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# Ruminal Solubility and Effect of Calcite Powder Supplementation on Dairy Animal Performance

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RUMINAL SOLUBILITY AND EFFECT OF CALCITE POWDER SUPPLEMENTATION ON DAIRY ANIMAL PERFORMANCE

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# Ruminal Solubility and Effect of Calcite Powder Supplementation on Dairy Animal Performance

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The daily dry matter consumption of calves in group I to III was 7.12±0.22, 6.52±0.29 and 6.95±0.33 kg respectively indicating that the treatment rations were acceptable to the animals and there was no significant difference (P>0.05) in the treatment groups, with respect to DMI of the animals. The results of this study showed that neither the different sources of calcium used in group I and group II nor the levels of calcite powder used in group II and III had any significant effect on digestibility, gain in body weight of calves or in the efficiency of conversion of diet to body weight gain of calves. Moreover The results suggested that neither the $CaCO_3$ nor the calcite powder had any adverse effect on the palatability of diet.

## I. Introduction

In animal production nutrition plays an important role in the farm economics, as more than 50% of the farm expenditure goes towards feeding of animals. Dietary nutrients promote programming and expression of the metabolic pathways that enables the animal to achieve its genetic potential with respect to production and reproduction. Minerals may constitute a small fraction of the total ration but perform vital role in the body. Mineral elements exist in the cells and tissues of the animal body and their characteristic concentrations vary with the element and tissue. The concentrations of essential elements must usually be maintained within the narrow limits, if the functional and structural integrity of the tissues is to be safeguarded and the optimum growth,

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Continued ingestion of diets that are deficient or excessive in a mineral, induce changes in the form of concentration of that mineral in the body tissues. In such circumstances, physiological functions are adversely affected which vary with the element, the degree and duration of dietary deficiency (Chesters and Arthur, 1988). Ultimate prevention of the changes requires that the animal be supplied with none toxic and palatable diet that contains the required minerals in adequate amounts and available forms.

On tracing the history of Ca supplements for use in mineral mixture, it appears that use of different sources remained changing, during the past century. In the 1960s, the use of bone meal, chalk powder and di-calcium phosphate as a source of Ca and P in mineral mixture was recommended. In 1982, ISI recommended the use of ground limestone in the list of ingredients for use in the formulation of mineral mixture. In 1992 specifications for Mg and S were laid down (BIS, 1992).

McDowell et al (1993) reported that various mineral supplements differ in their bio-availability and it is necessary to comparatively scan them for availability of useful elements aimed at ensuring the absence of toxic levels of incriminating minerals. Unfortunately here is no literature on the availability/ utilization of Ca from calcite powder in livestock although; calcite has been used as a buffer in high milk producing cows (Keyser *et al.,* 1985). This being the case, the objective of this research project was to study the ruminal solubility and effect of Calcite Powder supplementation on animal performance

## II. Materials and Methods

### a) *In vitro Ruminal Solubility*

*In vitro* experiments were conducted to study the ruminal solubility of Ca from dolomite, dicalcium phosphate, lime stone powder and calcite powder in comparison with pure calcium carbonate at different pH using the procedure of Witt and Owens (1983) with slight modification. Each of the Ca supplements was weighed into 250 ml conical flask. Hundred ml of the mixture of strained ruminal liquor (SRL) and McDougall's buffer was added to each flask containing the Ca supplements. The contents were well mixed and the pH was adjusted to 2.5, 6, and 7, using 0.1 N HCl. Finally the supernatant obtained after centrifugation was diluted



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to 100 ml and used for the estimation of Ca by AAS. Ca solubility was estimated according to Yano *et al.* 1979, employing the following formula.

$$\text{Ca solubility in SRL (\%)} = \frac{\text{Amount of Ca present in the supplement obtained from 25 ml of ruminal buffer (Aliquot I) - Blank}}{\text{Amount of Ca presen tin 25 ml of uncentrifuged ruminal buffer (Aliquot II) - blank}}$$

