Badri cattle's regular diet because they do not contain anti-nutritional elements which will prove fatal to them.

Table 6: Average Packed Cell Volume (%) of different groups of Badri cattle during the experimental period

Groups	Beginning	3 months	6 months	9 months	12 months	Overall
6-12 M						
T_0	36.95±.16^a	37.02±.14^a	37.03±.26^a	37.04±.24^a	37.05±.22^a	37.02±.19^a
T_1	36.42±.02^{ab}	37.01±.32^b	37.78±.51^b	37.93±.35^b	37.96±.41^b	37.42±.28^b
T_2	36.58±.12^b	37.00±.62^b	37.26±.82^b	37.42±.63^c	37.85±.52^c	37.22±.51^a
>12-18 M						
T_0	33.60±.06	33.62±.06^a	33.63±.06^a	33.63±.06^a	33.64±.06^a	33.62±.06^a
T_1	33.52±.08	33.58±.35^a	33.86±.36^b	34.22±.26^b	34.35±.30^b	33.91±.23^b
T_2	33.59±.06	33.74±.53^b	34.20±.47^c	34.34±1.28^b	34.54±2.99^b	34.08±.1.1^b
Lactation						
T_0	31.01±.38	31.02±.40^a	31.10±.42^a	31.14±.42^a	31.17±.42^a	31.09±.41^a
T_1	31.66±.05	31.81±.06^b	32.38±.80^b	32.82±.67^b	32.96±.57^b	32.32±.38^b
T_2	31.68±.19	31.98±.29^c	32.42±.28^c	32.86±.26^c	33.32±.32^c	32.45±.24^c

Effect on clotting time (CT)

The average values of CT of each group of Badri cattle measured at every 3 months from the beginning till the end of experimental period have been presented in the table 7.

From the beginning till the end of trial respectively, the average values of CT of T_1 sub-group in >12-18 months age group were non-significant (p>0.05) than T_0 sub-group. After 9th and 12th month of the trial respectively, the average values of TLC of T_2 sub-group (145.60±.68 and 145.20±.80 seconds) of 6-12 months group were lower and statistically significant

(p<0.05) than T_0 sub-group (146.60±.60 and 146.60±.60 seconds). The overall observations of CT of T_1 sub-group were higher and statistically significant (p<0.05) than T_0 and T_2 sub-groups which means that animals of T_1 sub-group showed lowering of platelet count in blood as their overall clotting time increased while the level of platelets in T_2 sub-group were similar to T_0 sub-group, showing no effect of treatment on T_2.

From the beginning till the end of trial respectively, the average values of CT of T_1 sub-group in >12-18 months age group were non-significant (p>0.05) than C sub-group. Only after 12th month of the trial, the average values of CT of T_2 sub-group (146.20±.58 seconds) in the same group were lower and statistically significant (p<0.05) than T_0 (148.00±.32 seconds) and T_1 (146.20±.37 seconds) sub-groups. The overall observations of CT for all the three sub-groups of the >12-18 months age group were non-significant to each other showing no change in the platelet count of the experimental animals of all the experimental animals of all three groups.

From the beginning till the end of trial, the average values of CT of T_1 sub-group in lactating animals were found to be non-significant (p>0.05) than C sub-group. After the 3rd, 9th and 12th month of the trial, the average values of CT of T_2 sub-group (144.40±.60, 142.80±.37 and 141.40±.40 seconds) were lower and statistically significant (p<0.05) than C (147.00±.45, 146.60±.68 and 146.00±.63 seconds) and T_1 (144.20±.58, 143.20±.58 and 142.60±.60 seconds) sub-groups in lactating animals, respectively. The overall observations of CT of T_1 and T_2 sub-groups were higher and statistically significant (p<0.05) than T_0 which means that animals of T_1 and T_2 sub-groups showed increase of platelet count in blood as their overall clotting time decreased as compared to T_0, thus showing the effect of treatment.

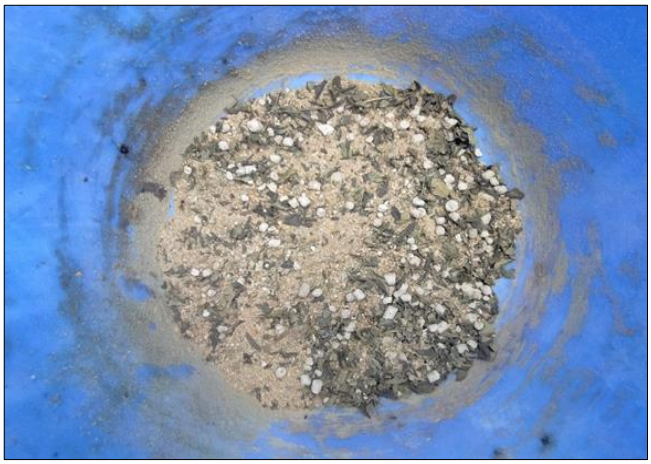
The vitamin B_{12} present in the *moringa* leaves may help in improving the platelet count in the blood of the Badri cattle, which may have caused the decrease in the clotting time as the experiment proceeded. Hence, feeding *moringa* leaves may prove helpful in increasing the platelet count of Badri cattle, thus treating the problem of low platelet count in a natural way.

Table 7: Average Clotting Time (seconds) of different groups of Badri cattle during the experimental period

Groups	Beginning	3 months	6 months	9 months	12 months	Overall
6-12 M						
C	146.60±.51	147.00±.71	147.00±.45	146.60±.60^{a}	146.60±.60^{a}	146.76±.49^{a}
T_1	149.20±.49	149.00±.32	148.00±.32	147.80±.20^{ab}	147.80±.20^{ab}	148.36±.31^{b}
T_2	148.00±1.14	147.00±.84	146.40±.81	145.60±.68^{b}	145.20±.80^{b}	146.44±.69^{a}
>12-18 M						
C	147.80±.37	147.00±.32	148.00±.32	148.00±.32	148.00±.32^{a}	147.76±.33
T_1	148.40±.24	148.20±.20	147.40±.24	147.00.32	146.20±.37^{a}	147.44±.35
T_2	149.20±1.16	148.20±.80	147.60±.60	147.20±.58	146.20±.58^{b}	147.68±.68
Lactation						
C	146.60±.51	147.00±.45^{a}	146.40±.87	146.60±.68^{a}	146.00±.63^{a}	146.52±.57^{a}
T_1	144.40±.75	144.20±.58^{a}	144.00±.71	143.20±.58^{a}	142.60±.60^{a}	143.68±.64^{b}
T_2	145.00±.71	144.40±.60^{b}	143.60±.75	142.80±.37^{b}	141.40±.40^{b}	143.44±.48^{b}

Picture 1: Moringa leaves' collection from Pantnagar and nearby areas

Picture 2: Drying of moringa leaves to make them ready for substitution



Picture 3: Moringa leaves' substituted in concentrate feed

Picture 4: Experimental animal being fed with the treatment diet

Conclusion

Feeding of dried *moringa* leaves to Badri cattle of different age-groups as a substitution for a part of concentrate feed increased their haemoglobin, total erythrocyte count and packed cell volume. The substitution also improved their packed cell volume and clotting time, thus proving beneficial to the overall haematology of both young and adult Badri cattle.

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