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Impact of Moringa Fodder Supplementation on Serum Mineral Profile in Anaemic Goats

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ABSTRACT

A field study was designed to evaluate the efficacy of feeding *Moringa oleifera* tree fodder on the recovery rate of anaemia in desi kids under semi-intensive rearing. Twenty Desi kids 6-8 months of age were selected and anaemic status of animals was assessed using FAMACHA chart, further confirmed by haematology study. Twelve animals were selected based on the levels of Haemoglobin and stratified into control (T0) and treatment groups (T1). The samples of *Moringa oleifera* fodder samples were collected and analysed. Chemical composition of *Moringa oleifera* fodder in terms of DM, CP, EE, CF and total ash were 20.24 ± 0.30, 25.79 ± 0.99, 5.89 ± 0.12, 11.2 ± 0.51 and 9.63 ± 0.13 percent, respectively. The mineral profile of the Moringa fodder was calcium (1.42 ± 0.06), magnesium (90.23 ± 2.19), copper (6.77 ± 0.59), zinc (45.81 ± 2.64) and iron (512.52 ± 4.4) in ppm. The provocative cause of anaemia eliminated by deworming and ectoparasitic drugs. The feeding trial was started after 48 hours of deworming offering 200g of fresh Moringa in the morning to T1 before allowing for grazing. Simultaneously, T0 was allowed for regular grazing without any supplementation. Haematological parameters after 45 days revealed a significant elevation of serum iron level in the T1 ($P = 0.00019$) with consequential increase of Haemoglobin ($P = 0.01$) and PCV ($P = 0.02$) level when compared to the T0. Zinc level ($P = 0.003$) in serum also significantly increased reflecting the high concentration of zinc in moringa. The study observed enhancement in recovery rate of anaemic kids with substantial increase of zinc level.

KEY WORDS: Anaemia, Haemoglobin, Iron, Moringa fodder, Zinc

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INTRODUCTION

Livestock sector contributes around 37% of global protein supply following agricultural sources (Smith et al. 2024) and it is crucial for the food resilience and economic stability of developing countries, as farming act as a backbone of their endurance and developments. Ruminants are the key factors of livestock sector providing all forms of essential nutrients in the form of milk and meat. Among ruminants, small ruminant rearing is more popular; particularly, goat rearing is abundant globally owing to their adaptability and survivability at different agro-ecological zones. Chevon is one of the most consumed meats in the developing countries of Asia, Africa and Middle East (Lamri et al., 2022). From the recent global livestock census an increase of 10.14% of goat population from 135.17 million to 148.88 million within 6 years was observed (Wakchaure and Sethi, 2024). The same is reflected in Indian statistics with 4.6 percent increase in goat population (Modi et al., 2024). This increase in goat population across the world and India is attributed to their versatility, less complexness, high fertility and disease resistance.

Goats are considered as 'Poorman's cow' as goat rearing is more affordable and profitable than cattle rearing which enables the small-scale farmers to prefer goat rearing (Ibrohimovna, 2024). Being browsers, goats mostly quench their nutritional requirements from natural vegetation making goat farming a more profitable one. In rural areas, few farmers rearing extensive and semi-intensive system experience economic losses mostly due to high kid mortality and poor growth rate followed by low fertility rates (Roy and Patbandha, 2024). Under these circumstances, the main factor affecting the folk is kids' mortality. One of the major factors contributing to kids' mortality is anaemia. Red blood cells, carriers of oxygen to vital organs are comparatively less in anaemic kids. Therefore, anaemia has been considered as the one of the most important causes for mortality in kids due to lack of oxygen supply to the vital organs (Pawaiya et al., 2017). Primarily, parasitism is the primary cause for these types of anaemia, resulting in the greater economic loss to the farmers. This problem stems from lack of knowledge on controlling ecto and endo parasites in young animals. Though these kids are treated periodically for ecto and endo parasites by farmers, it takes a longer period to revive from anaemic condition (Rizwan et al., 2023). This longer duration is crucial accounting for high requirement of iron for the incorporation onto the haemoglobin structure during erythrocytes synthesis. Iron supplementation during this critical period could augment the recovery stage (Pasini et al., 2021).

Moringa oleifera tree is a common fodder rich in protein, fibre, calcium, magnesium particularly iron (Hossain et al., 2020). *Moringa oleifera* is also a multipurpose tree possessing high significance in both human and animal nutrition for their nutritive value and phytochemicals (Singh et al., 2021). Since Moringa fodder aids in the treating anaemia, in this study we aimed to reduce the lag period of recovery of anaemic animals through oral supplementation of natural source of iron from easily available low-cost nutritious tree fodder.