## III. Feeding Trials

### a) *Experimental Treatment Ration Formulation*

Three different mineral mixtures/ experimental treatments i.e. commercial grade calcium carbonate ($T_1$), calcite powder ($T_2$) and 1.5% extra calcite powder than the second mineral mixture ($T_3$) were prepared, as shown in Table 1. Diammonium phosphate was used as source of phosphorus and the supply of other mineral elements was met by addition of pure salts. The mineral mixture was added to the concentrates mixture shown in Table 2 to supply 396, 396 and 1013 g of Ca/100 kg of the concentrate in treatment 1, 2 and 3 respectively.

*Table 1 :* Calcium and phosphorus supply from mineral supplements used in preparation of mineral mixtures* for each 100 kg of concentrate mixture

| Groups | Mineral supplement sources used | Ca supply (g/ 100 kg concentrate mixture) | P supply (g/ 100 kg concentrate mixture) |
|---|---|---|---|
| T1 | Calcium carbonate 1.0113 kg<br>Diamonium phosphate 0.70 kg | 396.43 | 1.21<br>161.00 |
| T2 | Calcite powder 0.9779 kg<br>Diamonium phosphate 0.58 kg | 399.96<br>- | 10.76<br>133.40 |
| T3 | Calcite powder 2.04779 kg<br>Diammonium phosphate 0.58 kg | 1013.46<br>- | 27.76<br>133.40 |

* In addition to the Ca and P source used the following ingredients were used per 100 kg of concentrate mixture for the preparation of complete mineral mixture sodium chloride 0.900 kg, trace mineral mixture 0.1185 kg containing magnesium carbonate 90 gm, ferrous sulphate 15 g, copper sulphate 2.1 gm, cobalt chloride 1.5 gm, potassium iodide 0.3 gm, zinc sulphate 7.5 gm and manganese dioxide 2.1 gm.

*Table 2 :* Composition of concentrate mixtures (kg/100kg)

| Ingredients | Groups I | Group II | Group III |
|---|---|---|---|
| Maize | 20.0000 | 20.0000 | 18.5000 |
| Barley | 20.5402 | 20.6486 | 20.6436 |
| Groundnut cake | 10.0000 | 10.0000 | 10.0000 |
| Wheat bran | 34.0000 | 34.0000 | 34.0000 |
| Mustard cake | 12.0000 | 12.0000 | 12.0000 |
| Urea | 0.7300 | 0.7550 | 0.7700 |
| Calcium carbonate | 1.0113 | -- | -- |
| Calcite powder | -- | 0.9770 | 2.4779 |
| Diamonium phosphate | 0.7000 | 0.5800 | 0.5900 |
| Sodium chloride | 0.9000 | 0.9000 | 0.9000 |
| Trace M. Mixture* | 0.1185 | 0.1185 | 0.1185 |
| CP% | 19.95 | 19.94 | 19.79 |
| Ca% | 1.2 | 1.2 | 1.7 |
| P% | 0.65 | 0.64 | 0.62 |
| TDN% | 73.75 | 74.04 | 72.75 |

*contained magnesium carbonate 90 gm, ferrous sulphate 15gm,copper sulphate 2.1gm, cobalt chloride 1.5gm, potassium iodide 0.3gm, zinc sulphate 7.5gm and manganese dioxide 2.1gm.

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## IV. Management of the Experimental Animals

Eighteen crossbred (Karan Fries) male calves of 14-16 months of age weighing 205.22 ±6.85kg taken from the Institute (NDRI) herd were dewormed and housed in individual pens with adequate space, plastic painted walls and easy access to sunshine. The animals were tied individually and washed daily with clean water. Finally the experimental animals were randomly allocated to the experimental treatment in completely randomized design with 6 replications for experimental period of 24 weeks as shown in Table 3.

