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Influence of dietary vanadium on body condition score and dry matter intake in Hariana heifers: A research article

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Abstract
The present study aimed to evaluate the impact of varying levels of vanadium (V) supplementation on body condition score (BCS) and dry matter intake (DMI) in indigenous Hariana heifers. A total of 18 heifers, aged between 1 to 2 years, were randomly allotted into three groups- (Control, T_1, and T_2), based on body weight, with six animals per group. The Control group received a standard basal diet, while T_1 and T_2 were supplemented with 2.5 ppm and 5.0 ppm vanadium, respectively, in the form of sodium metavanadate, along with the basal diet. The feeding trial spanned 90 days, during which DMI, body weight, and BCS were recorded at fortnightly intervals. All animals were fed to meet nutritional requirements as per NRC (2001) guidelines. Results indicated a significant increase ($p<0.05$) in both daily DMI and DMI per 100 kg body weight in the T_2 group compared to Control and T_1. However, no significant differences in BCS were observed among the groups throughout the study period. These findings suggest that higher vanadium supplementation may enhance feed intake in Hariana heifers without affecting body condition.

Keywords: Vanadium supplementation**,** Hariana heifers, Body condition score (BCS), Dry matter intake (DMI), Sodium metavanadate

Introduction

Minerals are typically divided into two main categories based on the amounts required by the body: macro (or major) minerals and micro (or trace) minerals. Macro-minerals- such as calcium, phosphorus, sodium, and chloride are needed in relatively large quantities. On the other hand, trace minerals- including iron, copper, cobalt, potassium, magnesium, iodine, zinc, manganese, molybdenum, fluoride, chromium, selenium, and sulfur are essential in much smaller amounts (Eruvbetine, 2003) [3]. As noted by Murray *et al*. (2000) [8], macro-minerals are defined as those required at levels exceeding 100 parts per million (ppm), whereas trace minerals are needed at concentrations below this threshold.

Beyond these two groups, scientists have identified a third classification known as 'ultra-trace elements' or 'occasionally beneficial elements'. This category includes elements like vanadium, chromium, boron, lithium, molybdenum, nickel, rubidium, and silicon. Though required in extremely minute amounts, these elements appear to play physiological roles, as deficiencies have been associated with negative health outcomes in animals, implying the presence of biological regulation mechanisms. In fact, the dietary requirement for ultra-trace minerals in laboratory animals is generally less than 1 microgram per gram (µg/g) of diet, and often even lower- below 50 nanograms per gram (ng/g), according to Nielsen *et al.* (1980) [9].

The nutritional importance of vanadium in higher organisms has been a subject of debate for many years. Before the 1980s, its role in animal nutrition was unclear, with no confirmed deficiency symptoms. However, key research conducted by Anke *et al*. (1983) [1] in goats and by Nielsen *et al*. (1983) [10] in rats provided the first strong evidence supporting vanadium's essential function. To expand on these findings, researchers at the University of Jena undertook a long-term investigation involving 15 generations of goats, examining the effects of vanadium deficiency throughout critical life stages including growth, gestation, and lactation, using a semi-synthetic diet specifically designed to limit vanadium intake.

Materials and Methods

The main objective of this study was to evaluate the effects of vanadium supplementation on the Body Condition Score (BCS) and Dry Matter Intake (DMI) in indigenous Hariana heifers. A brief summary of the experimental design and the analytical techniques applied during the course of the study is provided in the subsequent sections.

Study Location and Animal Selection

The study was conducted at the Instructional Livestock Farm Complex (ILFC), DUVASU, Mathura (Uttar Pradesh). A total of 18 indigenous Hariana heifers, aged between 1 to 2 years, were selected from the institutional herd based on uniformity in age and body weight. All experimental procedures were approved by the Institute Animal Ethics Committee (IAEC) and conducted in accordance with institutional guidelines. The animals were randomly assigned to three dietary groups (n = 6 per group) as follows:

Control: Basal diet without vanadium supplementation

Treatment 1 (T_1): Basal diet + 2.5 ppm vanadium (as sodium metavanadate)

Treatment 2 (T_2): Basal diet + 5.0 ppm vanadium (as sodium metavanadate)

