Studies on
The Utilization of Extra Calcium, Phosphorus And
Carotene In Growing Tharparkar Calves.

Thesis
Submitted to Magadh University in Partial
Fulfillment of the Requirements for the
Degree of M. Sc. (A.H.)
in
Nutrition

BY
K. Kumara Das
Post-Graduate Department of Nutrition
Bihar Veterinary College, Patna,
November, 1966
Studies on
The Utilization of Extra Calcium, Phosphorus And
Carotene In Growing Tharparkar Calves.

Thesis
Submitted to Magadh University in Partial
Fulfilment of the Requirements for the
Degree of M. Sc. (A.H.)
in
Nutrition

BY

K. KUMARA DAS
Post-Graduate Department of Nutrition
Bihar Veterinary College, Patna,
November, 1966
I certify that this Thesis has been prepared under my supervision by Shri K. Kumara Das, a candidate for the M.Sc.(A.H.) with Animal Nutrition as major subject, and that it incorporates the results of his independent study.

19 - 13. Mukherjee

G.V.Sc., M.Sc., Ph.D.,
Professor & Head of the Department of Nutrition,

November, 1966.

Bihar Veterinary College,
ACKNOWLEDGEMENT

The author acknowledges his deepest sense of gratitude and indebtedness to Dr. D. B. Mukherjee, M.Sc., Ph.D. (London), Professor of Animal Nutrition, Bihar Veterinary College, Patna for suggesting this problem, his esteemed inspiring guidance, critical perusal of the manuscript, stimulating discussions and his keen supervision throughout the study.

Occasional helpful advice by Sr. G. N. Sharma, M.Sc. (A.H.) of the Post Graduate Department of Nutrition of the College is gratefully acknowledged.

The author is grateful to the Principal, Bihar Veterinary College, Patna for the generous facilities extended throughout the present study.

Thanks are also due to the Manager and other Officers of the Government Cattle Farm, Patna for providing necessary facilities to carry out this experiment in the Farm.

PATNA,
November, 1966.

( K. Kumara Das )
CONTENTS.

I  INTRODUCTION  1 - 23
II  REVIEW OF LITERATURE  24 - 74
III MATERIALS AND METHODS  75 - 90
IV RESULTS AND DISCUSSION  91 - 142
V  SUMMARY  143 - 146
VI REFERENCES  1 - 1x
INTRODUCTION

Over seventyfive years ago the famous English Scientist Lawes and Gilbert performed the pioineer and laborious task of analysing the entire bodies of farm animals. From that times we have a large body of data regarding the composition of various species at different ages and in varying stages of nutrition. However, as late as thirty years ago, the knowledge was very limited concerning the exact amount of these minerals required by farm animals, and little was known about the need for any other minerals.

Minerals have many vital functions in the body. The skeletons of all vertebrate animals are composed chiefly of minerals, of which calcium and phosphorus form the major part. They are also necessary constituents of soft tissues and body fluids. For example, phosphorus is an essential ingredient of such biologically important compounds as the Nucleo-proteins, milk casein and the Phospholipids. The minerals, as a group also play important roles in the maintenance of proper reaction of such body fluids as the blood, digestive juices and urine. Many vital functions of the body like tonus of muscle, regular beating of heart, transmission of impulses through the nerves and at the neuromuscular junction are mainly guided by minerals.
### Table 1.1

**Table Showing the Calcium and Phosphorus Content of the Body in Foetal and New Born Calves.**

---


<table>
<thead>
<tr>
<th>Source</th>
<th>Age</th>
<th>No</th>
<th>Total Ca</th>
<th>Total P</th>
<th>Ca : P</th>
<th>Ca%</th>
<th>P% body</th>
<th>Body weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Foetus</td>
<td>135 days</td>
<td>1</td>
<td>8.0</td>
<td>5.8</td>
<td>1.38</td>
<td>0.41</td>
<td>0.29</td>
<td></td>
</tr>
<tr>
<td>1 Foetus</td>
<td>148 days</td>
<td></td>
<td>10.1</td>
<td>7.3</td>
<td>1.38</td>
<td>0.39</td>
<td>0.22</td>
<td></td>
</tr>
<tr>
<td>1 Foetus</td>
<td>160-190 days</td>
<td></td>
<td>24.8 to 16.4 to 1.56</td>
<td>0.65</td>
<td>0.42</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Foetus</td>
<td>201-222 days</td>
<td></td>
<td>60.1</td>
<td>41.9</td>
<td>1.56</td>
<td>0.65</td>
<td>0.42</td>
<td></td>
</tr>
<tr>
<td>Foetus</td>
<td>233-267 days</td>
<td></td>
<td>140</td>
<td>82</td>
<td>1.70</td>
<td>0.85</td>
<td>0.50</td>
<td></td>
</tr>
<tr>
<td>Foetus</td>
<td>267 days</td>
<td></td>
<td>375</td>
<td>210</td>
<td>1.79</td>
<td>1.15</td>
<td>0.64</td>
<td></td>
</tr>
<tr>
<td>At birth</td>
<td>673</td>
<td>376</td>
<td>1.79</td>
<td>1.37</td>
<td>0.76</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dairy Calves 3 months</td>
<td>314</td>
<td>519</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dairy calves 6 months</td>
<td>722 to 446 to</td>
<td>1503</td>
<td>837</td>
<td>1.79</td>
<td>1.37</td>
<td>0.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dairy calves 9 months</td>
<td>1256 to 730 to</td>
<td>2503</td>
<td>1446</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dairy calves 1 yr.</td>
<td>1509 to 855 to</td>
<td>3392</td>
<td>1912</td>
<td>1.79</td>
<td>1.37</td>
<td>0.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dairy calves 2¾ years to 3½ yrs.</td>
<td>4613 to 2252 to</td>
<td>7350</td>
<td>3221</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
They are responsible for the maintenance of acid base equilibrium and proper osmotic pressure in the body. Minerals also form an important part in the intricate enzyme system of the body. Although the minerals as such yield no energy to the body, yet they play a vital role in its metabolism and nutrition.

As far as the present knowledge goes the following are the minerals elements required by the body and must be present in the food: Calcium, Phosphorus, Sodium, Potassium, Chlorine, Magnesium, Sulphur, Iron, Iodine, Manganese, Copper, Zinc and Cobalt. Even though it is reported that minerals like Fluorine and Molybdenum are essential in minute amount for normal maintenance of health, these points are not proved beyond doubt due to the difficulty in giving ration completely free from these minerals. They are found to cause toxicity to man and animals when given in excess. But it is recently reported that when water supply contains 1 to 2 P.P.M. of Fluorine the incidence of dental caries is decreased compared to that where fluorine supply was low. Molybdenum due to its association with the enzyme Xanthine oxidase is also considered to be essential in minute amounts. This was reported in the work of Richert and Westerfield and by DeRenzo et al (1953).

The mechanism of the absorption of minerals is
different from those of the organic constituents like protein, fat and carbohydrate. The organic nutrients as is well known, are acted upon by the micro-flora present in the rumen and later by various gastric and intestinal enzymes. This is however, not the case with minerals. Neither the micro-organisms present in the rumen nor the biological catalysts have any direct action on minerals. Their absorption primarily depends upon the state in which they occur in the feed consumed as well as the gastro-intestinal reactions and various factors that promote or inhibit the permeability through the absorbing membrane of the intestine.

The study of mineral content of the ration and also their utilization by animals is also important in other respects also. The pH of the blood is maintained in a very narrow range. The mineral content of the food ingested will show wide range of potential acidity and alkalinity. The question of the influence of the acid-alkali ash value of the diet, on metabolism, has received much attention. This balance depends upon the amount of acid forming minerals, like phosphorus, chlorine and sulfur and base forming elements like sodium, potassium, calcium and magnesium, present in the food. Thus it was found that in general seeds and their bye-products are acid forming and roughages are base forming. High protein diets tend to be acid forming due to the sulfur present in it. It was also
shown that high acid forming diets decrease the alkali reserve of the blood, resulting in excretion of fixed bases even from bone. But in ruminants the production of ammonia is an effective mechanism to prevent the excretion of fixed bases.

**CALCIUM AND PHOSPHORUS:**

Over 70 percent of the ash of the body consists of calcium and phosphorus. These two elements are closely associated with each other in metabolism. They occur in the body combined with each other for the most part. Inadequate supply of any one of the elements in the diet affects the availability of both. Chossat was the first man to establish the effect of calcium in bone development as early as 1892. Later on works in France and Germany showed that skeletal development in various farm animals depends upon the supply of calcium and phosphorus in the ration. About 99% of the calcium and 80% of phosphorus of the body are present in the bone and teeth. Out of the 25% of ash in the bone, Calcium and Phosphorus is present to an extent of 36% and 17% respectively. Compounds of calcium and phosphorus also form more than 50% of the minerals in the milk.

The calcium and phosphorus content of the body of animals from foetus to adults has been analysed by various workers.
Moulton *et al.* (1922) and Ellenberger (1936 and 1950) have done many such analysis. They have reported that there is steady increase in the calcium and phosphorus ratio. It is shown that during the last two months of gestation the calf on an average retains about 9 gms. of calcium and 5 gms. of phosphorus daily. In cattle during their first year the percentage of calcium and phosphorus and the ratio between them remains constant, but in the later stages of growth there appears to be an increase especially in the calcium content.

According to Ellenberger *et al.* (1950) in adult cows about 98.5% of the total body calcium and 87% of the phosphorus are in the bones. Much of the phosphorus in the soft tissues is in organic compounds and probably plays little part in mineral turn over. In younger calves rather less of the phosphorus, about 83% is in the bones.

In the words of Gor (1925) "The bones act as a reservoir", especially for calcium and phosphorus, the two minerals required in largest amounts. Reserves can be deposited in the bones when the supply is in abundance, and mobilised in times of need. This function of bone is probably as important as the one providing rigid frame work in the body. It is probably more
fundamental, for, when the available mineral matter is insufficient to maintain both the physiological balance in the blood and the rigidity of the skeleton, it is the rigidity which is sacrificed. The fact is shown clearly elsewhere in this Chapter.

Roche and Mousge (1943) showed that calcium and phosphorus accumulate in foetal cartilage before the beginning of ossification. After analysing different bones, Ellenberger reported no difference in calcium and phosphorus contents between bones. On fat free dry matter basis, the percentage of calcium and phosphorus in skeleton increased from 12.4 and 6.3 in the foetus of six months' to 14 and 7 at birth and 18 and 9 in the year old calves. In adult this was 22 and 10 with ranges between 20 and 25 and between 9 and 12. There was not much variation so far as calcium and phosphorus ratio is concerned. It varied from 2 at foetal age of 7 months to 2.15 in adult. The range being 2.09 to 2.20.

Hitsche (1939) reported that bone of some calves by the end of the third month after birth, contained as high a proportion of minerals as adult bone.

Vander Wal (1956) showed that in the metatarsus the primary Haversian systems are progres-
progressively replaced by concentric lamellae and by secondary bone, in bulls as well as in cows.

It is often assumed that because the ratio of calcium: phosphorus in bone is of the order of 2:1, intake, retention and loss should be in the same ratio. But according to Dallemange et al (1955) there appears to be mechanisms which may allow storage of an excess of either element, and in bone some 15% of calcium is not bound to phosphorus.

In farm animals the requirement of calcium and phosphorus along with that of Vitamin D have been studied extensively. The principal needs for calcium and phosphorus during growth are for the formation of the skeleton and as such they are called bone forming nutrients. Phosphorus plays an important role in the growth of soft tissues, and exerts an indirect effect on growth because of its relation to appetite.

In assessing the requirement of these minerals for growth, the development of skeleton cannot be measured by increase in body weight, by determining the dimensional measurements of the body or even of the bones themselves. Size of the bone is governed largely by inheritance and a large bone may be very weak. The real measure of the adequacy of skeletal development is the density and strength of the bones formed as condition-
conditioned by their content of calcium and phosphorus and their histological structure. The requirement for the bone forming nutrients can be determined by slaughter experiments in which representative bones are analysed for their calcium and phosphorus content or studied histologically. The measurement of density and hardness and the determination of breaking strength are usual supplementary measures. Since the ash of bones consists almost entirely of calcium and phosphorus the determination of the ash content is more commonly used as the measure of the adequacy of bone nutrition than the more time consuming analysis for calcium and phosphorus.

Hugus and Cave (1931) and Duncan and Huffman (1934) estimated calcium and phosphorus requirement from balance trials. Mitchell and Mac Clure (1937) estimated calcium and phosphorus requirement from the relation between calcium and phosphorus requirement and nitrogen requirement for maintenance together with growth requirements estimated from N content of tissues by assuming a uniform retention of 0.27 Gm. of phosphorus to each Gm. of nitrogen and a calcium retention equal to 1.71 X phosphorus retention. Beeson, Bolin, Hickman and Johnson (1941) and Converse (1954) estimated the requirement from long term feeding trials with diets containing different amount of calcium and phosphorus.
More recently it has been suggested that the maintenance requirement for calcium and phosphorus is represented by the endogenous faecal excretion of these two minerals. Endogenous faecal calcium and phosphorus have been estimated by isotope method (Tomlin and Co-workers —1953).

If a maximum rate of calcification is considered to be optimum, a high intake in proportion to the amount stored must be supplied. Huffman and Associates (1933) used blood data for measuring the calcium and phosphorus requirements. His observation is based on the fact that inadequate bone nutrition is reflected in a lowering of blood level of calcium and phosphorus.

Mitchell (1947) has estimated the calcium and phosphorus requirement on the basis of calculated maintenance value, storage during growth as shown by carcass analysis, and percentage retention data.

**CALCIUM AND PHOSPHORUS IN SOFT TISSUES**

Calcium and phosphorus which occurs outside the bone is widely distributed throughout the organs and tissues. Where it exists in organic combination as phosphoprotein, nucleoprotein, Phospholipids, phosphoprotein, hexosephosphate etc. Phosphorus makes up 0.15
to 0.2 percent of the soft tissues of the body.