The experimental animals were offered concentrate mixture and wheat straw in the morning at 9.00 am. Body weight was recorded at weekly intervals. Feed conversion efficiency was calculated from body weight gain per kg of feed consumed. The growth rate was calculated by regression analysis of the cumulative weight gain during 24 weeks period as 'b' value, as shown below

$$\text{b value (kg/ week)} = \frac{\sum xy - \dfrac{\sum x . \sum y}{n}}{\sum X^2 - \left(\dfrac{\sum x}{n}\right)^2}$$

Samples of feed offered and residue left, if any, were taken each morning for dry matter and chemical analysis. After the completion of 24 weeks of growth study , a metabolic trial of 7 days collection period was conducted on all the eighteen calves in the metabolic shed. The quantity of faeces and urine voided by individual animal were recorded every morning (24 hr collection) for 7 days, and representative sample were drawn for further analysis.

*Table 3 :* Allocation of the treatments to the experimental animals

| S. No. | Animal No. | Initial body weight (kg) | Date of Birth |
|---|---|---|---|
| Group-I | | | |
| 1 | KF-3871 | 135 | 10.11.2004 |
| 14 | KF-3885 | 200 | 22.12.2004 |
| 17 | KF-3877 | 211 | 3.12.2004 |
| 18 | KF-6880 | 216 | 11.12.2004 |
| 6 | KF-6861 | 230 | 25.09.2004 |
| 16 | KF-6873 | 240 | 23.10.2004 |
| | Average | 205.33±15.20 | |
| Group-II | | | |
| 7 | KF-6895 | 158 | 18.01-2005 |
| 15 | KF-6888 | 185 | 24.12.2004 |
| 4 | KF-6877 | 205 | 23.10.2004 |
| 13 | KF-6869 | 220 | 02.11.2004 |
| 11 | KF-6868 | 226 | 15.11.2004 |
| 12 | KF-6866 | 240 | 18.10.2004 |
| | Average | 205.67±12.24 | |
| Group-III | | | |
| 2 | KF-6896 | 164 | 23.11.2005 |
| 9 | KF-6859 | 197 | 14.09.2004 |
| 5 | KF-6887 | 196 | 24.12.2004 |
| 3 | KF-6881 | 228 | 13.12.2004 |
| 10 | KF-6874 | 224 | 14.11.2004 |
| 8 | KF-6886 | 219 | 22.12.2004 |
| | Average | 204.67±9.85 | |



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Samples of feed and faeces were analyzed for proximate principles, dry matter, total ash, acid insoluble ash and nitrogen content as per AOAC (2000). Mineral content of feeds, faeces and urine samples was estimated using AAS and balances were calculated.

## V. Statistical Analysis

Data in different parameters were subjected to analysis of variance

## VI. Result and Discussions

### *a) Ruminal Solubility of Calcite Powder (In Vitro)*

Many mineral elements do not have similar solubility in different part of gastrointestinal tract. Solubility of any mineral element in the gastrointestinal tract is an important criterion to assess its availability to the animal (Chicco *et al.,* 1965). Ammerman *et al.* (1957) observed that ferrous sulphate and ferric chloride had higher biological availability to sheep than ferrous carbonate and ferric oxide as the latter two compounds were less soluble sources of iron. Similarly, Rahnema and Fontenot (1983) reported that Mg from MgO is more utilized by sheep than Mg from dolomite limestone because Mg from former source is more soluble, thus any other mineral which is less soluble is supposed to be less available to ruminants.

Solubility of any mineral in the gastrointestinal tract is related to the prevailing pH at that part of the gut. Storry, (1961) found that Ca and Mg present in the abdominal contents of sheep were in a soluble form. Bremner (1970) studied the changes in concentration and solubility of Zn, Mn and Cu in the different parts of alimentary tract of sheep and found that a relationship existed between the solubility of the metal and pH values of the gut content. This pattern of changes could be reproduced in *in- vitro* by adjusting the pH of rumen and abdominal samples.