MATERIALS AND METHODS

Selection of animals

Forty-five days of experimental study was conducted in non-descriptive goats, 6 to 8 months of age with an average body weight of 8 kg (8.0 ± 0.1 kg) reared in semi-intensive system of Pondicherry region. Twenty vaccinated animals under semi-intensive rearing were selected and their anaemic status was assessed by FAMACHA chart and confirmed by haematology. Twelve anaemic animals were identified based on low haemoglobin content and split into control (T0) and treatment groups (T1) each group consisting of six animals. All the animals were tagged for identification and dewormed with a combination of Albendazole and Ivermectin at a dose rate of 25mg/kg body weight.

Chemical composition and Mineral Profile

Samples of *Moringa oleifera* from six different Municipalities of Pondicherry region - Thirukanur, Villianur, Nettapakkam, Kalapet, Bahour, Ozhuvarkarai were analysed for their proximate principles (AOAC, 2023), fibre fractions (Van Soest et al., 1991) and mineral profile using Atomic Absorption Spectrophotometer (AAS Model ICE 3000 series).

Experimental Design

After 48hrs of deworming, animals in treatment group (T1) were offered with 200g of fresh Moringa fodder in the morning hours before allowing them for grazing. The daily voluntary intake of fresh moringa leaves was calculated for the entire experimental period of 45 days. Simultaneously, the control group animals (T0) were allowed for grazing with the treatment group animals without the supplementation of fresh Moringa fodder.

Blood collection and Analysis

Blood collection from the jugular vein was carried out aseptically from all the animals initially before deworming to identify the Hb level and at the end of feeding trial. Whole blood (2ml) was collected using Ethylene Diamine Tetra-acetic acid (EDTA) coated vacutainer for the Haematological analysis. Similarly, 2ml of whole blood was collected in a Clot activator vacutainer for serum separation. Serum separation was accomplished after clotting of blood with the help of centrifugation at 2500 RPM for 20 minutes and stored at -20°c. Whole blood samples was analysed for Haemoglobin (Hb) and Packed cell volume (PCV) immediately after the collection using Sahli's haemoglobinometer and Wintrobe tube, respectively. The stored serum was thawed to a room temperature and subjected to mineral analysis (Fe, Cu, Mg, Zn) in the Atomic Absorption spectrophotometer (AAS Model ICE 3000 series).

Statistical analysis

The data obtained from the blood and serum samples of two groups of goats was subjected to statistical analysis using SPSS (Version 29.0, 2022). Paired t-test and ANCOVA were used and Statistical significance was weighed when P value is less than 0.05.

RESULTS AND DISCUSSION

The Moringa tree is a multi- purpose species with a high nutritive value in their every parts. In addition to their use as human food and medicine they are also used as animal fodder for the ruminants across the world (Lata and Mondal, 2021). Since Moringa fodder is a rich source of iron (El-Massry et al., 2013), in this study we have attempted to ameliorate the anaemic condition of non- descriptive goat kids reared in the semi-intensive system by supplemental feeding of fresh Moringa fodder. Initially, proximate principles and fibre fractions of *Moringa oleifera* from different municipalities of Pondicherry region were analysed and the values are represented in the Table 1. Proximate analysis showed higher crude protein level in Moringa fodder (25.79 ± 0.99) on DMB in accordance with the Sultana (2020) equivalent to other nutritive green fodders and tree leaves. The fibre fraction revealed a moderate level of NDF (44.5 ± 0.45) and ADF (27.31 ± 0.72) in the Moringa fodder which implies its enhanced digestibility as higher NDF and ADF in a fodder can decrease the digestibility and feed intake (Schulze et al., 2014). The low lignin content (13.25 ± 0.50) in the fiber fractions with a higher amount of cellulose (14.06 ± 0.60) and hemicellulose (17.18 ± 0.95) implies a better digestibility. This in turn may be attributed to the fact that low lignin level is not favourable for strong ligno-cellulosic bonds in cell wall components of the fodder (Zeng et al., 2014).