Blood cells are almost devoid of calcium, but the serum contains 9 to 12 mg. of calcium per 100 ml. and 4 to 9 mg. phosphorus per 100 ml. In serum, calcium is in diffusible and non-diffusible form. The non-diffusible calcium is bound to protein. The primary source of blood calcium in food and is not influenced to a very great extent by dietery intake.

ABSORPTION AND EXCRETION OF CALCIUM AND PHOSPHORUS:

The absorption of calcium and phosphorus depends upon their solubility at the point of contact with the absorbing membranes. Following factors favour the absorption of calcium and phosphorus, mainly by providing suitable surroundings to keep them in solution:

1. An acid medium favours the absorption by preventing the formation of insoluble and unabsorbable tricalcium phosphate. Lactose promotes an acid reaction in the digestive tract. The hydrochloric acid present in the gastric juice also favours the absorption of calcium and phosphorus.

2. Large intake of minerals like iron, aluminum and magnesium interfere with absorption of phosphorus by forming insoluble phosphates.

3. Beryllium will make phosphorus unsoluble.
and is proved to be the reason for beryllium rickets.

(4) Even though some amount of fat is found to be favourable for absorption of calcium examination of fatty acids forms insoluble calcium soaps and render them inabsorbable.

(5) Excess of calcium or phosphorus will adversely affect the absorption of the other mineral.

(6) Vitamin D is an important factor in favouring the absorption of calcium and phosphorus, the deficiency of which is responsible for causing rickets.

(7) Undigested phylate precipitates calcium and prevents its absorption.

(8) Oxalates and oxalic acid forms insoluble oxadates with calcium and prevents its absorption. But this absorption is questioned in the case of ruminants, due to the fact that ruminal micro-flora splits the oxalates present.

The faeces is the main source of excretion of calcium and phosphorus. Some part is excreted through urine also. The amount excreted in urine depends upon the age of the animal. Older the animal, more calcium is excreted as they require only less calcium and phosphorus for bone formation.

**STATUS OF BONE IN CALCIUM AND PHOSPHORUS METABOLISM:**

The availability of free calcium and
phosphorus depends upon the extent of the storage of these minerals in the bone. During growth, when there is good dietary supply, a major part of these minerals is deposited in bones and is mobilised when the ossification of calcium and phosphorus is inadequate, either due to insufficient dietary supply or due to some other reason. Thus bone acts as a storehouse of calcium and phosphorus. The mobilization is affected more during lactation in dairy cows and egg production in birds. This explains the necessity to have an optimum dry period with good dietary supply of calcium and phosphorus in order to replenish the depleted bone calcium reserve.

The growth of bone in length takes place at the junction between epiphysis and diaphysis. The epiphysial cartilage grows of its own multiplication and continues to be replaced at both surfaces by calcified bone. The trebuculae are lace-like structures acting as a main reserve for calcium and phosphorus, to be mobilized at the time of need. The ephyseal are located at the ephyseal ends. They are the main sites where parathromere acts to mobilize calcium and phosphorus to maintain their blood level. This store is utilized when the body needs more calcium and phosphorus as in lactation, later part of pregnancy, egg production.
etc. It is shown that there is a constant exchange of minerals at this epiphysis and between the blood and bone. This exchange is most active in the strong bones. The mechanism of deposition of calcium and phosphorus in the bone is not clearly known. It is thought that from the blood, which bathes the bone, is supersaturated with tricalcium phosphate and that deposition occurs by precipitation of this salt. But due to the fact that deposition occurs normally in bones and cartilages only, it is believed that some enzymes present exclusively at bone and cartilage play a part in the deposition of calcium and phosphorus. The enzyme phosphatase is reported to be one of the factors. Vitamin D is another factor responsible for deposition of calcium and phosphorus.

Brouwer (1952) while studying the microscopic structures of the long bones found that the arrangement of laminae lacked the highly developed Haversian system of adult human bones and he thought the difference might be due to repeated breaking down and rebuilding of bone tissue in successive cycle of pregnancy and lactation.

**DEFICIENCY DISEASES:**

Due to its important role in the formation
of bones any deficiency will be directly reflected on the status of the osseous tissues. Due to the dynamic action of calcium and phosphorus in the bone and that calcium and phosphorus can be mobilised from bone stores for meeting any current needs. Deficiency will be more acutely exhibited by young and growing animals. Deficiency of any of the elements will reduce milk production and egg production drastically. Any deficiency of calcium and phosphorus at the later part of gestation will have devastating effect on the new bones, resulting in abortion, still birth etc.

Deficiency of calcium and phosphorus is directly reflected by a negative balance or improper retention. More in reduced bone ash content and the bones are weakened. As a result in adult animals external symptoms like lameness, fractures without any apparent reason are seen.

In young and growing animals deficiency is responsible for the development of the disease called rickets. Rickets represents a disturbance of the mineral metabolism so that normal calcification of the growing bones does not take place. The cause of rickets is either due to inadequate supply of calcium, phosphorus and Vitamin D or such other factors which will adversely affect the utilization
of calcium, phosphorus and Vitamin D. As a result of reduced absorption, the blood that is bathing the bone also will be deficient in the nutrients, thereby causing an improper or reduced deposition of calcium and phosphorus in bone. In rickets, the blood may be low in calcium, phosphorus and Vitamin D or may show a low-phosphorus-high calcium picture. The arrest in the development of the bone is followed by enlargement of the epiphysial region. This is more conspicuous on ribs, on either side of the chest, and this lesion is popularly called as rickety rossary. Constant failure of adequate nutrition puts much pressure on weakened bones by way of the tension of the muscle and it deforms the bones causing bends, buckles and even fracture.

Failure of utilization of calcium and phosphorus in adult animals causes osteomalacia. This is due primarily to excessive mobilization of calcium and phosphorus from bones. The excessive mobilization of calcium may be due to increased parathyroid activity. This also occurs in the later part of gestation, to those animals which are subjected to continuous calcium and phosphorus deficient diet. Here also the blood may be low in calcium or phosphorus or both. In acute deficiency, tetany is seen.
When dairy cows are maintained at low calcium and phosphorus diet for a long time especially at the later part of gestation, they suffer acutely due to the deficiency, immediately after parturition. This is due to the fact that milk production warrants a considerable part of calcium and phosphorus, and that lactation suddenly ensues sometime before parturition, causes severe drain in calcium and phosphorus reserves causing acute calcium and phosphorus deficiency. This is exhibited as weakness, prostration, tetany etc., immediately after parturition.

Deficiency of phosphorus causes loss of appetite, a condition called Pica, develops. Pica is characterised by eating of wood, cloth, bone and other material by the suffering animal.

Diseases of the animals caused by deficiency of Vitamins are probably as old as the human race. From the skeletons of the pre-historic man definite signs of existence of rickets and scurvy are obtained. But during that period with the exception of a remedy for night blindness no effective therapeutic methods were known for curing these diseases. As early as 1720, Karner an Austrian Physician advocated lime juice and fresh vegetables as a cure for scurvy. In 1657 Hoefer and in 1954 Von Bergen expressed the view that night
blindness is caused by malnutrition. Hopkins (1909) for the first time emphasized the physiological and universal importance of specific nutritional constituents. Funk (1912) tried to isolate the compound which prevents beri-beri in man. Even though Funk did not succeed in isolating the pure substance obtained nicotinic acid as a by-product. He concluded that all these materials causing deficiency symptoms, other than the proximate principles viz., carbohydrate, protein, fat and water, are chemically amines. Funk coined the term "Vitamines" to designate these compounds, which later on changed to "Vitamins".

Rossenberg (1943) defined Vitamins as "organic compound which are required for the normal growth and maintenance of life of animals including man, who, as a rule are unable to synthesize these compounds by anabolic processes that are independent of environment other than air, and which compounds are effective in small amounts, do not furnish energy and are not utilized as building units for the structure of the organism, but are essential for the regulation of the metabolism of structural Units".

The following are the Vitamins whose chemical composition and physical properties are known at present:

1) Vitamin A;
2) Vitamin $B_1$ - Thiamin;
3) Vitamin $B_2$ - Riboflavin;
4) Vitamin $B_6$ - Pyridoxin;
5) Nicotinic Acid;
6) Pantothenic Acid;
7) Inositol;
8) P. Amino Benzoic Acid;
9) Vitamin $B_{12}$ - Cynacobalamine;
10) Vitamin C - Ascorbic Acid;
11) Vitamin D;
12) Vitamin E;
13) Vitamin H - Biotin;
14) Vitamin K; and
15) Vitamin P - Citrin.

Vitamin A is a fat soluble, nearly colourless substance having the formula $C_{20}H_{30}O$. It occurs only in the animal organisms and has not been found in plants. It is contained as an unsaponifiable constituent extractable by lipid solvents. It occurs both as free alcohol and also as esters of higher fatty acids and is related to unsaturated acids.

Vitamin A is combined with a protein in visual purple, a compound required for dark adaptation. Vitamin A is required for the maintenance of the intactness of the epithelial tissue. Vitamin A is concerned in the
normal development of bone. Deficiency of Vitamin A causes impairment of vision especially adaptation to darkness, stratification and keratinization of the epithelium, causing reduced resistance to general infections, reproductive disorders, improper development of bone causing narrowing of osseous bone channels, resulting in nervous symptoms, congenital malformations etc.

Carotene, an yellow pigment associated with the chlorophyll of plants is a precauser of Vitamin A. They are present in animal tissue only in insignificant amounts. Traces of carotene have been found in the body fat. They occur in small amounts in plasma, milk, butter and egg yolk. They are also found in corpus luteum, testis of bulls and adrenal gland. They are also found to occur in yellow bone marrow. They are mainly bound in simplex form to proteins in both plant and animal materials. All green or yellow parts of the vegetable kindom forms the major source of carotene available to animals.

Carotene is found in four forms, alfa carotene, beta carotene, gamma carotene, and hydroxy beta carotene. The Vitamin A activity of beta carotene is greater than that of the other forms. Most of the carotene of feeds is in the beta form. Carotene is
extremely sensitive to oxidation, auto-oxidation and light. They are readily soluble in chloroform carbon di-- sulphide and benzene and less soluble in petroleum ether. They are soluble in fats.

Karrer and Kuhn (1921) established the chemical structure of this highly complex hydrocarbon. The structure of all provitamin A is identical. They have a symmetrical aliphatic chain of 18 carbon atoms with the continuous system of conjugated double bonds and four methyl groups constituting side chains. They confirmed the empirical formula C_{40}H_{56}.

Due to its importance in disease resistance, calcification of bone and other metabolic processes, all higher animals require Vitamin A for proper growth. Deficiency of Vitamin A results in moribound condition and stunted growth in calves. Many workers have shown that carotene is essential for growth. Deficiency of carotene and Vitamin A causes reduced body gain. It is also shown that Vitamin A is essential for the growth of tissue proteins but not for its maintenance. Vitamin A is concerned in the normal development of bone through a controle exercised over the activity of the osteoclasts and osteoblasts of epithelial cartilages.

Absorption of carotene varies according to
the nature of the diet and the species. Differences in the digestibility of food sources are reflected in variations in the amount of the provitamin available for absorption. Fats promote the absorption of both Vitamin A and carotene. Emulsifying agents may have an additional beneficial effect. Some of the ingested provitamins are destroyed in the intestine. Presence of Vitamin E lessens this destruction. Absorption depends upon the availability of carotene in the ration. Cattle shows greater plasma carotene value when green grass is supplied in plenty. There occurs some kind of species variation in the absorption of carotene. In goats, sheep and swine only little amount of carotene is absorbed into the blood stream even when fed with ration high in carotene. Blood of cattle and horses contains substantial amounts of carotene.

It was assumed that carotene was converted into Vitamin A in liver but later on studies by Wiese et al (1947) have shown that atleast in rats this conversion occurs in small intestines. Similar conversion has been reported in pig, calf, goat and chicken. Later on studies by Bicri and Pollard (1954) have shown that this conversion is not affected by removal of small intestine and 60-70% of liver. This shows that conversion of caroten to Vitamin A occurs
at many places other than liver and small intestine. It is also shown that all animals do not possess equal ability to convert carotene to Vitamin A. According to Ahmad and Malick (1933) rats are most efficient converter of carotene to Vitamin A. Chickens, guineapig, rabbits, pigs and cattle shows serial efficiency in conversion to Vitamin A. It is seen that carnivorous animals are least efficient converter of carotene to Vitamin A. Perhaps this may be due to the fact that they get more of Vitamin A from their ration.

The present study "FATE OF EXCESS OF DIETARY, CALCIUM, PHOSPHORUS AND CAROTENE IN YOUNG CALVES" was designed to study the extent of absorption and retention of these elements in growing THARPARKER CALVES with a view to ascertain the beneficial role, if any, of liberal intakes of these nutrients so essential for proper growth.
REVIEW OF LITERATURE

Voluminous literature is available regarding the importance of calcium and phosphorus and its subsequent utilization by various farm animals. This Chapter includes the Review of Literature about the absorption, excretion, utilization and requirement for various body functions of calcium and phosphorus.

The attention of the early investigators was mostly focused on the quantitative sufficiency of the proximate principles such as protein, fats and carbohydrates. However, the work during the first half of this century has shown that growth, milk yield and reproduction are significantly influenced by nutrients that are not generally taken into consideration in calculating rations. It is now known that even if the diet is adequate in various organic nutrients, deficiency in certain minerals and Vitamins can cause serious impairment of body functions and physiological activities like growth, milk production etc. Even though most of them are required only in small amounts, they play an important role in the physiological functions of the living organism. It has been established that many problems of nutrition
as maximum production potential and incidence of disease are ultimately related with the sufficiency of the inorganic elements in the ration, especially calcium and phosphorus. Apart from calcium and phosphorus manganese, sodium, potassium and chlorine which are required in relatively larger amounts, other elements such as iodine, magnesium, iron, copper, cobalt and fluorine though required in minute quantities also exert a profound influence on general health and well being of the animal. A mass of evidence has been accumulated to show that the rations of our animals are considerably deficient in these mineral elements.