The solubility data of the different Ca supplements studied in the current experiment presented in Table 4. and Fig. 1. It was observed that at any pH studied, Ca solubility from different chemical forms of supplements was essentially not-similar. At pH 6.0 Ca from calcite powder showed better solubility 11.15±4.65% while dolomite showed the least than others. At pH 2.5 calcium carbonate, limestone powder and calcite powder showed higher solubility i.e.72.74±5.47, 72.63±6.12%and72.39±12.34 respectively. The data (Table 4) further revealed that Ca solubility from dicalcium phosphate, dolomite, lime stone powder, calcite powder and calcium carbonate was not similar even at neutral pH of 7. At neutral pH 7 of the buffer the solubility ranged from 1.74 % (dolomite) to 2.94% DCP. By scaling down the pH of the ruminal buffer the Ca solubility was seen to increase in all the cases which are in concurrence with the findings of Lall (1987). In case of CaCo3 it reached to 72.74%, whereas in case of dolomite and calcite it was 47.84 and 72.39% respectively. Lall (1987) reported the solubility of $CaCl_2$ to the extent of 98.8% in ruminal buffer at pH 4.0. It was further evident as pH approached that of abdominal fluid, the solubility of all forms of Ca studied (Table 4) increased.

*Table 4 :* Ca solubility from different Ca supplements in relation to ruminal pH

| | Predominant chemical form | Ca solubility % | | |
|---|---|---|---|---|
| | | PH | | |
| | | 7 | 6 | 2.5 |
| Calcium Carbonate | $CaCO_3$ | 2.81 ±1.8 | 5.77±0.64 | 72.74 ±5.46 |
| Calcite | $CaCO_3$ | 2.05 ± 0.25 | 11.15±4.65 | 72.39 ±12.34 |
| Dolomite | $Ca Mg (CO_3)_2$ | 1.74 ±1.36 | 3.71±0.25 | 47.84±13.16 |
| LSP | $Ca CO_3$ | 2.81±1.8 | 5.33±0.87 | 72.63±6.12 |
| DCP | $CaHPO_4$ | 2.94 ±0.95 | 7.18 ±2.93 | 61.06±7.86 |

The calcium solubility at pH 6 and 2.5 increased in all the calcium sources under study. Storry /. 1961) have reported all the Ca and Mg present in abdominal content of sheep were in a soluble form where the pH was in the range of 2-3. Bremner (1970) suggested that pH of gut influenced solubility and availability of certain trace elements. He studied the changes in the concentration and solubility of Zn, Mn and Cu in the different parts of the alimentary tract of sheep and found that a relationship existed between the solubility of the metal and pH of the gut contents