Table 1. Chemical composition of Moringa fodder (DMB%) (n=6)

	Thirukanur	Villianur	Nettapakkam	Kalapet	Bahour	Ozhuvarkarai	Mean ± SE
Moisture	78.73	79.82	79.93	81.55	78.57	79.96	79.76 ± 0.44
CP	23.78	29.69	26.00	22.69	26.75	25.82	25.79 ± 0.99
EE	6.500	5.660	5.73	5.820	5.80	5.870	5.89 ± 0.12
CF	9.810	10.95	11.75	10.85	10.47	13.39	11.20 ± 0.51
TA	9.900	9.43	09.79	9.140	9.940	9.58	9.63 ± 0.13
AIA	0.360	0.36	0.240	0.550	0.150	0.33	0.33 ± 0.06
NDF	45.56	42.76	45.15	44.97	45.04	43.52	44.5 ± 0.45
ADF	26.32	29.48	29.59	25.75	26.85	25.89	27.31 ± 0.72
ADL	12.07	15.00	13.37	11.90	12.86	14.27	13.25 ± 0.50
Hemicellulose	19.24	13.28	15.56	19.22	18.19	17.63	17.18 ± 0.95
Cellulose	14.25	14.48	16.22	13.85	13.99	11.62	14.06 ± 0.60

The mineral composition (Copper, Iron, Magnesium, Zinc) of Moringa fodder from different areas of Pondicherry region was carried out in Atomic Absorption Spectrophotometer using diluted acid soluble extract of dried Moringa fodder (Table. 2) The results from the Table 1 projects only less variations in the chemical composition of Moringa fodder sampled from different municipalities of Pondicherry which implies the more or less identical nature of plant across the region of Pondicherry. However, the mineral composition of Moringa fodder showed mild variations in the present study (Table 2). This mild variation reflects the peculiarity of the soil composition of minerals as different soil conditions like clay soil, red soil and sand areas possess dissimilar concentrations of macro and micro minerals as stated in Osinuga et al. (2024). Moringa fodder is rich in iron content (512.52 ± 4.4 ppm) compared to commonly available fodder grasses Hybrid Napier grass – 308.22 ppm (Shankhpal et al., 2019) and tree fodder Subabul- 397 ppm (Jain and Rane, 2011). Since iron is the major element in erythropoiesis, the rich iron content in Moringa could play a major role in the recovery of anaemia by contributing to the increased need. In addition, the Zinc level in the Moringa fodder is high (45.81 ± 2.64 ppm) with low copper (6.77 ± 0.59 ppm) and Magnesium level (90.23 ± 2.19 ppm).

Table 2. Mineral composition of Moringa fodder (in ppm)

Area	Ca (in g%)	Cu	Fe	Mg	Zn
Thirukanur	1.452	7.04	522.66	93.03	42.89
Villianur	1.48	5.98	522.24	95.16	57.57
Netapakkam	1.6	8.79	498.57	93.36	44.94
Kalapet	1.24	5.65	510	93.00	42.67
Bahour	1.23	5.13	510.06	82.53	38.92
Ozhuvarkarai	1.49	8.06	521.75	84.30	47.88
Mean ± SE	1.42 ± 0.06	6.77 ± 0.59	512.52 ± 4.4	90.23 ± 2.19	45.81 ± 2.64

The kids reared in the semi-intensive condition showed a slow rise in the average daily feed intake (FI) of Moringa fodder during the experimental period of 45 days (Fig.1). Initially the FI of fresh Moringa fodder for six goats was low (114.9 ± 1.31 g/day) for the first 10 days and slowly the FI increased and reached a maximum of 155.16 ± 1.25 g/day by 45 days. The numerical differences among the groups T0 and T1 have been proved insignificant ($P > 0.05$) by independent t-test on comparing the means of Haemoglobin (Hb) and Packed cell volume (PCV) from the Hematological analysis on pre-experimental period (Table 3). However, an increase in the Haemoglobin as well as the PCV in both the groups of goats on 45th day of the trial which was proved statistically different from the 1st day Hematological values. The statistical significance (T0- P= 0004, T1 – P=0.000015) was observed in both the groups in which the Hb and PCV values on 1st and 45th day were analyzed using paired t-test. This health improvement in both the groups of goats may be due to the removal of the etiology of anemia in goats as the animals were treated with the broad spectral dewormer and ectoparasitic drug assuming that the anemia is solely due to parasitic infestation in addition to feeding Moringa fodder.