The metabolism of these minerals is discussed under the following heads:

1) Absorption;
2) Excretion; and
3) Utilization and Requirement.

1) ABSORPTION:

In the animal body calcium and phosphorus have so much in common that a biological discussion can be completed only when they are discussed together. Absorption of calcium and phosphorus from alimentary tract must be preceded by the transformation of the two elements in the ingested feed into
soluble state. By the process of mastication, regurgitation and rumination the food is broken up into particles and is mixed up with the alkaline salivary juice discharged during the process. As a result of bacterial action in the rumen it is quite possible that the mineral matter released from the organic incrustations passed into solution. Largest amount of solubilization takes place as the food moves into the true stomach. The hydrochloric acid present in the gastric juice transforms most of the insoluble calcium into soluble salts. However, it appears that a portion of the phosphorus of the feed in combination with organic compounds is not affected by the gastric juice. The calcium salts which exists a chloride and as acid calcium phosphate are mostly absorbed in the upper part of the small intestine before the complete neutralization of the gastric juice.

A further transformation of the unabsorbed elements takes place in the duodenum in contact with the pancreatic secretions, that are rich in alkali carbonates. At this stage several factors operate which may accelerate or retard the solubility of calcium and phosphorus. The solubility may be retarded by extra alkali. A partial solubility of calcium
salts may be brought about by bile notably from insoluble calcium soaps which are formed by the combination of calcium salts and fatty acids (Langley et al. - 1932). According to some authors, it is at this alkaline region of the alimentary tract, where the insoluble organic phosphorus compounds can be acted upon by the appropriate enzymes, of the intestinal secretions and converted into absorbable ester compounds. The fats are broken up into fatty acids and glycerine in the intestinal tract and the former reacts with calcium to form soaps which are insoluble in water but soluble in bile. Some workers are of opinion that this soap may remain insoluble in bile also which led to the assumption that dietary fat under certain conditions may affect the calcium assimilation. Some neutral fat may not affect the assimilation of calcium.

**INTESTINAL REACTION ON CALCIUM AND PHOSPHORUS METABOLISM:**

Apart from general reactions of the medium there are other complicated mechanisms which operate in the small intestine to facilitate the absorption of calcium and phosphorus. The mechanism regulating the H+ ion concentration in the alimentary tract, particularly of the small intestine where the
absorption may be considerably influenced by local conditions (Furguson- 1925 and Irving- 1926). An acidic condition of intestine is favourable for better absorption of calcium. In rickets where considerable disturbance takes place in the absorption mechanism, the reaction of the intestinal tract as well as the faeces is generally more alkaline than normal (Eastman and Miller- 1935). Under rachitogenic conditions, if an antirachetic agent like cod-liver oil, sunlight or ultraviolet rays is administered, the intestinal reaction is restricted to neutrality or slight acidity.

Under normal dietary conditions the H+ ion concentration of the intestinal contents is remarkably stable. Certain conditions of feeding, disturb the H+ ion concentration of intestine. Guthouse et al (1938) are of opinion that lactose is not so efficient as cod-liver oil but is much more efficient than starch or sucrose in producing favourable intestinal reaction and thereby increasing retention of calcium and phosphorus. With lactose he reported high bone ash value in rats. When rations containing inorganic acids as A.I.V. silage symptoms of acidosis is common. However, it appears that if the acid is neutralised no detrimental effect is observed.

ROLE OF PHOSPHATASE IN CALCIUM AND PHOSPHORUS ABSORPTION:

According to Cayle et al (1935) the absorption
of calcium and phosphorus is also influenced by an enzyme called Phosphatase present in the intestinal mucosa. It appears the enzyme liberates ortho-phosphoric acid thus liberated reacts with insoluble calcium salts present in the intestine to produce sufficient absorbable mono-calcium phosphate.

**INFLUENCE OF CALCIUM : PHOSPHORUS RATION ON THEIR ABSORPTION:**

Shohi et al (1927) and Bethke et al (1932) have shown that even if the level of intake of these minerals is adequate, a wide ratio may affect the utilization. A ratio of 10 : 1 between calcium and phosphorus will impair its utilization.

Palmer et al (1928) observed that the ingestion of magnesium sulphate by heifers on a low phosphorus diet results in serious and continuous loss of calcium. It appears that provided both calcium and phosphorus are supplied in plenty, ingestion of at least a moderate excess of magnesium will not markedly disturb calcium retention. Hawkins et al (1935) reported that manganese supplementation enhanced weight gains only in calves receiving excessively high dietary calcium and phosphorus. But high intake of calcium and phosphorus suppresses the manganese of the blood. Supplemental manganese did not affect significantly
the level of calcium, inorganic phosphorus or the activity of the alkaline phosphatase in blood. The results show that dietary requirements of magnesium is low and that increased amount of calcium and phosphorus intensify the needs for magnesium.

Turnear et al. (1931) have suggested that a disturbance in the calcium : phosphorus ratio in the dairy cows may lead to a poor assimilation of calcium and phosphorus. Optimum growth and bone formation was assured when the dietary ratio of calcium and phosphorus is 2 : 1. A large excess of calcium in proportion to phosphorus has definitely a bad effect on growth by forming insoluble tricalcium phosphate.

H. C. Sherman and Booher (1931) using diets containing increasing levels of calcium noted that not only is maturity reached earlier but also an increased storage of calcium per unit of body weight.

Maynard (1932) reported beryllium rickets due to the ingestion of beryllium. This element prevents the absorption of calcium and phosphorus by forming insoluble phosphates.

Outhouse and Mendel (1933) reported an increased body growth in a diet rich in all nutrients including calcium and phosphorus. It was accompanied by an increased rate of calcification compared with
that in the slower growing animals. But when these two groups reached the same mature weight there was no difference between two groups in the ash content of bone, suggesting that the calcification lags markedly behind body growth.

Du Toit et al. (1933) gave little importance to the ratio between calcium and phosphorus, if the ration is rich in these minerals.

Martson and Linos (1934) asserted that sheep are not as susceptible to phosphorus deficiency as are cattle because owing to the massive skeleton of large ruminants the amount of phosphorus required per unit increase of body weight is approximately double than that of sheep. The growing calves require considerably more calcium and phosphorus than lambs. Moreover the bovines being much less selective in its feeding habits, ingest much more poor herbage which is usually discarded by sheep, if given an option.

When fluorine was ingested in excess amounts disastrous effects in the availability of calcium and phosphorus was recorded by Jantz and Smith (1934) and Fober et al. (1935).

Rottensten (1935) by feeding rats on low level and high level of calcium and phosphorus found that 60% more calcium and 25% more phosphorus was found
to be retained in the high level feeding group. In the early period the depleted animals proved to be more efficient in utilization of calcium and phosphorus. On carcass analysis it was found that in these animals the tissue was saturated with calcium and phosphorus. He concluded that the degree of calcium saturation has an effect on the efficiency of calcium utilization. The efficiency is greater with depleted than with replenished stores. He believed that positive balance is not necessary a proof of adequate intake and vice versa. It might be in part of reflexion of the level of previous mineral nutrition.

Sherman et al (1937) found that the addition of extra calcium, Vitamin A and riboflavin in an already adequate diet expedited growth and development in rats.

Laskoskin (1937) reported that the rate of absorption of phosphorus is proportional to its concentration in the intestine. The absorption is more rapid at the upper than at the lower portion of the small intestine.

Street (1942) reported evidence on the inhibiting effect of aluminum sulphate on the availability of phosphorus.

Luick et al (1957) working on biokinetic aspects of calcium metabolism with the help of radio
active calcium found that the specific activity of the serum calcium against time did not become linear until at least 35 days after injection (I/V) of radio active calcium. This shows that, since previous work has shown that mixing between serum calcium, soft tissues and exchangeable bone calcium is complete within a few hours, there is a redistribution of isotope through much larger a pool of skeletal calcium. After 35 days, the decrease in the specific activity of serum calcium was linear for at least 150 days, in that period, he believes that there is a single large "mobilizable calcium pool". According to him this mobilizable calcium pool showed its size as from 2000 to 3200 gms. or 36 to 60% of the total body calcium, if that is 1.24% of the body weight in the mature cow. The size of this pool fell, and the rate of turn over rose as the calcium:phosphorus ratio was increased from 1:7 to 6:1. In bones the ratio of trabecular and compound bone did not seem to be affected by the diets. But autoradiograph showed that the lower the calcium:phosphorus ratio in the ration the heavier the deposition of radio active calcium and more diffuse its distribution within the bone. Whatever may be the calcium intake nearly all the trabecular bone calcium may be considered part of the mobilizable
calcium pool. But proportion of cortical bone calcium in the pool appeared to vary from 7% in the cow given the highest calcium : phosphorus ratio to 17% in that of the lowest ratio. The cows with higher calcium : phosphorus ratio in the diet had consistently and highly significant lower serum calcium.

**EFFECT OF SUGAR ON CALCIUM AND PHOSPHORUS ABSORPTION:**

Some organic constituents of the feed have significant influence upon the utilization of calcium and phosphorus. Hart *et al* (1927) showed that assimilation of calcium and phosphorus increases when green grasses are fed to the lactating cows.

Robinson *et al* (1929) observed that the addition of lactose in the ration of calves significantly improves the absorption of calcium. Similarly sucrose, glucose and maltose exert a favourable action in the absorption of calcium by causing more acidity in gastrointestinal tract.

**EFFECT OF CRUDE FIBER:**

Maynard (1932) considered that calcium was utilized poorly from a diet high in crude fiber. This may be due to an indirect effect whereby the mineral existing in cells surrounded by fiber are denied contact with the absorbing membranes. According to him
treatment of fiberous materials like straw with alkalies, acids or steam increases the utilization of calcium. Hydrochloric acid present in the gastric juice is not strong enough to extract calcium from undigested crude fiber.

Some authors believe that a high intake of protein tends to favour calcium absorption. This is probably because the insoluble phosphates and carbonates of calcium are generally more soluble in amino acid solutions.

**EFFECT OF VITAMINS:**

Even when a sufficient quantity of calcium and phosphorus is present in the ration in a suitable ratio, a deficiency of Vitamin D affects the assimilation of both calcium and phosphorus. Maynard and Loosli (1951) observed that when plenty of Vitamin D is present in the diet the calcium : phosphorus ratio becomes less important and more efficient utilization is made of the elements. But in tropical countries where sunlight is abundant unless they are prevented from access to sunlight Vitamin D deficiency is practically uncommon.

Fish and Haris (1934) proved the essentiality of Vitamin C for activity of bone cells.
Mitchell and MacIura (1937) reported that even those animals which can synthesise Vitamin C may use dietary Vitamin C for the better utilization of calcium and phosphorus. It appears that Vitamin C is essential for the functional activity of certain type cells as odontoblasts.

Booth et al. (1938) reported that Vitamin D free fats and synthetic triglycerides exert a beneficial effect on calcification in rats receiving a high calcium low phosphorus diet, but not when this calcium phosphorus relation is reversed. Vitamin C and calcium and phosphorus.

But Mullick and Ahmad (1941) have shown that the effect of orange juice in their experiment was not entirely due to its ascorbic acid content as the administration of pure ascorbic acid did not lead to the normal calcification of the dentene.

Carnes et al. (1942) found that hypo calcaemia produced in rats by a diet low in calcium and phosphorus is accompanied by parathyroid enlargement.

Falken (1942) reported very little effect on phosphorus turn over by administration of thyroxine.

Krishnan (1942) has studied the influence of anterior lobe of pituitary on calcium metabolism. The results in general indicated increased absorption and
utilization since faecal calcium was lower in treated animals and urinary output unchanged.

Stoerk et al. (1945) found the effect of ratio of dietary calcium and phosphorus on serum calcium and parathyroid volume. The size of the parathyroid gland was inversely related to calcium phosphorus ratio in the diet.

Migeovsky (1961) found that addition of Penicillin greatly increased calcium absorption.

2) EXCRETION:

Nearly 90% of ingested calcium and phosphorus is generally excreted through the faeces in ruminants (Basu et al. - 1939). The urinary excretion of these minerals is so low in the case of ruminants so that the calcium and phosphorus balance is not likely to be materially affected even if the urinary excretion of these minerals is neglected. The net balance of calcium retained in the body can be easily determined by deducting the total output from the total intake.

Flint (1871) has shown that increased muscular exercise in intact animals causes an increase in the phosphate excretion in the urine and that the activity of striated muscles results in an increase in the inorganic phosphate contained in it. These results
show that in active muscle inorganic phosphate is produced from some organic phosphorus compound and that inorganic phosphate so formed tends to escape into the blood and to be excreted. But MacGleod has shown that muscle of exercised animal contains more phosphorus than unexercised.

Mendel and Benedict (1909) have shown that intravenous injections of magnesium salts caused a marked loss of calcium through urine.

Palmer et al (1928) have shown that on a phosphorus deficient diet the ingestion of magnesium sulphate in cattle causes loss of calcium from body.

Cowell (1937) recorded from experiments on rabbits that calcium can be excreted by the upper part of the colon in rabbits.

Nicolaeen et al (1937) reported that Vitamin D favours an increased absorption of calcium from the gut and increases the excretion of phosphorus in urine.

Westerland (1939) observed that faecal excretion of calcium in cows varies in direct proportion to the consumption of calcium, and protein and inversely to the phosphorus concentration and the amount of milk calcium. Roughage in the form of regenerated cellulose produced no significant increase
in the faecal calcium.

Mitchell and Hamilton (1949) in their studies in man, recorded, that in profuse sweating substantial percentage of their total calcium and phosphorus were excreted. This observation has not been applicable to farm animals, because of the absence of sweat glands.