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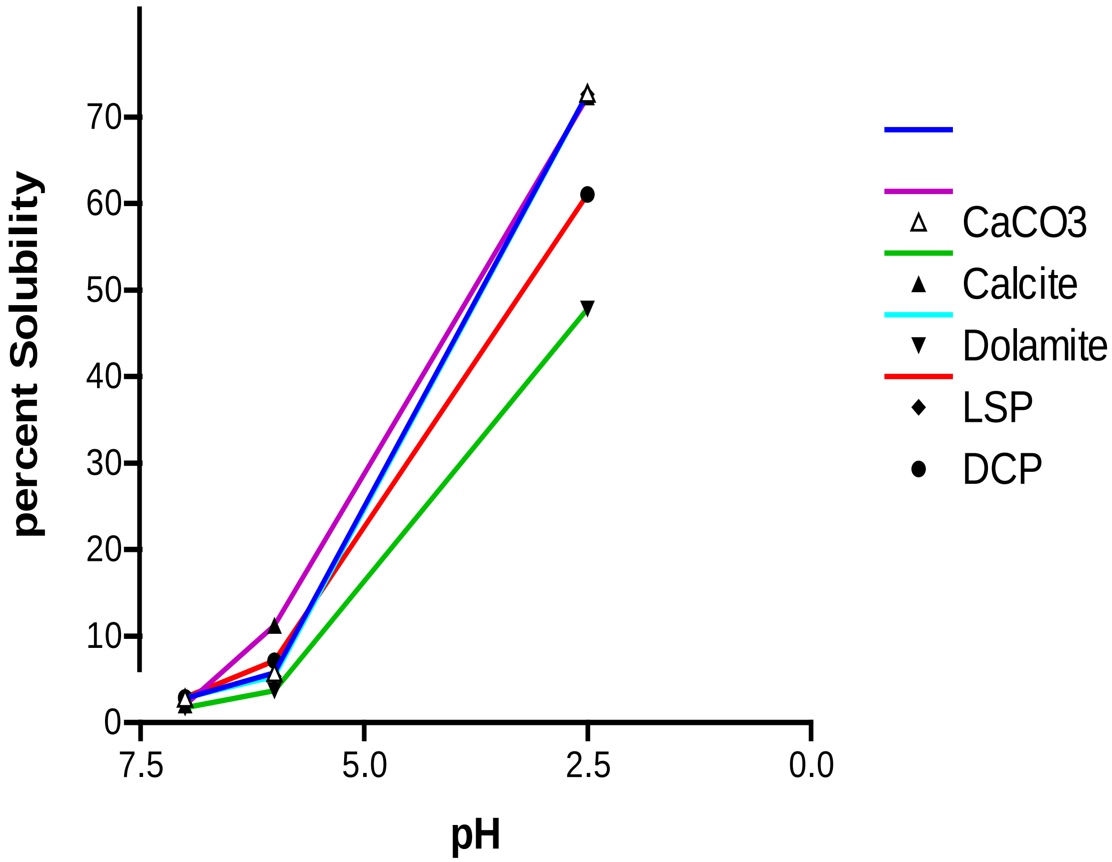


*Fig. 1:* In vitro ruminal calcium solubility at different pH

If reaction of the gut influenced the solubility of Ca from different Ca supplement sources to such a great extent, It may be anticipated that the distribution of Ca into soluble and particulate phases in the rumen and flow rates of the two phases from the rumen may influence the rate at which Ca could be made available at the absorption sites lower down the gut. Therefore, different sources of Ca supplements may not be of similar value. Evidently, there is need to modify the quantitative proportion of alternate sources of Ca in a mineral mixture not only on the basis of composition but also on the basis of Solubility and net availability

## VII. Effect of Calcite Powder Supplementation on Animal Performance

### *a) Feed Intake*

The daily dry matter consumption of calves in group I to III was 7.12±0.22, 6.52±0.29 and 6.95±0.33 kg respectively. Figures for dry matter intake per 100 kg body weight were 2.44, 2.06 and 2.18 kg in the respective groups. The present observations are in concurrence with the findings of Udeybir *et al.* (2000) who reported that voluntary dry matter intake in growing cattle weighing 320 kg was 2.08±0.09 percent of the body weight. The figures of present study further suggested that the rations were acceptable to the animals and there was no significant difference (P>0.05) in the treatment groups, with respect to DMI of the animals.

Ricketts et. al (1970) fed diets containing three Ca/ P ratio (1:1, 4:1 and 8:1) and observed the performance of Holstein steers and reported that different Ca and P ratio had no effect on average daily feed intake in total experimental period of 168 days. They further observed that during the first 14 weeks of experiment the ad lib fed steers receiving 8:1 Ca/ P ratio diets consumed significantly less DM than did the steers, receiving 1:1 or 4:1 Ca/ P ratio diets. After 14 weeks the average feed intake of steers fed 8:1 Ca to P ratio diets did not differ from those receiving from 1:1 or 4:1 Ca to P ratio diets. Analysis of variance for feed intake/ B.W. $^{0.75}$ was the same as for average daily feed intake. This indicated that animals in different weight groups consumed the same amount of feed per unit metabolic body weight (B.W. $^{0.75}$).