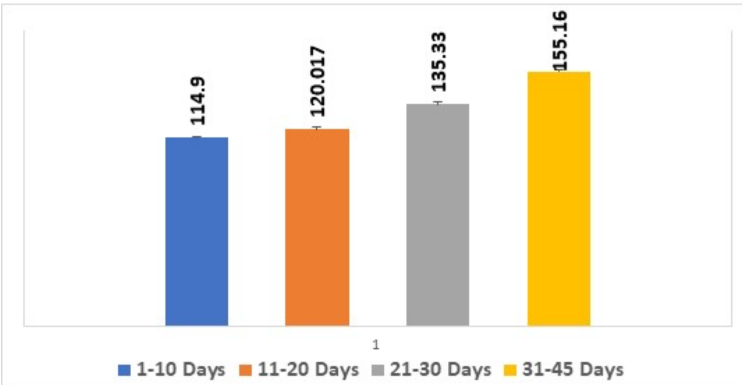

Fig. 1: Voluntary intake (g/d) of Moringa during the course of experiment

Table 3. Comparison of Haemoglobin and PCV in the Control group (T0) and Treatment group (T1) (n=6)

		Haemoglobin (g%)		Packed Cell Volume (%)	
Animal	Body weight (kg)	1st day	45th day	1st day	45th day
Control	8.06 ± 0.14	5.10 ± 0.46	9.67 ± 0.56	15.37 ±1.42	29.07 ± 1.72
Treatment	7.94 ± 0.16	5.33 ± 0.34	6.65 ± 0.41	16.1 ± 1.0	20.03 ± 1.27
Significance	NS	***	***	***	***

*** Significant at $P<0.001$; NS-Non Significant

Microscopic examination of Blood smear of selected animals revealed a small sized paler erythrocytes pointing to microcytic hypochromic anemia wherein the iron deficiency is a common factor. Supportive studies by Furtado et al. (2024), on the etiology of anemia also stated that the intestinal parasitic infection is one of the major causes of anemia in animals especially in young animals. The intestinal parasites adhere to the intestinal mucosa sucking the blood of host animal for their growth and reproduction resulting in deterioration of animal's health finally leading to anemia. These intestinal worms also cause malabsorption of nutrients including iron by reducing the height and depths of crypts of lieberkuhn (Pearson et al., 2012). Ectoparasitic infestations is another important principal cause of anemia in goat kids which sucks blood as like the helminths in the intestine (Insyariati et al., 2024). So, the process of deworming and removal of ectoparasites invariably removed the cause of anaemia allowing the animal to slowly recover from anaemic condition. This might be the reason for the improvement in haematocrit values of both the groups on 45th day.

To substantiate the hypothesis the effect of Moringa fodder in the T1 group on 45th day was evaluated and the results of two groups were compared to identify the influence of Moringa fodder feeding on the treatment group. By statistical comparison using ANCOVA, the feeding of Moringa fodder to the T1 group of goats had resulted in a very high significant rise in the Haemoglobin (P = 0.01) and PCV (P = 0.02) values in the T1 group from the T0 group of goats. Meel et al. (2018) also observed a consequential rise of hematocrit values on 100% replacement of concentrate by moringa leaves.

Bearing a resemblance to the hematological values on the 1st day in two groups, there was statistical similarity (P = 0.957) in the serum iron level between the two groups. The average serum iron level in the control and treatment group on 1st day were 87.7 ± 0.03 µg/dl and 87.91 ± 0.24 µg/dl. Since the normal serum iron level of goat ranges from 16–35 µmol/l of iron which is equivalent to 89 – 195 µg/dl (Suttle, 2010; LABOKLIN, 2022), both the groups had slightly lower level of iron in their serum which might be one of the major reasons for anaemia as iron forms the crucial component of haemoglobin. The serum iron indices in T0 had increased from 87.7 ± 0.03 µg/dl to 127.0 ± 0.05 µg/dl (P= 0.00019). Similarly, the serum iron concentration has been augmented from 87.91 ± 0.24 µg/dl to the maximum level 193.54 ± 0.08 µg/dl (P = 0.00004). The rise of iron levels in both the groups might be result of deworming as the internal worms interfere in the iron absorption at the intestinal villi (Hall et al., 2008). The kids in the T1 group offered with Moringa fodder had significantly high rise in iron concentration from 87.91 ± 0.24 µg/dl to a maximum level of 193.54 ± 0.08 µg/dl, compared to the control (T0) group wherein only a minimal rise of serum iron level from 0.88 ± 0.03 µg/dl to 1.27 ± 0.05 03 µg/dl was revealed. On comparing the values serum Fe (Table 4) significant difference (P = 0.001) was observed in the mean of serum iron levels between two groups on 45th day implying the high mean serum iron in the T1 group. These comparative results from T0 and T1 groups envisioned a quick and better amendment in the Moringa fodder supplemented group.