Hansard et al (1952) while studying the absorption and tissue distribution of calcium in cattle with the help of radio active isotopes, reported by analysing various parts of the gastrointestinal tract, that circulating calcium was secreted mainly into the small intestine. Circulating calcium atoms are continuously removed from the blood and are replaced by calcium atoms absorbed from the tract of exchanged out of the skeleton or soft tissues.

Hansard et al (1954) has reported that out of the total intake of calcium 78% was excreted in the faeces. Of the calcium entering the intestinal tract 41% was absorbed, but 3% was re-excreted leaving 36% in the body for deposition and/or exchange. The unabsorbed calcium increases with advance in age. Thus it is reported that there is a high calcium absorption in young animals. The total calcium retention decreased from 98% in 10 days old calf to 28 in the mature and down towards 16% in the aged animals. The calcium in
the faeces originating from body stores increased with the age of the animal. There was little difference between the apparent and true digestibility values for calcium in young animals but an increasing difference with increasing age. Absorption and true digestibility values for calcium were greatest in young animals. Daily endogenous faecal calcium increased with age. According to him the maintenance requirement calculated on the basis of endogenous and true digestibility values ranged from 0.5 gms. at 10 days to 2 gms. at 6 months remained constant to maturity.

Conrad (1956) reported that when in adults animals the calcium intake was 26.9 gms. and phosphorus 30.3 gms. the animals showed a negative balance of 1.1 gm. of calcium and 0.3 gms of phosphorus. During this period urinary excretion of calcium was 0.1 gm. and phosphorus 1.22 gms.

**UTILIZATION**

It is well known that during the active period of growth, calcium and phosphorus are required in large quantities for bone formation. Similarly during heavy lactation also the requirement of these two minerals is quiet heavy. During the last quarter of pregnancy when the foetal growth is rapid, the requirement for both
calcium and phosphorus is very high. Thus the
utilization of food calcium be conditioned by various
factors such as—

(a) Growth;
(b) Maintenance;
(c) Pregnancy; and
(d) Milk production etc.

At maintenance level the requirement is
minimum.

The net utilization of food calcium and
phosphorus is generally reflected in the balance of
this mineral in the body. But the true digestibility of
calcium is difficult to obtain, because of the fact
that the absorbed calcium and phosphorus re-excreted
later in the lower part of the intestine. The term
net absorption is generally used to indicate the amount
of these minerals which remain in the body.

Lindsey et al (1931) conducted a long term
balance trial using two groups of heifers in three age
groups viz., 1 year, 2 years and 3 years. They were
given two rations one rich and other poor in calcium.
It is seen that total amount of calcium retained was
greater in the group given the higher calcium intake.
The retention was more in the 1st year than other years.
But the percentage of intake retained showed that the
lower intake was used more efficiently after the 1st year.
### TABLE NO: 2.1.

**CALCIUM AND PHOSPHORUS BALANCE OF DAIRY HEIFERS.**


<table>
<thead>
<tr>
<th>GROUP</th>
<th>Calcium (Gm.)</th>
<th>P. in (Gm.)</th>
<th>P. ret. (Gm.)</th>
<th>Retained (Gm.)</th>
<th>Gain (Gm.)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>High calcium group:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calves 1 year-</td>
<td>35</td>
<td>9.5</td>
<td>27.2</td>
<td>10</td>
<td>4.1</td>
<td>40.9</td>
</tr>
<tr>
<td>Calves 2 years-</td>
<td>43</td>
<td>7.3</td>
<td>16.5</td>
<td>13</td>
<td>3.2</td>
<td>25.5</td>
</tr>
<tr>
<td>Calves 3 years-</td>
<td>57</td>
<td>7.1</td>
<td>12.5</td>
<td>17</td>
<td>3.2</td>
<td>18.5</td>
</tr>
<tr>
<td>Low calcium group:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calves 1 year-</td>
<td>17</td>
<td>4.8</td>
<td>27.6</td>
<td>11</td>
<td>2.6</td>
<td>23.6</td>
</tr>
<tr>
<td>Calves 2 years-</td>
<td>20</td>
<td>4.1</td>
<td>20.5</td>
<td>16</td>
<td>1.9</td>
<td>12.0</td>
</tr>
<tr>
<td>Calves 3 years-</td>
<td>27</td>
<td>4.7</td>
<td>17.5</td>
<td>19</td>
<td>1.3</td>
<td>12.5</td>
</tr>
</tbody>
</table>

Phosphorus retention was more in the high calcium group rather than in the low calcium group. One year calves retained more phosphorus in both groups.

Liebscher (1932) reported that on addition of mineral mixture consisting of equal parts of ground lime stone and bone meal to a calcium and phosphorus poor basal ration improved the growth of the experimental animals.

While working with growing pigs Patterson...
of minerals from ragi straw containing on an average 1.136% calcium oxide and 0.193% phosphorus pentoxide. Barley hay containing 0.824% of calcium oxide and 0.078% phosphorus pentoxide. Four bullocks were maintained on—

(a) the basal ration alone;
(b) with supplementation of calcium phosphates; and
(c) with calcium phosphate and green feed, and the calcium and phosphorus utilization was noted. Addition of calcium phosphate improved not only the phosphorus balance but also the utilization of calcium. According to him green grass had no further effect.

Maynard (1932) using various forms of calcium free from impurities, found that different forms of calcium proved to be of equal value as far as the chemical composition and strength of bone, was concerned.

Dufait and Green (1932) reported that on phosphorus deficient diets, the mineral reserves are exhausted during gestation and lactation and that one or more barren year are required to build up the skeletal reserves before pregnancy again ensures. As a result more cows become repeaters and their
(1931) observed practically no difference in the positive balance of calcium when the mineral was supplemented in the form of chemically pure calcium carbonate or ground lime stone or ground lime stone.

Otto (1932) reported that addition of sodium phosphate to a ration low in phosphorus increased the retention of calcium.

Haag et al (1932) conducted a calcium and phosphorus balance experiments on two cows. The basal ration was supplemented with:

(a) Disodium Phosphate;
(b) Calcium Gluconate; and
(c) Bone Flour, separately and compared with the basal ration of alfa-alfa hay alone. On a ration of alfa-alfa hay alone the calcium and phosphorus balance was negative. Addition of disodium phosphate to the basal ration resulted in a positive balance of calcium as well as phosphorus. While addition of calcium carbonate showed a negative balance of both calcium and phosphorus. With bone meal this showed a positive balance.

Otto (1932) showed that phosphorus of bone meal was 70% as available as that of disodium phosphate.

Wrath et al (1932) studied the availability
reproductive efficiency is greatly reduced. He concludes by saying that pregnant animals will require more minerals especially calcium and phosphorus.

Takahashi et al (1933) while trying to find out the efficiency of utilization of calcium from various supplemented sources, like calcium chloride, calcium carbonate, calcium lactate and calcium gluconate observed that calcium gluconate was the best source of calcium.

Watkin (1933) compared the efficiency of utilization of calcium by steers from disodium phosphate and bone meal. He recorded that disodium phosphate owing to its higher solubility has got greater efficiency over bone meal.

About the therapeutic use of calcium Loew (1934) took exception to the idea that calcium should never be used unless accompanied by phosphorus. He pointed out that the excess of phosphorus over calcium in an ordinary diet was so marked that there could actually or relatively no phosphorus deficiency.

Fobers et al (1935) reported that steamed bone meal proved to be better utilized than lime stone and rock phosphate.
### TABLE NO: 2.2.
**BALANCE DATA.**


<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>35</td>
<td>+3.4</td>
<td>22</td>
<td>+5.6</td>
</tr>
<tr>
<td>18</td>
<td>27</td>
<td>+3.1</td>
<td>17</td>
<td>+4.0</td>
</tr>
<tr>
<td>18</td>
<td>18</td>
<td>+0.4</td>
<td>11</td>
<td>-1.0</td>
</tr>
<tr>
<td>12</td>
<td>9</td>
<td>+0.4</td>
<td>5</td>
<td>-0.5</td>
</tr>
<tr>
<td>18</td>
<td>52</td>
<td>+1.6</td>
<td>17</td>
<td>+4.3</td>
</tr>
<tr>
<td>18</td>
<td>25</td>
<td>+2.2</td>
<td>16</td>
<td>+3.0</td>
</tr>
</tbody>
</table>

Kohman (1935) showed that oxalates reduce the availability of calcium for bone formation. The addition of soluble oxalates to food reduced the availability of calcium.

Archibald and Bennet (1935) conducted the same type of experiment as that of Lindsey et al. They fixed the amount of calcium in the ration and the content of phosphorus was low in one ration and high in the other. Here also as with calcium lower intake of phosphorus was more efficiently utilized by calves of all age, retention being more in the first year.
Bunninghaus (1936) observed in pigs that there was insignificant difference in the availability of calcium from organic and inorganic sources.

Newlander et al (1936) carried out calcium and phosphorus balance studies using dicalcium phosphate and bone meal as mineral supplements. He concluded that the availability of calcium and phosphorus was equal from both dicalcium phosphate and bone meal.

Sheehy (1936) reported that growing calves were able to retain more calcium from inorganic salts when calcium : phosphorus ratio was less than 1:1, and that the addition of inorganic supplements not only made good the deficiency but also raised the phosphorus retention.

Schmuf (1936) recorded no appreciable difference in the effect of individual calcium salts. In sheep clover hay restored calcium and phosphorus equilibrium and increase in weight.

Schmitt et al (1937) studied the availability of calcium from calcium gluconate and calcium phosphate. When these salts were orally administered he observed that 66% of calcium was available from calcium phosphate and 31.5% from calcium gluconate. On intravenous administration the
the availability of calcium gluconate increased to 33%.

Otto (1938) carried a series of experiments in calves, designed to determine the availability of phosphate supplement, supplied with varying amounts of calcium carbonate. The animals were fed with phosphorus well below the requirement and a constant calcium : phosphorus ratio of 2 : 1 was maintained. He found that disodium phosphate was slightly more available than either dicalcium phosphate or bone meal. He concluded that the main factor which determines the retention of calcium and phosphorus was the level of intake of the elements in question, apart from the ratio in which it was associated with the other mineral elements of the food.

**TABLE No: 12.3.**

**CALCIUM PHOSPHORUS BALANCE OF STEERS.**

<table>
<thead>
<tr>
<th>Ca. intake</th>
<th>Ca. ret.</th>
<th>Ca. retention %</th>
<th>P. intake</th>
<th>P. ret.</th>
<th>P. retention %</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.4</td>
<td>6.4</td>
<td>38.7</td>
<td>8.3</td>
<td>4.4</td>
<td>53.0</td>
</tr>
<tr>
<td>16.4</td>
<td>4.1</td>
<td>44.0</td>
<td>8.6</td>
<td>4.6</td>
<td>53.2</td>
</tr>
<tr>
<td>12.6</td>
<td>4.1</td>
<td>32.7</td>
<td>6.4</td>
<td>2.1</td>
<td>33.3</td>
</tr>
<tr>
<td>12.1</td>
<td>3.7</td>
<td>30.3</td>
<td>5.8</td>
<td>2.5</td>
<td>42.3</td>
</tr>
<tr>
<td>24.1</td>
<td>5.1</td>
<td>21.1</td>
<td>5.5</td>
<td>2.0</td>
<td>37.0</td>
</tr>
<tr>
<td>24.4</td>
<td>4.2</td>
<td>17.3</td>
<td>5.8</td>
<td>2.2</td>
<td>37.6</td>
</tr>
<tr>
<td>8.9</td>
<td>2.5</td>
<td>27.7</td>
<td>4.8</td>
<td>1.2</td>
<td>25.0</td>
</tr>
</tbody>
</table>
Iyer et al (1938) observed that the supplementation of calcium phosphate to the ration of a cow already on positive balance, resulted in an increased retention of both calcium and phosphorus. But no beneficial effect of both calcium and phosphorus. But no beneficial effect on the health and general appearance was noticed.

Otto (1938) reported that health and appetite of the cattle were more affected by low phosphorus intake, when it was combined with high calcium intake. But the high calcium intake was not detrimental unless the phosphorus intake was absolutely too low.

Henery et al (1939) reported that milk calcium is more available than calcium phosphate for young calves.

Lenkeit and Deppa (1940) reported diarrhoea in sheep, thereby disruption in calcium phosphorus absorption, when the diet only of beet leaves, which subsided when supplements like calcium carbonate and calcium phosphate was used. As calcium chloride causes excessive acidosis calcium chloride should not be used with fresh leaves.

Giri (1940) while working on the availability of calcium and phosphorus from cereals in rats found
that retention of calcium and phosphorus as follows:

<table>
<thead>
<tr>
<th>Food</th>
<th>Ca%</th>
<th>P%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ragi</td>
<td>63%</td>
<td>53%</td>
</tr>
<tr>
<td>Combu</td>
<td>89%</td>
<td>74%</td>
</tr>
<tr>
<td>Cholam</td>
<td>84%</td>
<td>67%</td>
</tr>
</tbody>
</table>

He has not given any explanation about the variations found in the retention.

Kelly (1943) found that the utilization of calcium from Savoy - cabbage, turnips, Swede - turnips and beet leaves were 93 - 88 - 87 and 46% respectively compared with 100% for the calcium from milk.

Harvey and Associates (1943) have reported that hard work has no effect on calcium and phosphorus in horses. Tolle and Maynard (1931) working on rats and pigs observed that phosphatic lime stone, bone meal and lime stone have equal value as far as the growth is concerned.

Talapatra (1944) reported a negative calcium balance in cattle fed with paddy straw alone, probably due to the effect of oxalates and high content of crude fiber.

Reid et al (1946) found with cattle that utilization of calcium was enhanced when the ration was high in calcium. He believed that the retention of calcium was directly proportional to the availability of calcium in the food and also to the demand of the
animal for calcium.