Grouping of Experimental Animals

Control Group

S. No.	Animal No.	Body Weight (kg)
1	840	184
2	853	152
3	535	135
4	843	125
5	863	107
6	849	80
Mean		130.50

Treatment Group T_1

S. No.	Animal No.	Body Weight (kg)
1	529	178
2	534	151
3	836	132
4	537	118
5	852	104
6	866	102
Mean		130.83

Treatment Group T_2

S. No.	Animal No.	Body Weight (kg)
1	812	169
2	837	166
3	539	144
4	847	119
5	855	111
6	804	75
Mean		130.67

Housing and Management

All heifers were housed in Shed No. 1 at ILFC, which provided a well-ventilated, clean, and hygienic environment. Individual feeding arrangements were ensured. The shed was cleaned daily, and special attention was given to the removal of faeces and debris. Prior to the start of the study, all animals were dewormed to ensure uniform health status.

Feeding and Diet Composition

The animals were fed a basal diet consisting of concentrate mixture, wheat straw, and green fodder (either berseem or oat), all sourced from ILFC. The diet was formulated to meet the nutritional requirements as per NRC (2001) [11] standards, maintaining a 50:50 ratio of roughage to concentrate throughout the study. The feeding trial lasted 90 days, preceded by a 7-day adaptation period.

Vanadium Supplementation

Vanadium was administered in the form of sodium metavanadate. A stock solution was prepared and the calculated dose was mixed with approximately 50 g of concentrate, offered individually to each animal. The remaining concentrate and roughage were then provided.

Composition of Experimental Diet

The concentrate mixture consisted of the following ingredients:

Ingredient	Proportion (%)
Barley grain	25
Wheat grain	25
Wheat bran	10
Gram chunni	10
Mustard oil cake	28
Mineral mixture	2

The diet composition for each treatment group is summarized below:

Ingredient	Control	T_1	T_2
Barley grain	12.5	12.5	12.5
Wheat grain	12.5	12.5	12.5
Wheat bran	5	5	5
Gram chunni	5	5	5
Mustard oil cake	14	14	14
Mineral mixture	1	1	1
Green fodder	25	25	25
Wheat straw	25	25	25

Note: Green fodder and wheat straw were adjusted to maintain the roughage-to-concentrate ratio at 50:50. The dry matter content and chemical composition of green fodder and concentrate mixture were determined weekly using standard procedures.

Body Condition Score (BCS)

The body condition of the experimental heifers was assessed based on visual and tactile examination, considering the following anatomical points:

Vertebral column: flesh covering over the spinous processes of the chine, loin, and rump.

Spinous processes: prominence and sharpness.

Tail head region: depression between the backbone and pins, and between pins and hook bones.

Ribs: degree of flesh covering.

The body condition scoring system used in this study was adapted from the guidelines presented by NRC (2001) [11] (see Table below). Scoring was conducted fortnightly during the trial period by a panel of expert scientists.

Table: Body Condition Score Card (Adapted from NRC, 2001) [11]

Criteria	Score 1	Score 2	Score 3	Score 4	Score 5
Back bones	Prominent	Visible	Visible	Well covered	Very well covered
Hips & shoulders	Prominent	Visible	Faintly visible	Not visible	Showing fat deposits
Ribs	Clearly visible	Faintly visible	Generally, not visible	Well covered	Very well covered
Tail-head area	Recessed	Slightly recessed	Not recessed	Slightly lumpy	Very lumpy
Body outline	Skeletal	Bony	Almost smooth	Rounded	Bulging due to fat

Dry matter intake
Dry matter intake was recorded fortnightly by subtracting the residual dry matter from the quantity of dry matter offered

Results
Body Condition Score (BCS)
The BCS of experimental animals is shown in Table 1 and Fig 1. BCS was found similar in all the fortnights between treatments and control group. The overall BCS ranged from 2.33 to 3.90. The overall BCS was found similar ($P>0.05$) in all the experimental groups.

Table 1: Effect of vanadium supplementation on body condition score

Days	Treatment			SEM	P value
	Control	T_1	T_2		
0	2.42	2.33	2.37	0.06	0.60
30	2.80	2.75	2.82	0.13	0.93
60	3.27	3.50	3.42	0.13	0.45
90	3.72	3.85	3.90	0.11	0.50
Total	3.05	3.11	3.13	0.13	0.91

Dry matter intake (DMI)
The percentage DMI (kg/100 kg BW) in experimental animals in control, T_1 and T_2 groups during different fortnights of experimental feeding has been presented in Table 2. The overall DMI (kg/100 kg BW) was found to be significantly higher in T_1 and T_2 groups with respect to control group. Dry matter intake (kg/d) in control, T_1 and T_2 groups during different fortnights of experimental feeding has been presented in Table 3. At fortnightly interval DMI of control, T_1 and T_2 ranged from 4.55 to 5.61, 4.35 to 5.92 and 4.49 to 6.42 kg/d, respectively. The overall DMI (kg/d) was found to be significantly higher in T_1 and T_2 groups with respect to control group.