Sharma *et al.* (2004) fed diets containing varying levels of Ca with different levels of minerals to lambs and reported that the average value of daily DM intake was similar among the treatments. Wise *et al.* (1963) fed diet containing 0.4 : 1 to 14.3:1 ratios of Ca/ P to Herford calves and observed that daily feed intake of calves varied from 2.7 to 3.63 kg per animal and the differences among group being non significant. Combs and Wallace (1962) fed diets containing varying level of Ca i.e. (0.4 and 0.88%) to pigs through various sources of Ca such as $CaCO_3$, ground lime stone and Oyster



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shell and observed that neither the levels of Ca nor the sources of Ca had any effect on DM intake. Lall (1987) reported that different sources of Ca had no effect on DM intake in growing calves. Our present findings are in agreement with the present study, the ratio of Ca/ P in the diets varied between 1.95:1 to 2:1 with different sources i.e. $CaCO_3$ and calcite powder (group I and II and 2:1 to 2.64:1 with different levels of the one source (calcite) powder (group II and III) and had no effect on daily DMI. In contrast to above findings Clark *et al.* (1989) observed that addition of 1.4% $CaCO_3$ to basal diets of cows reduced the DMI which they speculated as might be due to increased ash content of 1.4% lime stone added diet. Similar observations were also recorded by Rogers *et al.* (1982).

## VIII. Digestibility

The digestibility coefficients of DM, CP, CF, EE and NFE are presented in Table 4.13. The corresponding values in the three groups were 60.12 ±0.92, 63.01±1.72 and 59.71±0.75 for DM 55.63±1.89, 57.10±2.19 and 55.97±3.57 for CF, 81.25±2.47, 82.51±2.38 and 80.35±1.91 for EE, and 69.37±0.73, 73.51±1.67 and 70.64±1.28 for NFE, respectively. These values of digestible coefficient for DM, CP, CF, EE and NFE did not show any significant difference among the experimental treatments.

The digestibility data showed that neither the sources of Ca i.e. calcium carbonate/ calcite powder nor the addition of additional calcite powder had any effect on the digestibility's of organic nutrients. indicating that compositional characteristics of calcite powder had no influence on utilization of dietary organic nutrients and is comparable to calcium carbonate when used as Ca source (Group I). The f additional 1.5% calcite powder in group III as compared to group II also did not show any significant effect on the digestibility of organic nutrients (Table 4.13).

Lall (1987) showed that inclusion of rock phosphate or super phosphate as a source of Ca/ P had no effect on the intake and utilization of organic nutrients in calves, compared with Dicalcium phosphate. Combs and Wallace (1962) compared the effect of 0.4 and 0.88% Ca on nutrient digestibility and observed that 0.88% Ca in the diet significantly reduced the digestibility of EE and CF, while DM and CP digestibility was significantly lowered when gypsum rather than ground lime stone or oyster shell was used as supplement Ca source. The same authors reported that the sources of calcium did not significantly affect the apparent digestibility of ether extract, but digestibility of CP was significantly influenced by the level of calcium. Feeding of calcium carbonate in the diet is reported to improve apparent total tract digestibility (Wheeler *et al.,* 1976; 1977), which is just contrary to the observation made by other workers, (Fernandez *et al.,* 1982; Nocek *et al.,* 1983; and Rogers *et al.,* 1985) who demonstrated that supplementation of calcium carbonate to the diet of dairy cows did not improve starch digestibility.