Mukherji and Chatterji (1947) working with bullocks showed that on a diet of napier grass silage and linseed cake, the animals were on negative calcium balance. When 25 gms. of calcium carbonate was supplemented in the basal diet the calcium balance observed was slightly positive. He also pointed out that the addition of calcium carbonates tend to depress the digestibility of organic matters.

Kung (1947) reported that the effect of whole bone last beyond its period of administration, in monogastric animals. The calcium and phosphorus were continuously absorbed and retained, while this calcium absorbed from other supplements in the experimental period was quickly excreted during the following period.

Talapatra et al. (1948) is of opinion that the presence of oxalic acid does not appear to interfere with the assimilation of calcium in ruminants. They showed that oxalates of sodium and potassium were converted into bicarbonates or carbonates and if present in large quantities may induce a severe alkalosis.

Mercer et al. (1949) reported that an interruption in milking results in a significant
elevation of blood serum calcium during the period of interruption, proves the close relationship between blood calcium and milk calcium. The authors explain the increase in the blood calcium due apparently to the result of saturation of mammary tissue with calcium.

Hogan et al (1950) reported that guinea pigs developed abnormal deposition of calcium and phosphorus in soft tissues when the intake of calcium and phosphorus was in great excess.

Saurineth (1950) showed that an excessive amount of calcium and phosphorus in the ration may be favourable in maintaining a high content of these elements in the blood.

Talapatra (1950) conducted an extensive study about the utilization of calcium and phosphorus from grasses cut at various stages (late and early) in adult as well as in young growing animals. He found that adult animals fed on late cut grasses were on negative balance and the urinary calcium excretion was to an extent of 20%. The adult animals fed with early cut grass showed a positive balance with an urinary calcium excretion to an extent of 10% of the total intake. The growing calves fed with an early cut grass showed a definite positive
and incidents of milk fever.

Visek et al (1953) showed that milk calcium was derived from a fraction of blood calcium, which had a higher specific gravity. But when blood calcium was fractionated the activity of all fractions was equal.

Murthy et al (1954) observed that iodinated casein given at the rate of 2 gm/100 Lbs. body weight had no effect on the metabolism of calcium and phosphorus except for a slight improvement in the absorption of phosphorus.

Colovos and Keener (1955) reported that addition of lime stone decreased the digestibility and daily balance of protein and energy. Dicalcium phosphate did not have any adverse effect on the digestibility of protein and energy. They suggested that addition of 2% Dicalcium Phosphate to the 2% lime stone supplement minimized the depressing effect of the lime stone on the digestibility of other organic nutrients.

Brune and Kudlich (1959) carried out balance experiments with wethers with a basal ration low in calcium and phosphorus. They reported that addition of water insoluble calcium oxalates improved utilization of calcium.
Utilization of available calcium from oxalates was between 15.7 and 38.1%. Phosphorus balance improved with the calcium balance but to a lesser extent.

Henry and Tothica (1960) indicated that processing of milk did not affect the availability of calcium.

Roberts and Yadkin (1961) studied the effect of phytate on calcium and phosphorus utilization. Phytate and citric acid increased the availability of inorganic phosphorus by combining with excess of calcium.

Gorg (1962) found no difference as far as the availability of calcium was concerned between ground nut cake, til cake and berseem. Probably berseem has some lower values.

REQUIREMENT:

Many of the minerals undergo a very active metabolism in connection with various processes which are essential for the normal functioning of the body maintenance. Since there is regular and substantial loss of these mineral elements from the mature animals for maintenance, the ration provided to them must substantiate this loss. This loss can be readily calculated by balance studies.
Huges and Cave (1931), Duncan and Huffman (1934), Lamb et al. (1934) and Blaxter and Woods (1952) calculated maintenance requirement from balance trials.

Mitchell and MacClure (1937) calculated the maintenance requirement from the relation between calcium and phosphorus requirement and nitrogen requirement for maintenance from nitrogen content of the tissues, assuming a uniform retention of 0.2 gms. phosphorus to each gm. of nitrogen and a calcium retention equal to \(1.71 \times\) phosphorus retention.

Beeson et al. (1941), Blaxter (1952) and converse (1954) estimated phosphorus and calcium requirement by long term feeding trials.

Calcium and phosphorus requirement is calculated on the basis of data derived from animals slaughtered at different stages by Ellen and Berger et al. (1950).

Blaxter (1952) recorded the requirement of calcium and phosphorus for cattle as 0.2 and 0.3% of the dry matter ingested for maintenance.

Recently it has been suggested that the maintenance requirement for calcium and phosphorus is represented by the endogenous faecal excretion of calcium and phosphorus using radio active isotopes endogenous. Faecal calcium excretion was recorded by Conar et al. (1953), Visek et al. (1953) and Hansard.
et al (1957) and endogenous faecal phosphorus excretion was calculated by Kleiber et al (1951) and Lofgreen et al (1952).

The requirements calculated by some of these authors, that recommended by N. R. C. (1953) and by Morrison are tabulated in Table Nos. 2.4 and 2.5.

**TABLE NO. 2.4**

<table>
<thead>
<tr>
<th>Body weight (Lbs.)</th>
<th>Calcium percentage</th>
<th>Phosphorus percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>0.37</td>
<td>0.23</td>
</tr>
<tr>
<td>600</td>
<td>0.25</td>
<td>0.21</td>
</tr>
<tr>
<td>800</td>
<td>0.19</td>
<td>0.17</td>
</tr>
<tr>
<td>1000</td>
<td>0.16</td>
<td>0.16</td>
</tr>
</tbody>
</table>

TABLE SHOWING THE DAILY CALCIUM AND PHOSPHORUS REQUIREMENTS FOR NORMAL GROWTH OF STEERS.

(In percentage per pound of air dry feed)

TABLE NO. 2.5

TABLE SHOWING THE DAILY REQUIREMENT OF CALCIUM AND PHOSPHORUS FOR GROWING DAIRY CATTLE.

(Morrison Feeding Standards)

F.B. Morrison (1957).

<table>
<thead>
<tr>
<th>Body weight (Lbs.)</th>
<th>Calcium Gm.</th>
<th>Phosphorus Gm.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>2.</td>
<td>3.</td>
</tr>
<tr>
<td>100</td>
<td>7</td>
<td>8.6</td>
</tr>
<tr>
<td>200</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>300</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>400</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>500</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>600</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>700</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>800</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>900</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>1000</td>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>

CAROTENE:

The importance of carotene in growth and production has been abundantly worked out by many workers. For herbivorous animals green leafy materials from the major source of carotene, and a precursor to Vitamin A.
Many of the fundamental theories about the absorption, and utilization of carotene were worked out in rats. In this Chapter a review of the available literature about digestion, absorption, conversion, utilization and requirement of carotene in ruminants especially in cattle has been made. Care was taken not to include much of the work carried out in rats.

DIGESTIBILITY OF FOOD CAROTENES:

The amount of carotene which disappears in the passage food through the digestive tract is considered to be the amount of carotene digested and absorbed.

Witnah et al (1937) reported that a large number of carotene was excreted in the faeces of cows and that from 79 to 21.0% of the carotene consumed was recovered in the faeces. The highest recovery higher than the uptake in probable that the carotene determined in the faeces was contaminated with other yellow pigments.

The extent of digestibility of carotene as well as its absorption is influenced by a number of extraneous factors.

ROLE OF FAT: Bashir Ahmad (1931), Wilson and Cowarker (1937) and Kemmerer and Fraps (1938) of carotene recorded that some amount of fat promotes absorption. Thomas et al
(1962) reported that low fat diets increased the absorption of carotene while high fat diets depressed the absorption of carotene. Wise et al (1958) showed that emulsifying oil supplements in milk significantly enhanced the apparent digestibility of carotene in calves.

2) AMOUNT OF CAROTENE PRESENT IN THE FOOD: Kenmerer and Fraps (1938) reported that the digestibility of carotene varied with the amount of intake. Fraps and Meinke (1945) recorded similar observations. Wagner et al (1951) working on calves by feeding two groups of calves on low level and high level of carotene found that high level group retained more carotene than the other.

3) EFFECT OF HORMONES: Throid is reported to be playing some role in the absorption of carotene.

Chonda et al (1951) reported that digestibility of carotene in both cows and goats was increased by thyroxine and reduced by thiouracil. They reported that goats were able to digest carotene more efficiently than cows. This difference in digestibility can be attributed to the fact that thyroid gland is more active in goats than in cows. This difference in digestibility can be attributed to the fact that thyroid gland is more active in goats than in cows.
Eton et al. (1952) reported about the association of ascorbic acid deficiency in severe ovitaminosis-A. But this report does not contain any mention about the effect of ascorbic acid on digestibility of carotene.

Substances like mineral oils, tocopherol etc. were reported to have some effect in the absorption of carotene.

According to Jackson (1934) the tocopheroles are known to enhance the Vitamin A effect of carotene. Perhaps it may be due to the action of tocopheroles as antioxidants in reducing the destruction of carotene by oxidation in the gastrointestinal tract. Major and Watts (1947) were unable to demonstrate any improvement in the utilization of carotene on high tocopherol diet.

Olson (1959) reported that sodium glycocholate and perhaps other bile salts are required in utilization of Beta-carotene by rats and not a simple emulsifying agent.

4) CONVERSION OF CAROTENE TO VITAMIN A: It is a well known fact that carotene can be converted to Vitamin A in the animal body. This has been reported as early as 1929 by Thomas Moore.

It is known that one molecule of carotene is converted to one molecule of Vitamin A only. Underhill and
Coward (1939) showed that even under most optimum conditions an unsymmetrical fission of pro-vitamin A occurs which in the case of carotene yields a maximum of only one molecule of Vitamin A plus other decomposition products.

Until quite recently it was assumed that the liver is the organ in which carotene is changed to Vitamin-A. Sexton et al. (1946) reported that intestine is the site of conversion of carotene to Vitamin A. They reported that "the conversion of carotene to Vitamin A may be an extra-hepatic function in the rat. The wall of the intestine is suggested as a possible site of such transformation." Mattson et al. (1947) demonstrated that Vitamin A could be detected in the intestinal wall of Vitamin A deficient rats shortly after the feeding of Beta-carotene. In the same year Wiese et al. have also shown in rats that ingested carotene is converted to Vitamin A in the intestinal wall.

Sobel et al. (1953) showed that allomadiabetic rats stored only one fourth as much Vitamin A in the liver after a fixed dose of carotene, as did non-diabetic controls. This proves the involvement of pancreas in the conversion of carotene to Vitamin A. It is not proved whether pancreas is a site of conversion of carotene to Vitamin A or any of the secretions of
pancrease helps in the conversion.

Benhard (1953) reported that as much Vitamin A could be recovered from intestinal lymph as from thoracic duct lymph (which contains lymph from liver) following oral dosage.

Beri and Pollard (1954) have shown that water soluble carotene injected into the blood stream was changed into Vitamin A. This conversion was not affected by ligation of bile duct, removal of small intestine or removal of 60 to 70 percent of liver. This goes to prove that various body tissues other than liver and intestine are able to convert carotene to Vitamin A.

Baton et al. (1959) observed some kind of breed variation in the conversion of carotene to Vitamin A. They reported that with the same intake of carotene Guernsey calves showed higher values for carotene in blood plasma and liver than Holstein. Holstein showed increased plasma and liver Vitamin A values. They concluded that Holstein calves converted carotene to Vitamin A between 1.4 and 1.8 times as efficiently as Guernsey.

**EFFECT OF THYROID IN THE CONVERSION OF CAROTENE TO VITAMIN A**—There seems to be some evidence to suggest that the thyroid gland regulates the conversion of
carotene to Vitamin A.

Kunde (1926) reported the appearance of xerophthalmia in rabbits, eight to twenty months after total thyroidectomy.

Fassold and Heidemann (1933) observed that the carotene content of goat milk following thyroidectomy coincided with a decrease in the Vitamin A content.

Although the above reports are in agreement in supporting the belief that carotene Vitamin A change is regulated by the thyroid glands, several reports are in disagreement.

Weise et al. (1947) were unable to demonstrate any difference in the liver storage of Vitamin A after the administration of 348 micrograms of Beta-carotene irrespective of whether or not the rats had previously been treated with thiourecil.

Morgan and Arnich (1953) also concluded that the normally functioning thyroid gland was not essential for carotene utilization in rats and dogs.

High and Wilson showed that Vitamin B_12 appears to increase tissue deposition of Vitamin A when carotene was fed.

Although bulk of evidence would seem to support the belief that the thyroid secretion regulates
the conversion of carotene to Vitamin A, more proof is needed before this theory can be accepted unequivocally.

**Utilization**

Baumann and Rissing (1934) reported that small amounts of pro-vitamin A were better utilized by calves than large amounts. Goodwin and Wilson (1951) showed that level of carotene and Vitamin A in plasma remained fairly constant while animals were on grass, but reduced as the intake lowered. This suggests that utilization was directly related to the availability of carotene in the diet. Thomas and Moore (1952) conducted an experiment about the plasma and storage levels of Vitamin A and carotene in relation to intake in calves. He recorded an increase in the plasma carotene level and liver carotene level in the groups receiving supplementation. He concluded that there was a linear relationship between the level of carotene intake and plasma carotene level and extent of storage of carotene in liver.

Hyardez *et al* (1954) working on the utilization of carotene by dairy calves of two to twelve years of age showed that the efficiency of utilization was less when carotene was supplied in excessive amounts. He showed that carotene and Vitamin storage of the
liver increased as age advances.

McGillivary et al. (1953) showed that utilization of carotene was influenced by the level of intake of carotene, concentration of carotene in oil, degree of unsaturation of oil and also by presence of tri-stearin or bees wax.

Repp and Watkins (1953) reported that a close relationship exists between the intake of carotene and Vitamin A and carotene content of plasma. Lowest plasma values were recorded when the carotene intake was lowest in range cows. Bousseau et al. (1958) recorded similar observations.