Table 4. Comparison of Serum Mineral Profile in the Control group and Treatment group (in ppm) (n=6)

Group	Fe (1st Day)	Cu (1st Day)	Mg (1st Day)	Zn (1st Day)	Fe (45th Day)	Cu (45th Day)	Mg (45th Day)	Zn (45th Day)
Control	0.8770 ± 0.03	1.8699 ± 0.22	18.7067 ± 1.55	0.9626 ± 0.14	1.2639 ± 0.06	2.341 ± 0.12	38.7272 ± 3.31	1.5988 ± 0.15
Treatment	0.8791 ± 0.03	1.213 ± 0.12	26.3786 ± 1.14	2.692 ± 0.55	1.9355 ± 0.09	2.1491 ± 0.26	39.5657 ± 1.09	8.5487 ± 1.41
Significance	***	**	***	*	***	**	***	**
P value	0.00019	0.009	0.0003	0.015	0.00004	0.005	0.00014	0.002

*** Significant at P<0.001; ** Significant at P<0.01; * Significant at P<0.05; NS-Non-Significant

The serum copper levels in two groups differ significantly (P = 0.029) on the 1st day itself outlining the irrelevance in their serum copper concentration. The serum copper concentration in T0 (P = 0.009) and T1 (P = 0.005) groups has been increased in the period of 45 days irrespective of their diets. This progressive escalation observed owing to the removal of cause of malabsorption as stated earlier. Moreover, P value for copper (0.088) describes that there is no significant effect on copper concentration of treatment goats while feeding Moringa fodder. Analogous to copper concentration, the initial serum magnesium level diverges more among the two groups signifying their dissimilarities. As like other minerals and health parameters, magnesium also steadily increased in both group of kids, but there were high remarkable differences in control group (20.02ppm) which is much higher than the treatment group (13.18ppm) signalling the opposing effect of Moringa fodder on the serum magnesium concentration. This dismissive effect may be due to different mineral interactions that reduce the bioavailability of magnesium at the luminal site of intestine. High levels of iron, calcium and zinc in the feed reduces the availability of magnesium in light of high interactions among them. (Pallavi et al., 2022). Since the zinc level is higher in Moringa fodder, the supplemental feeding of the same is reflected in the augmented levels of serum zinc concentration at a faster rate in T1 than the T0 group (P = 0.003). The serum zinc level in the control group has increased from 0.96 ± 0.14 ppm to 1.6 ± 0.15 ppm, while the treatment group has experienced an enormous escalation of serum zinc concentration from 2.7 ± 0.55 ppm to 8.5 ± 1.40 ppm. This significant increase of zinc levels in treatment group can be attributed to the high bioavailability of zinc from moringa fodder (Oladeji et al., 2017). The high dietary zinc levels might act as immunomodulators enhancing the cell mediated immunity in treatment animals. Zinc was reported to have a positive effect on reproductive efficiency in goats by augmenting the regular oestrous cycles, and increasing the fertility rates (Oladeji et al., 2017; Habeeb et al., 2013).

The results from this experimental feeding trial forecasted that the Moringa fodder feeding to the anaemic animals hastened the recovery as they are rich in iron than most of the commonly available feedstuffs. This high rise of serum iron level and Hb level in a short time is crucial for the survival and optimum production of the animal as anaemia affects both the growth rate and immunity of the animals. Since the copper content is less and almost equals the other fodder and tree leaves, the Moringa fodder feeding had no effect on the serum level of T1. Consequently, there were slight rise in serum copper level in both groups as a result of elimination of parasites. Interestingly a slight decline in the progressive rise of magnesium level was observed in the treatment group on comparing with the control group. This effect was observed as a consequence of magnesium interactions with the other major and minor minerals reducing its bioavailability. Additionally, the Moringa fed group of animals had experienced a rapid amplification in serum zinc concentration which could improve the growth rate by strengthening the immune status of the animal (Wang et al., 2013).

CONCLUSION

The experiment proved that the Moringa fodder supplementation is useful improving the anaemic condition of goats as well as augmented the recovery period with much economical and beneficial results. Moringa fodder feeding also improved the zinc level in the animals which could have a positive effect on the immune status of animals.

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