Keyser *et al.* (1985) showed that the effect of calcium carbonate on starch digestibility was dependent on its particle size and rate of reactivity. Clark *et al.* (1989) demonstrated that supplementation of calcium carbonate in the diet of cows did not influence the apparent total tract digestibility of DM, OM, CP, EE. The apparent digestibility of starch was increased ($P<0.01$) by supplementation of calcium carbonate to the control ration, A similar increase in starch digestibility was also reported by Rogers *et al.* (1982). In subsequent experiment Rogers *et al.* (1985) fed cow basal diet (0.6% Ca) and basal diet with 1.4% lime stone (Ca 1.1% P 0.52%) and observed that digestibility of DM and CP were similar in all the groups, which are in concurrence with the findings of the present experiment.

Lall (1987) fed different sources of Ca and P (DCP, rock phosphate and super phosphate) in the diet of calves and observed that there was no difference in the digestibility of organic nutrients (OM, ADF and CP).Amrutkar (2006) added 0, 5 and 10% lime stone powder in the concentrate mixture of three different groups of calves. (Dietary Ca: P ratio 1.9:1, 3.7:1 and 6.4:1) and observed that there was no significant difference in the digestibility of organic nutrients.

## IX. Growth Rate and Feed Conversion Efficiency

The data pertaining to initial and final body weights, feed efficiency and average daily gain are presented in table 4.26. The mean average daily gains in calves of group I, II and III were 448.39±19.78, 463.00±13.26 and 515.89±29.15 gm respectively, which were statistically non significant. Feed conversion ratios (DMI/ kg gain) in group I, II and III were 12.72±0.80, 12.46±0.63 and 11.36±0.6 which were also statistically similar in all the groups (Table 6). These results indicated that neither the different sources of calcium used in group I and group II nor the levels of calcite powder used in group II and III had any significant effect on gain in body weight of calves or in the efficiency of conversion of diet to body weight gain of calves. Huffman *et al.* (1933) observed satisfactory growth among dairy calves fed rations containing Ca and P ratio between 4:1 and 5:1.

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*Table 6 :* Growth and feed conversion efficiency of calves in different groups

| | Groups I | Group II | Group III |
|---|---|---|---|
| Initial body weight (kg) | 223.67±15.60 | 226.83±12.64 | 225.83±11.49 |
| Final body weight in24 week( kg) | 299.0±13.51 | 304.67±11.48 | 312.5±14.99 |
| Mean weight gain | 75.33±3.23 | 77.84±1.58 | 86.67±4.90 |
| Average daily gain (gm) | 448.39±19.18 | 463.30±13.26 | 515.89±29.15 |
| Growth rate 'b' value (kg/ week) | 3.61±0.15 | 3.77±0.15 | 3.62±0.02 |
| Feed to gain ratio(feed intake/ Kg bodyweight ) | 12.72±0.80 | 12.46±0.63 | 11.36±0.60 |

*Table 7 :* Cumulative body weight (kg) of calves in different groups

| Weeks | Group I | Group II | Group III |
|---|---|---|---|
| 1 | 223.67 | 226.83 | 225.83 |
| 2 | 229.00 | 229.50 | 228.83 |
| 3 | 223.33 | 228.00 | 226.67 |
| 4 | 233.67 | 235.00 | 237.17 |
| 5 | 235.33 | 241.00 | 241.17 |
| 6 | 244.00 | 248.17 | 248.33 |
| 7 | 247.50 | 248.00 | 252.00 |
| 8 | 247.00 | 250.67 | 253.83 |
| 9 | 251.33 | 252.83 | 256.50 |
| 10 | 251.50 | 255.50 | 258.50 |
| 11 | 259.33 | 264.50 | 264.33 |
| 12 | 262.50 | 266.50 | 265.50 |
| 13 | 262.33 | 272.33 | 272.83 |
| Weeks | Group I | Group II | Group III |
| 14 | 270.17 | 272.00 | 272.17 |
| 15 | 274.00 | 277.83 | 279.17 |
| 16 | 277.00 | 283.50 | 282.83 |
| 17 | 281.00 | 289.50 | 289.00 |
| 18 | 290.67 | 294.17 | 301.00 |
| 19 | 291.33 | 293.67 | 300.33 |
| 20 | 293.17 | 300.17 | 305.67 |
| 21 | 297.00 | 304.17 | 312.50 |
| 22 | 297.67 | 303.50 | 308.83 |
| 23 | 300.17 | 304.83 | 311.17 |
| 24 | 299.00 | 304.67 | 312.50 |