Schah et al. (1959) observed that following intravenous injection of carotene in aqueous solution with Tween 40, there was a large increase in the carotene content in plasma. Increase in plasma Vitamin A value and liver Vitamin content.

Keener et al. (1942) reported the existence of a relationship between blood Vitamin A level and environmental temperature. They were of opinion that either Vitamin A is required in greater amounts during cold or that more of the Vitamin is required by increased metabolism. They also reported that greater amounts of Vitamin A in relation to carotene in the blood of young calves as compared to that of older calves. This
indicate that young animals convert carotene to Vitamin A more efficiently or more rapidly as a means of giving increased protection during its critical life.

Mellamby (1943) observed that Vitamin A was necessary for normal growth of bone and that when there was a deficiency, bone does not stop growing, but the activity of the bone was incoordinated and growth becomes excessive in places.

Brown and Morgan (1943) reported that in Vitamin A deprived animal, urinary nitrogen increased and nitrogen balance decreased to a great extent, than those with the Vitamin A supplement. There was a reduction in the utilization of nitrogen in the young animals without affecting the character of nitrogen metabolism except during the terminal period of the deficiency state. They concluded that Vitamin A was essential for the growth of tissue protein but not for its maintenance.

Basu and De (1943) reported that Vitamin A or carotene, Vitamin C and D, the heat stable factors of the Vitamin B-Complex and ribo flavin help in the utilization of calcium, phosphorus and magnesium, thereby promoting growth.

Ross and Collup (1949) observed an inverse relationship between blood plasma inorganic phosphorus and carotene level in cattle feed with phosphorus
deficient rations.

Eaton and Mattereson (1952) showed that calves receiving carotene suspension either intravenously or orally had greater weight increase and feed consumption than control group.

Goodwin and Wilson (1951) reported that the plasma carotene and Vitamin A level dropped after parturition when a large amounts of both carotene and Vitamin A were transferred to the colostrum.

Rousseau et al (1948) found that growth was unrelated to the level of carotene of Vitamin A intake. Tarjan (1958) reported that Vitamin A deficiency often had a poor protein intake. Increasing the protein content of the diet increased the Vitamin A in liver and kidney. The amount of Vitamin A stored was more with animal protein than with gluten.

Eaton et al (1959) found that carotene supplements did not affect growth rate of calves.

Many authors have reported about variations in utilization of carotene according to sex, species, stage of production etc.

Church et al (1953) reported that there was a major difference in the manner in which cattle and sheep utilize intravenously injected carotene. Presumably
sheep can convert carotene into Vitamin A with a better efficiency while cattle cannot to any appreciable extent.

Crowley and Allen (1953) observed that blood plasma Vitamin A level increased from 24 to 18 micrograms per 100 ml. within four hours after ethanol was administered to goats and calves that were on an adequate Vitamin A ration. But in Vitamin A depleted animals no such increase occurred.

Rowland et al. (1953) showed that in the cow, the daily concentration of Vitamin A and carotenoids during the period of prepartum milking was negatively correlated with daily weight of fat produced and positively correlated with the daily weight of globulin produced.

Steer et al. (1956) reported that abundance of carotene as green fodder showed an insignificant slight rise in plasma inorganic calcium, slight rise in alkaline phosphates and moderate rise in acid phosphatase.

Ganguly et al. (1953) recorded an increase in the carotene content of blood and ovaries on supplementation. He showed that ovaries retained a proportionately large amount of carotene than other tissues. This was believed due to the presence in the ovary of a specific protein receptor for carotene. Various other workers
have also reported the association of carotene with protein. In blood it is associated mainly with beta globulin fraction. In the liver also presence of a protein carotene complex was reported.

Erwin et al (1959) showed that carotene and Vitamin A were mainly bound with albumin fraction of the bovine serum.

Varnell and Erwin (1959) observed by giving a known dose of adrenaline intramuscularly, that there was no effect of adrenaline on serum protein, plasma carotene or Vitamin A or on liver carotene of Vitamin A.

Dutt et al (1959) reported in goats that a deficiency of Vitamin A might predispose the formation of urinary calculi.

REQUIREMENT:-

Guilbert and Hart (1935) while studying the Vitamin A requirement for cattle reported that 1.5 mg. of carotene was sufficient to prevent night blindness in calves. This dose was considered as the minimum requirement.

Guilbert et al (1936) reported that Vitamin A requirement was directly proportional to the body weight and to the tissues that are highly correlated with the body weight like nervous tissue, liver, lung, kidney etc.
Tissues like nervous tissue requires Vitamin A and the quantity required, depends upon the amount of these tissues, and not to their rate of metabolism. They were of the opinion that although the minimum requirement per unit of body weight was same for young as well as adult animals the former were more susceptible to pathological manifestations. As such calves require more carotene and Vitamin A than adults. They reported 26 to 33 microgram of carotene per kilogram body weight was sufficient to prevent Vitamin A deficiency in cattle. Minimum requirement of carotene for cattle, sheep and swine to be between 25 to 30 micrograms per kg. body weight.

Ward et al (1939) reported that increased carotene intake does not result in increased growth of calves. The average growth rate of two calves receives hay containing 65 micrograms per gram was not greater than that of the calves receiving hay containing 1.3 micrograms per gram. They reported that the later group later on showed Vitamin A deficiency symptoms.

Keener et al (1942) reported that the minimum carotene requirement of dairy calves for maintenance at 50-70° F, was approximately 12 micrograms per pound live weight. They observed that the minimum requirement for growth depends upon environmental temperature.
During winter minimum requirement may be twice as that during summer.

Boyer et al. (1942) observed that when plasma Vitamin A values were 10 micrograms or above per 100 ml. of blood plasma, calves gained a pound or more weight per day. Lower concentrations were accompanied by decreased growth. They gave 60 to 40 and 20 micrograms of carotene per kg. of body weight per day for two groups of Holstein and Guernsey calves. It was found that 20 and 40 level were totally inadequate and 60 was subminimal. They also reported the existence of breed difference in carotene requirement.

Rosin et al. reported that minimum safe level of carotene intake for successful reproduction in Guernsey cattle appears to be 90 micrograms per pound body weight per day.

Baker et al. (1953) showed that carotene intake at the rate 60 micrograms per pound body weight per day was inadequate and 333 micrograms was more than adequate in cows during last stage of gestation.

Table showing the requirement of carotene for growth laid down by Morrison (1957) and by National Research Council are shown in Table Nos: 2.6 and 2.7.
**TABLE NO: 2.6**

TABLE SHOWING THE DAILY CAROTENE FOR NORMAL GROWTH OF STEERS.

( per pound of air dry feed)

---


<table>
<thead>
<tr>
<th>Body weight (Lbs.)</th>
<th>Carotene mg. per Lb.</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>2.0</td>
</tr>
<tr>
<td>600</td>
<td>2.2</td>
</tr>
<tr>
<td>800</td>
<td>2.5</td>
</tr>
<tr>
<td>1000</td>
<td>2.8</td>
</tr>
</tbody>
</table>

---

**TABLE NO: 2.7**

TABLE SHOWING THE DAILY REQUIREMENT OF CAROTENE FOR GROWING DAIRY CALVES.

---

_Morrison Feeding Standards—F.B. Morrison, 1957._

<table>
<thead>
<tr>
<th>Body weight (Lbs.)</th>
<th>Carotene (mg.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>4</td>
</tr>
<tr>
<td>200</td>
<td>8</td>
</tr>
<tr>
<td>400</td>
<td>16</td>
</tr>
<tr>
<td>600</td>
<td>24</td>
</tr>
<tr>
<td>800</td>
<td>32</td>
</tr>
<tr>
<td>1000</td>
<td>40</td>
</tr>
</tbody>
</table>
MATERIALS AND METHODS

EXPERIMENTAL ANIMALS

Six Tharparker calves were selected from Government Cattle Farm, Patna for the experiment. The age of the calves varied from 1 year 7 months to 2 years 4 months and the body weight varied from 128 to 154 Kgs. The Experimental Calves were confined in concrete floored separate stalls having good ventilation. These animals were fed individually in both concentrate and roughage.

DESIGN OF THE EXPERIMENT AND FEEDING SCHEDULE

Before the beginning of the experiment all the experimental calves were weighed and the weight recorded. The whole experiment was broadly divided into two periods viz., unsupplemented feeding period and supplemented feeding period. Each period lasted for eighteen days. Both the periods were again divided into two periods of nine days each viz., preliminary period and collection period. During nine days collection period urine as well as faeces were collected quantitatively for twenty-four hours for nine days. The method of collection of urine and faeces is described in detail, later in this chapter. The nine days collection period was divided into three sub periods of three days each. The urine and faeces voided
during these three days were recorded and the average was taken as the day's excretion for the sub-periods.

FEEDING SCHEDULE:

Unsupplemented Feeding Period: The experimental calves were fed individually on both concentrate mixture and roughage. The calves were provided with a concentrate mixture of the following composition:

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Nut Cake</td>
<td>33%</td>
</tr>
<tr>
<td>Guar Meal</td>
<td>33%</td>
</tr>
<tr>
<td>Wheat Bran</td>
<td>33%</td>
</tr>
<tr>
<td>Common Salt</td>
<td>1%</td>
</tr>
</tbody>
</table>

1.5 Kg of the above concentrate mixture was provided to each animal. Left over of the concentrate mixture, if any was weighed on the next day and recorded. The calves were provided with ad libitum, freshly cut and chopped paragrass. The weight of the paragrass given was recorded and the left over if any was weighed on the next day and the paragrass actually taken by the animals was recorded. Weighed quantities of paragrass was supplied twice a day, morning and evening to the calves. The experimental animals were provided with ad libitum fresh water. The water was given twice a day, morning and evening. No record of the amount of intake of water was maintained. This same feeding schedule was continued
throughout the unsupplemented feeding period. No dry roughage was given to the animals.

Supplemented Feeding Period: Over above the ration provided to the calves during the unsupplemented feeding period, in this period the calves were provided with di-calcium phosphate as a source of calcium and phosphorus supplementation and crystalline Beta-carotene (E. Merk, Germany) as carotene supplementation. This supplementation was continued for fifteen days, 9 days preliminary period and six days during collection period. On chemical analysis it was found that di-calcium phosphate contained 29 percent of calcium and 21.5 percent of phosphorus.

100 gms. of di-calcium phosphate was accurately weighed and was mixed thoroughly with a small portion of the concentrate mixture. This portion was initially fed to each calves in separate trays to be sure that the whole mineral compounds has been consumed by the animal. Since di-calcium phosphate does not have any objectionable taste or odour, the animals ingested it readily. Sufficient care was taken to see that no salt passed out during mastication. This mineral was followed immediately by the full quota of the concentrate mixture.

75 mg. of Beta-carotene was carefully weighed
and was filled in small containers made as follows. A small portion of the concentrate mixture was finely powdered with the help of mortar and pestle. This powdered concentrate mixture was made into a thick paste by adding sufficient quantity of water. This pasty materials was moulded into the shape of small cylindrical bolus of about 1" length and ½" to ¾" in diameter with a depression of about ¼" in the centre to hold the carotene. Then they were left in the hot air oven for drying. When it was completely dried 75 mg. of Beta carotene was carefully weighed in it. Immediately the mouth of the cylinder was closed with a flat piece made out of the powdered and moistened concentrate mixture to prevent oxidation. When six samples were made like that they were immediately fed to the animal. These bolus were put inside the mouth of the calves directly and care was taken to prevent any escape of the material from the mouth by closing the mouth of the animals for some time. The beta carotene also was not having any objectionable taste or odour and the calves tolerated it well.

The feeding of the supplements, both di - calcium phosphate and beta carotene was discontinued on the six day of the collection period and the collection was continued for the third sub-period of three days also to study the effect of overdosing on retention
and also to study the residual effect of overdosing on discontinuation of the supplementation.

The intake of concentrate mixture and roughage per day for calculating the intake of elements in question was arrived at by calculating the average intake of both concentrates and roughages during the nine days collection period, of unsupplemented feeding period. For supplemented feeding period average intake of the first six days collection period was taken as the daily intake and the average of the next three days were calculated separately to form the intake during the last three days daily intake.

**Collection of Urine and Faeces:** Before the beginning of the experiment the animals were put on to the urine collection device to make them accustomed to it. During the collection period the animals tolerated the urine collection device well. The urine collection was accomplished as follows:

A big funnel shaped bag was made out of rexin cloth. The bag was about 8" in width or diameter and 10" long tapering towards the tip. A small opening of about 1/2" was made at the tapered end and a small plastic pliable funnel was fit inside the rexin bag and was kept in position. A rubber tube of about 2 meters was connected
PHOTOGRAPH SHOWING THE URINE COLLECTION APPARATUS IN POSITION.
at the tip of the plastic funnel and was taken out through the opening of the resin bag. The funnel was put in the bag in such a manner so that there were no leakage of urine. The other end of the tube was put inside a container of about 2 litres capacity. This device was tied to the belly of each calves with the help of four flat tapes attached to the wide mouth of the resin bag.

During collection period, constant 24 hours watch was made to see that the end of the rubber tube was held inside the container. The movement of the animals was restricted to such a manner so that the tube will be inside the container and on no account the animal will have access to the container.

When the container got filled in, the urine was mixed well and the quantity of urine was measured, a 10% portion of the urine was saved as sample for analysis and the rest of it was thrown away after recording the volume. Measurement was made four to five times daily. The urine collection apparatus thus made, even though warranted constant watching, worked well and amount of urine voided could be recorded with considerable accuracy. The 10% aliquote of the urine saved as sample was pooled together for three days and this pooled samples were used for analysing the mineral content. Three samples of three days pooled urine were collected during unsupplemented
unsupplemented period and three samples during
supplemented feeding period of which the last sample was
collected after discontinuing supplementation with a
view to study the residual effect.