Table 2: Effect of vanadium supplementation on dry matter intake (kg/ 100kg BW)

Days	Treatment			SEM	P value
	C	T_1	T_2		
15	3.51	3.39	3.43	0.11	0.74
30	3.48	3.46	3.83	0.19	0.31
45	3.39^a	3.41^a	4.02^a	0.18	0.04
60	3.34^a	3.49^{ab}	3.98^b	0.16	0.03
75	3.26^a	3.44^{ab}	3.85^b	0.13	0.02
90	3.29	3.52	3.74	0.16	0.18
Total	3.38^a	3.45^{ab}	3.81^b	0.06	<0.01

Means bearing different superscript in a row differ significantly ($P<0.05$)

Table 3: Effect of vanadium supplementation on dry matter intake (kg/d)

Days	Treatment			SEM	P value
	Control	T_1	T_2		
15	4.55	4.35	4.49	0.43	0.94
30	4.75	4.65	5.16	0.38	0.62
45	4.87	4.85	5.75	0.43	0.26
60	5.13	5.28	6.11	0.49	0.34
75	5.28	5.55	6.27	0.52	0.40
90	5.61	5.92	6.42	0.56	0.59
Total	5.03^a	5.10^{ab}	5.70^b	0.20	0.04

Means bearing different superscript in a row differ significantly ($P<0.05$)

Discussion
No significant change in overall BCS was reported in the experimental groups. However, the present results were in contrast with findings of Heidari *et al*. (2016) [6] that found no significant effect of vanadium supplementation on dry matter intake (DMI), body condition score (BCS) in prepartum cows. Similarly, the overall DMI (kg/d, kg/100 kg BW) were also found to be significantly higher in T_2 group. The DMI was higher in T_2 group receiving 5.0 ppm of vanadium supplementation as sodium metavanadate. In accordance with the present study, Bonomi *et al*. (2002) [2] also reported the use of vanadium as an integrator in rabbit feeding. Hansard *et al*. (1982) [5] also reported higher feed intake in V supplemented sheep at 50 ppm and 200 ppm. Although nutritional essentiality and specific deficiency sign for V in poultry and ruminant animals have not been established. However, in a long-term experiment inducing V deficiency in growing, pregnant, and lactating goats over 15 generations using the semisynthetic feed ration by the University Jena team reported suppressed feed intake and milk production as well as reduced survival rate and reproduction efficiency accompanied by high abortion rate (Haenlein and Anke, 2011) [4]. Based on these experimentations, the authors (Haenlein and Anke, 2011) [4] claimed that V was a nutritionally essential element at 2.0 mg per kg DM feed for goats and that no deficiency sign could occur under normal farm conditions. With these postulations, V might be essential for higher animals and hence is categorized as "occasionally beneficial element" for farm animals (Miller, 1974; Suttle, 2010) [7, 13]. However, the present results were in contrast with findings of Heidari *et al*. (2016) [6] that found no significant effect of vanadium

supplementation on dry matter intake (DMI), body weight (BW), body condition score (BCS) in prepartum cows. The source of vanadium used in the above study is vanadyl sulphate and it is also established that different vanadium compounds show different potencies. The tetravalent vanadium supplemented as vandyl sulphate or acetate, was utilized but produced smaller responses than vanadium supplemented as sodium orthovandate and metavanadate (Schwarz and Milne, 1971) [12]. The higher DMI in T_2 group supplemented with 5.0 ppm of vanadium supplementation indicate the positive role of vanadium in growth performance of indigenous hariana heifers.

Conclusion

Although no significant change in overall BCS was observed, vanadium supplementation at 5.0 ppm as sodium metavanadate significantly improved DMI in indigenous Hariana heifers. This suggests a potential role of vanadium in enhancing feed intake and growth performance, with its effectiveness likely influenced by the specific form of vanadium used.

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