Theiler *et al.* (1937) stated that a Ca P ratio of 4:1 did not significantly affect performance of growing beef heifers and steer when an adequate amount of P was supplemented in the ration. In contrast, Ricketts *et al.* (1970) observed that steers receiving 8:1 Ca/ P diet gained significantly ($P<0.01$) less weight than the steers receiving either 1:1 of 4:1 Ca/ P diet



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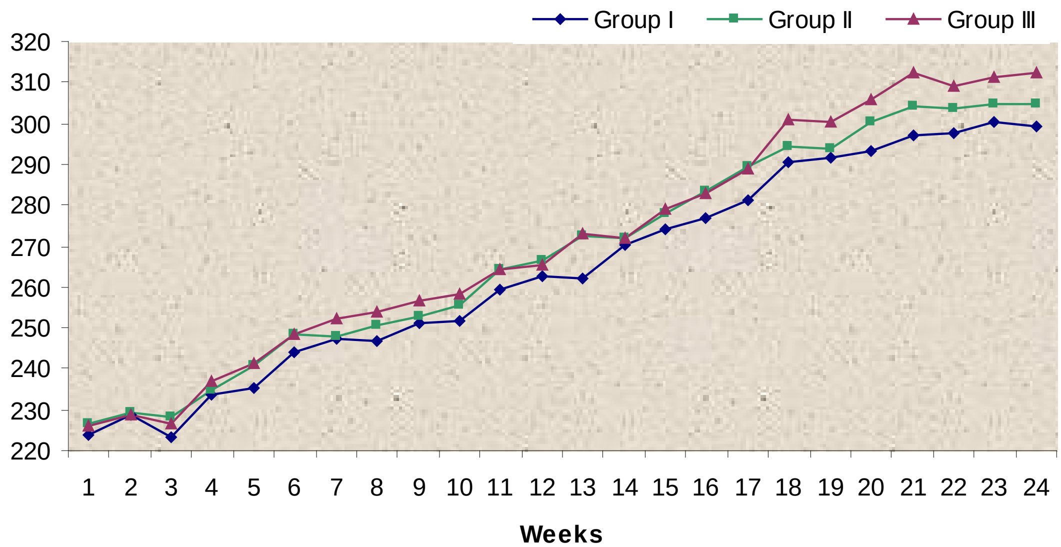


*Fig. 4.3 :* Cumulative body weight (kg) of calves under different treatment groups

Wise *et al.* (1963) fed 45 Herford calves in a factorial experiment with three levels of Ca (0.27, 0.81 and 2.43% of diet) and P (0.17, 0.34 and 0.68% of diet). Nine resulting, levels and ratios 0.4:1 to 14.3:1 of Ca and P were obtained by addition of varying amounts of calcium carbonate, defluorinated rock phosphate and dibasic sodium phosphate to a semi purified diet, They reported that performance and nutrient conversion were markedly decreased with Ca: P ratios lower than 1:1 ratios and between the ratios 1:1 and7:1 gave similar and satisfactory results. Ca: p ratios while above 7:1 resulted in decreased performance and nutrient conversion, but adverse effects were not marked with the ratio below 1:1.

Lall (1987) reported that there was no difference in growth rate, feed and mineral utilization in calves fed various sources of Ca and P in the diet. Similarly, many other workers (Aflaro *et al.,* 1988; Amrutkar, 2006) have observed that average daily gain, average feed intakes, feed efficiency and general health of calves were not affected ($P>0.05$) by wide range of Ca: P ratio, the result in the present study are in agreement with those reported above.

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