Faeces collection was done by manual collection
from the ground. The faeces was removed immediately after
it was being voided to prevent mechanical wastage. Just
as in urine samples of faeces were collected for
analysis of calcium and phosphorus during unsupplemented
feeding period.

COLLECTION OF SAMPLES OF FEED:

Concentrate Mixture: The different components
for analysis of the concentrate mixture was weighed
separately and are mixed together, thoroughly. Concentrate
mixture was made in bulk and were stored in gunny bags
in cool dry place. There was no spoilage during storage.
Samples in duplicate were taken from various parts of the
well mixed concentrate mixture, and were pooled together
to form the samples for chemical analysis.

PARAGRASS: The paragrass was finely chopped
by chopping machine, and samples were taken from various
parts of the well mixed chopped heap. Particular care
was taken to prevent bias by taking more of stem or leafy
parts. Samples were taken from the grass cut from
faeces immediately after it was being voided by the animals to prevent the loss of the dung by the movement of the animal.

A small portion of the well mixed dung was saved immediately after it was being voided. This sample was saved whenever there was defaecation and was taken in small amber coloured bottles and kept in refrigerator under carbon dioxide. All the samples collected in a single day are pooled together and mixed well manually. 5 Gms. of this dung was utilised for the estimation of carotene which was done next day after collecting the samples for the whole of the previous day. Samples from faeces voided late in the night were collected early in the morning. Sufficient care was taken to prevent the exposure of the dung sample to the sunlight to avoid oxidation of carotene.

One percent of the total dung voided per day was saved from different regions of the well mixed (manually) total faecal excretion. This sample was kept well covered to prevent loss of moisture. Samples saved like this for three days, were pooled together, mixed well and were utilized for chemical analysis. Faeces samples were taken from each animal.

METHODS OF CHEMICAL ANALYSIS:

**Drymatter**—A portion of the composite sample
different plots for separate analysis. The results of all the plots were added together and the average was taken as the final reading of the chemical analysis. The samples were taken during hot summer from fields, were no irrigation was done at least for one week, to prevent error in the estimation of dry matter.

Paragranf, for the estimation of carotene was taken from freshly chopped and well mixed heaps in duplicate, samples were thus taken from different plots, when feeding was started from those plots and the carotene content was calculated from the average of all the readings taken.

**URINE:** Urine was collected continuously for 24 hours during nine days collection period. 10% of the total urine voided per day was collected in different flasks. Three days urine samples thus saved were pooled together and this was used for estimation of calcium and phosphorus. A little amount of thymol was added as a preservative to each days urine sample to prevent bacterial fermentation. Urine samples were taken from each animals separately.

**FACES:** As it is said earlier the faeces were collected manually from the pucca cement concreted floor of the cattle shed. Care was taken to remove the
drawn from the concentrate mixture as described above, was, carefully weighed into a clean, dry, and previously weighed porcelain dish. This was left in the hot air oven over night. After cooling the porcelain dish along with the contents were again weighed and recorded. Heating, cooling and weighing were continued till constant figure was obtained. From the reduction in the weight, the dry matter content was calculated. The method followed for the estimation of dry matter in concentrate mixture, paragrass and faeces was same.

Ashing and Aliquote Making:— The method followed in ashing and making of aliquote in concentrate mixture, paragrass, faeces and urine was same.

Except in the case of urine, 5 gms. of the moisture free material was taken in clean, dry viterosil basins. They were kept in the muffle furnace and the temperature was not allowed to raise above 500 to 550°C to prevent loss of alkali metals and phosphorus by melting and volatalization. They were kept in the muffle furnace for four hours in this temperature. When they were cooled, the materials were completelyashed.

The ash was dissolved in dilute hydrochloric acid, and boiled for two minutes over a flame in a beaker. It was then filtered to a 100 ml. volumetric flask. The
funnel and the filter paper was repeatedly washed with sufficient quantities of hot water, to make them acid free. After cooling the volume was made upto the mark.

Lot of difficulties were experienced in the ashing and estimation of calcium and phosphorus in urine. Urine contained so little of calcium and phosphorus, that large samples were to be taken for obtaining accurate results. The large volume of 200 ml. of urine was slowly evaporated over boiling water bath in beakers. When it became a pasty material it was transferred quantitatively to large viterosil basin for evaporation to dryness and further ashing. Ut-most care was taken to prevent spurting, especially at the last stages of drying by constant adjustment of the heat, as the drying urine sample showed high tendency for spurting. When the sample was dried completely it was ashed and aliquote was prepared as in the other case. Ashing to destroy all organic matter, in urine was necessitated by the interference of hippuric acid, in the estimation of calcium and phosphorus, which was present in large quantities in liquid urine.

**ESTIMATION OF CALCIUM AND PHOSPHORUS**:

Calcium: Calcium was estimated by A. O. A. C. method modified by Talaptra et al. 10 ml. of the
aliquote was measured into a clean dry beaker. To this 10 ml. of saturated solution of ammonium oxalate was added. A pitch of ammonium chloride was added to keep the magnesium in solution. Two drops of methyl red was added as an indicator. To this, dilute ammonia was added drop by drop till the addition of one or two more drops of ammonia will change the red colour of the solution to straw colour. Calcium is precipitated as calcium oxalate at a pH little below 5. The solution was mixed well and kept undisturbed for some time. The solution was boiled for few minutes to make the precipitate granular. After cooling the beaker along with precipitate was kept undisturbed for overnight. Afterwards the precipitate was filtered through Whatman's No: 40 filter paper, taking care to retain as much precipitate as possible, in the beaker. The precipitate, the funnel, and the filter paper was repeatedly washed with hot distilled water to make it oxalate free. Ammonium oxalate being water soluble, will be quickly removed by washing with hot water. When the filter paper and precipitate has been free from free oxalates they were transferred to the original beaker and brought down by washing with distilled water. The calcium oxalate thus isolated was titrated against N/10 Potassium permanganate in presence of sulphuric acid. 1 ml. of N/10
potassium permanganate being equal to 2 mg. of calcium.

Phosphorus: Here also the method used was that of A. O. A. C. modified by Talapatra et al.

10 ml. of the aliquote was taken in a beaker to which 10 ml. of Con. nitric acid and 20% Ammonium molybdate was added. During addition and afterwards the solution was constantly stirred with the help of a glass rod. The precipitate formed was allowed to settle and the beaker was left over night undisturbed. The solution was decanted through Whatman No: 42 filter paper, taking care to keep as much precipitate in the beaker as possible. Decantation was done in small portions. Then the precipitate was thoroughly washed with a weak solution of nitric acid (2%). This solution also was decanted in small portions as before. The precipitate was then repeatedly washed and then decanted with 3% potassium nitrate solution, till the precipitate, the funnel and the filter paper became acid free. This point was not ascertained by collecting 5 ml. of the filtrate in a test tube and addition of one or two drops N/10 sodium hydroxide brought about a definite alkaline colour in presence of phenol pthalin. When the precipitate became acid free, the precipitate was dissolved in known amount of N/10 sodium hydroxide. The excess of sodium hydroxide
potassium permanganate being equal to 2 mg. of calcium.

**Phosphorus:** Here also the method used was that of A. O. A. C. modified by Talapatra et al.

10 ml. of the aliquote was taken in a beaker to which 10 ml. of Con. nitric acid and 20% Ammonium molybdate was added. During addition and afterwards the solution was constantly stirred with the help of a glass rod. The precipitate formed was allowed to settle and the beaker was left over night undisturbed. The solution was decanted through Whatman No: 42 filter paper, taking care to keep as much precipitate in the beaker as possible. Decantation was done in small portions. Then the precipitate was thoroughly washed with a weak solution of nitric acid (2%). This solution also was decanted in small portions as before. The precipitate was then repeatedly washed and a decanted with 3% potassium nitrate solution, till the precipitate, the funnel and the filter paper became acid free. This point was not ascertained by collecting 5 ml. of the filtrate in a test tube and addition of one or two drops N/10 sodium hydroxide brought about a definite alkaline colour in presence of phenol pthalin. When the precipitate became acid free, the precipitate was dissolved in known amount of N/10 sodium hydroxide. The excess of sodium hydroxide
was titrated against N/10 nitric acid to assess the exact amount of sodium hydroxide required to dissolve the precipitate. 1 ml. of N/10 sodium hydroxide being equal to 0.2 mgr. of phosphorus.

**ESTIMATION OF CAROTENE**

Carotene in the biological materials like feeds and faeces, was estimated by Bacharahis method—1950 modified by Majumdar and Gupta (1960). Various laboratories have observed and confirmed that, treatments like application of heat or the use of alkali in the extraction of carotene was prejudicial to an accurate determination of carotene in biological materials. Therefore, attempts have been made to avoid treatment with heat and alkalis in the extraction processes. The method adopted for estimation of carotene in feeds and faeces was practically same.

The warring blender homogenisation suggested by Majumdar and Gupta (1960) has been found to be very convenient for extraction of carotene in all types of biological materials. This method was, therefore, used for estimation of carotene in feeds and faeces.

Five gms. of the material (Wet basis) was accurately weighed in a 50 ml. beaker. 25 ml. of 1:1 acetone and petroleum ether (boiling point 40-60°C.) was
was titrated against 5/10 nitric acid to assess the exact amount of sodium hydroxide required to dissolve the precipitate. 1 ml. of 5/10 sodium hydroxide being equal to 0.2 mgf. of phosphorus.

**ESTIMATION OF CAROTENE:**

Carotene in the biological materials like feeds and faeces, was estimated by Bacharachis method—1950 modified by Majumdar and Gupta (1960). Various laboratories have observed and confirmed that treatments like application of heat or the use of alkali in the extraction of carotene was prejudicial to an accurate determination of carotene in biological materials. Therefore, attempts have been made to avoid treatment with heat and alkalis in the extraction processes. The method adopted for estimation of carotene in feeds and faeces was practically same.

The warring blender homogenisation suggested by Majumdar and Gupta (1960) has been found to be very convenient for extraction of carotene in all types of biological materials. This method was, therefore, used for estimation of carotene in feeds and faeces.

Five gms. of the material (Wet basis) was accurately weighed in a 50 ml. beaker. 25 ml. of 1:1 acetone and petroleum ether (boiling point 40-60°C.) was
added to it along with a pinch of hydroquinone as antioxidant and thoroughly mixed with glass rod. After mixing the entire material was run in a Waring blender and homogenized for two minutes. The extraction was repeated four times, each time adding 25 ml. of 1:1 petroleum ether and acetone. The extract was then filtered through glass wool to remove all gross and suspended particles.

The filtrate was collected in a separating funnel. The glass wool was further washed with 10 ml. of 1:1 acetone petroleum ether mixture to remove the last trace of carotene to the filtrate. Acetone being miscible with water is removed from the filtrate by washing with water in a separating funnel. Four washings were done to remove all traces of acetone. The residual petroleum ether was then collected in a 100 ml. volumetric flask to which 10 gms. of anhydrous sodium sulphate was added to absorb the last trace of moisture. For separation of xanthophylls and other non-carotenoid pigments from carotene, chromatography was suggested by Majumdar and Gupta (1960). Petroleum ether extract free from traces of acetone and water was shaken with 7 gms. of specially prepared bone meal powder in a beaker. Xanthophylls and other carotenoid pigments were absorbed in the bone meal. The pure carotene extract was then allowed to stand for
half an hour and filtered through Whatman No. 40 filter paper.

Before taking the final reading in the photo-electric calorimeter, the volume was made constant to 10 ml. The reading for carotene was taken at 440 millimicron wave length using filter No. 42. The reading of the unknown was taken against the blank set of zero.

The concentration of the unknown is calculated from the following formula:

\[
\text{Concentration of unknown} = \frac{\text{Reading of the unknown}}{\text{Calibration factor}}
\]

\[
\text{Calibration factor} = \frac{\text{Concentration of the standard}}{\text{Reading of the standard}}
\]

**PREPARATION OF BONE MEAL:**

The bone meal was carefully cleaned from any adhering tissues, then washed thoroughly with hot tap water and dried. It was then boiled in absolute alcohol under reflux for four hours. After drying it was left in petroleum ether overnight in a refrigerator and finally dried in the oven. The processing was necessary to remove the fats and pigments if any.

**PREPARATION OF STANDARDS:**

10 mg. of crystalline Beta carotene was dissolved in 100 ml. of petroleum ether (boiling point
40 - 60°C.). Therefore, 1 ml. of petroleum ether contained 100 micrograms of Beta-carotene.

0.05 ml., 0.1 ml., 0.2 ml. and 0.4 ml. of stock solution of Beta-carotene was taken in different test tubes and the final volume was made to 10 ml. with petroleum ether. Hence, the standard contained 5, 10, 20 and 40 micrograms of Beta-carotene respectively. For each concentration of standard, calibration factor was determined in duplicate. From their average value, calibration factor used in the estimation of carotene was finally determined. The calibration factor used in this experiment for estimation of carotene was 1.97.

The method adopted for the estimation of carotene was the same for both feeds and faeces. The estimations were carried out without drying the materials to minimise the loss of carotene by heating and auto oxidation by storage.

The experiments lasted for a period of about forty days. The experiments were conducted from the first week of June and lasted till the last week of July.
RESULTS AND DISCUSSION

This work was designed to study the extent of absorption and utilization of extra dietary calcium, phosphorus and carotene in young Tharparkar calves of growing age. Two balance experiments, one un-supplemented and the other supplemented, were conducted to assess the rate, extent of absorption and retention in normal diet and in a diet supplemented with extra of calcium, phosphorus and carotene. The supplementation was given to provide the nutrients in question to an extent of at least two or three times than that of the requirement recommended by Morrison Feeding Standard.

The experimental calves were selected from the Government Cattle Farm, Patna and the whole balance experiment was conducted there itself. The age and weight of the calves are given in Table No: 4.1 of Chapter-IV. The experiment started in the first week of June, 1966 and continued till the 3rd week of July, 1966. The whole of the experiment was conducted during summer. The composition of the concentrate mixture and roughage used is shown in Chapter-I.
TABLE NO: 4-1.

TABLE SHOWING AGE AND BODY WEIGHT OF EXPERIMENTAL CALVES.

<table>
<thead>
<tr>
<th>Animal Number</th>
<th>Age</th>
<th>Body weight (Kg.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>78</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>16</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>111</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>94</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>171</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>142</td>
<td>1</td>
<td>7</td>
</tr>
</tbody>
</table>

INTAKE OF DRY MATTER AND MINERALS:

Unsupplemented Feeding Period:— Average dry matter intake varied from 7.63 to 8.18 Lbs., out of which dry matter intake from concentrate mixture varied from 2.9 to 3.0 Lbs. and that from roughage varied from 3.19 to 4.63 Lbs. The proportion of concentrate to roughage intake was about 40 and 60 percent. On an average the intake of dry matter was about 2% of the body weight for each calves. Total calcium intake varied from 12.95 to 22.02 gms. and phosphorus intake was from 8.15 to 9.50 gms. This variation in mineral
<table>
<thead>
<tr>
<th>Ani. No:</th>
<th>Concentrate mixture intake (Wet basis)</th>
<th>Dry matter percentage</th>
<th>Dry matter intake</th>
<th>Green roughage intake (Wet basis)</th>
<th>Dry matter percentage</th>
<th>Dry matter intake</th>
<th>Total dry matter intake (lb.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>78</td>
<td>3.3</td>
<td>91.5%</td>
<td>3.0</td>
<td>24.10</td>
<td>18%</td>
<td>4.33</td>
<td>7.33</td>
</tr>
<tr>
<td>16</td>
<td>3.3</td>
<td>91.5%</td>
<td>3.0</td>
<td>25.70</td>
<td>18%</td>
<td>4.63</td>
<td>7.63</td>
</tr>
<tr>
<td>111</td>
<td>3.2</td>
<td>91.5%</td>
<td>2.9</td>
<td>18.50</td>
<td>18%</td>
<td>3.33</td>
<td>6.23</td>
</tr>
<tr>
<td>94</td>
<td>3.2</td>
<td>91.5%</td>
<td>2.9</td>
<td>17.75</td>
<td>18%</td>
<td>3.19</td>
<td>6.18</td>
</tr>
<tr>
<td>171</td>
<td>3.3</td>
<td>91.5%</td>
<td>3.0</td>
<td>21.90</td>
<td>18%</td>
<td>3.94</td>
<td>6.94</td>
</tr>
<tr>
<td>142</td>
<td>3.3</td>
<td>91.5%</td>
<td>3.0</td>
<td>23.60</td>
<td>18%</td>
<td>4.25</td>
<td>7.25</td>
</tr>
</tbody>
</table>
### Table No: 4-3

<table>
<thead>
<tr>
<th>No.</th>
<th>Ca Intake, Total</th>
<th>Phosphorus Intake</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cons. Rough.</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>13.62-7.76</td>
<td>21.38</td>
</tr>
<tr>
<td>111</td>
<td>13.62-6.04</td>
<td>19.20</td>
</tr>
<tr>
<td></td>
<td>13.62-5.79</td>
<td>18.95</td>
</tr>
<tr>
<td>171</td>
<td>13.62-7.15</td>
<td>20.77</td>
</tr>
<tr>
<td>142</td>
<td>13.62-7.72</td>
<td>21.74</td>
</tr>
</tbody>
</table>
intake was due to the variation in the dry matter intake (Dry matter intake varied according to the body weight of the calves). Carotene intake during this period varied from 118.2 mg. to 171.1 mg. This variation also was due to the variation in the dry matter intake especially due to that of the green roughage. Carotene intake also showed similar type of variation according to the body weight as that for calcium and phosphorus. The heaviest animal took the maximum amount of carotene and the lighter calf took the lowest amount. Dry matter and mineral intake of calves is given in Table No: 4.2 and 4.3.

Supplemented Feeding Period:—The mineral intake of the calves varied from 49.74 to 51.12 gms. of calcium and 30.50 to 31.15 gms. of phosphorus. In this sub period all the calves were provided with 100 gms. of dicalcium phosphate and 75 gms. of carotene. The dry matter intake showed negligible variation to that of the unsupplemented feeding period. Carotene intake during this period varied from 123.2 to 171.1 mgr.

EXCRETION OF URINE AND FAECES:—

URINE:—

Unsupplemented Period:—The amount of urine voided by individual calves during unsupplemented feeding
period and supplemented feeding period is given in Table No: 4.4 and 4.5.

During unsupplemented feeding period the total urine excretion varied from 2200 to 5322 ml per day. It can be seen from the table that the amount of urine voided during the first sub period in all the calves was more than that of the other two periods. It may be due to the fact that the calves were little excited due to the tying of the urine collection apparatus or the constant touching of the preputial hairs in the sides of the collection bag might have acted as a stimulant and thereby increasing the frequency of urination and amount of urine voided. The reduction in the excretion of urine during the second and third sub periods may be because by that time the calves were accustomed to the attachment of the urine collection outfit.

During the whole unsupplemented feeding period animal No: 142 excreted maximum amount of urine. In the first sub period the urine excretion varied from 5322 to 3913. During second sub period this variation was between 4133 and 2800. During third sub period urine excretion varied from 3633 to 2983. The same animal showed some variation in the excretion of urine in sub
### Table No: 4-4

**Table showing the average amount of urine voided per day in three sub periods of the unsupplemented feeding period** (in ml.)

<table>
<thead>
<tr>
<th>Animal No.</th>
<th>Body Weight (Kg.)</th>
<th>First</th>
<th>Second</th>
<th>Third</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>78 - 158</td>
<td>5323</td>
<td>3250</td>
<td>3533</td>
</tr>
<tr>
<td>16</td>
<td>160 - 4866</td>
<td>2800</td>
<td>2800</td>
<td>3633</td>
</tr>
<tr>
<td>111</td>
<td>144 - 4880</td>
<td>3433</td>
<td>3433</td>
<td>3116</td>
</tr>
<tr>
<td>94</td>
<td>130 - 3950</td>
<td>3050</td>
<td>3050</td>
<td>2983</td>
</tr>
<tr>
<td>171</td>
<td>150 - 3813</td>
<td>3650</td>
<td>3650</td>
<td>3443</td>
</tr>
<tr>
<td>142</td>
<td>153 - 4816</td>
<td>4133</td>
<td>4133</td>
<td>3900</td>
</tr>
</tbody>
</table>

### Table No: 4-5

**Table showing the average amount of urine voided per day in three sub periods of the supplemented feeding period** (in ml.)

<table>
<thead>
<tr>
<th>Animal No.</th>
<th>Body Weight (Kg.)</th>
<th>First</th>
<th>Second</th>
<th>Third</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>78 - 158</td>
<td>5423</td>
<td>5983</td>
<td>5600</td>
</tr>
<tr>
<td>16</td>
<td>160 - 4983</td>
<td>4533</td>
<td>4533</td>
<td>4866</td>
</tr>
<tr>
<td>111</td>
<td>144 - 4963</td>
<td>4733</td>
<td>4733</td>
<td>5706</td>
</tr>
<tr>
<td>94</td>
<td>130 - 4170</td>
<td>3950</td>
<td>3950</td>
<td>4150</td>
</tr>
<tr>
<td>171</td>
<td>150 - 4040</td>
<td>3933</td>
<td>3933</td>
<td>4050</td>
</tr>
<tr>
<td>142</td>
<td>153 - 5256</td>
<td>6166</td>
<td>6166</td>
<td>5316</td>
</tr>
</tbody>
</table>
periods and the trend of this variation was also different in different animals. Thus during the first sub period animal no: 78 excreting 5323 ml. of urine per day was the highest for this period while calf no: 171 excreting 3813 ml. per day was the lowest. In the next sub period however, animal number 78 excreted as low as 3250 ml. per day while for animal number 171 the figure was higher at 3650 ml. per day. Individual animals showed only limited variation in urinary excretion during second and third sub period. This variation was as little as 333 to 333 ml. The calf that excreted maximum amount of urine during second sub period excreted maximum urine during third sub period also. But for few exceptions, the amount of urine excreted was correlated to body weight and age.

**Supplemented Period:** During the supplemented period invariably all calves excreted more urine than in unsupplemented period. Here the variation between sub periods was very little. This agrees with the presumption that the increased excretion during the first sub period of the unsupplemented period was due to the excitation caused by the urine collection apparatus. This increased excretion during the supplemented feeding period can most probably be attributed to the change in climatic conditions. The unsupplemented feeding period was during hot summer months of June and supplemented feeding was
done during the month of July when the temperature started dropping down.

This variation between calves in the excretion of urine is in accordance with the observations made by Neigs et al. (1919). They in their calcium and phosphorus metabolism studies observed that the urinary excretion varied from 3274 to 5153 ml. between animals. They have not recorded the variations between sub periods as they have taken only one reading during the collection period.

PAGES:

Unsupplemented Period: - The amount, dry matter percentage and dry matter excreted during the three sub periods of the unsupplemented feeding period is shown in Table No: 4.5 and that during supplemented feeding period is given in Table No.4.6. There was appreciable variation between animals to animals in the wet weight of faeces voided and their moisture contents, as also for the same animal for the various sub periods. During this period percentage of dry matter of faeces varied from 18.36 to 11.28 percent. There seems to be no correlation between dry matter percentage of the faeces and age and weight of the calves. Calf no: 94 took 6.23 Lbs. dry matter per day and dry matter
<table>
<thead>
<tr>
<th>No.</th>
<th>1st. Sub - Period</th>
<th>2nd. Sub - Period</th>
<th>3rd. Sub - Period</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>D.M.</td>
</tr>
<tr>
<td></td>
<td>Amount  Dry</td>
<td>Dry</td>
<td>Amount  Dry</td>
<td>Dry</td>
</tr>
<tr>
<td></td>
<td>voided  matter</td>
<td>matter</td>
<td>voided  matter</td>
<td>matter</td>
</tr>
<tr>
<td></td>
<td>Kg.   tage</td>
<td>Kg.</td>
<td>Kg.   tage</td>
<td>Kg.</td>
</tr>
<tr>
<td>1</td>
<td>78.25  18.86</td>
<td>1.37</td>
<td>9.83  16.71</td>
<td>1.66</td>
</tr>
<tr>
<td>16</td>
<td>9.91   16.23</td>
<td>1.60</td>
<td>10.58  21.03</td>
<td>2.22</td>
</tr>
<tr>
<td>111</td>
<td>8.00   16.29</td>
<td>1.40</td>
<td>7.17   20.03</td>
<td>1.44</td>
</tr>
<tr>
<td>94</td>
<td>8.33   15.40</td>
<td>1.28</td>
<td>9.33   20.98</td>
<td>1.96</td>
</tr>
<tr>
<td>171</td>
<td>7.78   11.28</td>
<td>0.88</td>
<td>8.50   14.89</td>
<td>1.27</td>
</tr>
<tr>
<td>142</td>
<td>7.25   14.45</td>
<td>1.10</td>
<td>8.25   18.76</td>
<td>1.55</td>
</tr>
</tbody>
</table>
percentage voided was 15.40. Calf No: 171 took 6.94 Lbs. of dry matter and excreted 11.28 percent dry matter in faeces.

Even though much variation was noted in the amount of dung voided, this variation was reduced to some extent in dry matter voided, due to variation in dry matter percentage of faeces. Dry matter excretion during this period varied from 0.88 to 1.60 Kgm. Except for calf no: 171 and 111 the dry matter excreted in the faeces were positively correlated with dry matter intake. Animal no: 16 which has taken maximum amount of dry matter excreted maximum amount of faeces. Calf no: 171 even though took 0.94 Lb. of dry matter excreted only 0.88 total of all periods of dry matter in faeces during this period due to the low percentage of dry matter in faeces. Throughout the unsupplemented period and supplemented period this calf excreted minimum amount of dry matter.

In the second and third sub period also the trend of variation shown in the first sub period was maintained. In both sub periods calf no: 16 excreted maximum amount of dry matter in faeces and calf no: 171 excreted as in the other sub period the minimum amount of dry matter. Variation between animals and between
sub periods showed the same trend.

It is interesting to observe that the all the animals showed a tendency to excrete more dry matter in faeces in the second sub period. Since digestibility of dry matter is unlikely to fluctuate in the same animal within such a short interval of time, this variation is accounted to the uneven rate of excretion of faeces from day to day.

Supplemented Feeding Period:— During supplemented feeding period the faecal excretion varied from 7.03 to 9.5 kg. for the whole of the supplemented feeding period. In this period also excretion of faeces was related to the amount of intake. The trend of variation seen in this period was similar to that of unsupplemented feeding period. Variation between animals and between sub—period was same as that of the unsupplemented feeding period. There was an increase in the dry matter percentage of faeces. The dry matter excretion varied from 1.55 to 2.01 kgs. This was probably due to the fact that during this period all calves excreted more water in urine as a result the moisture percentage of faeces showed a corresponding decrease. All calves including calf no: 171, which excreted faeces with minimum dry matter percentage, even though continued its trend in this period also, The dry matter excretion was
<table>
<thead>
<tr>
<th>Table No: 4-7</th>
</tr>
</thead>
<tbody>
<tr>
<td>TABLE SHOWING THE AMOUNT, DRY MATTER PERCENTAGE AND DRY MATTER OF EXCRETA EXCRETED PER DAY DURING THE SUPPLEMENTED FEEDING PERIOD.</td>
</tr>
<tr>
<td>lst. sub-period</td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>No. per day</td>
</tr>
<tr>
<td>Kgm.</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>78</td>
</tr>
<tr>
<td>16</td>
</tr>
<tr>
<td>111</td>
</tr>
<tr>
<td>94</td>
</tr>
<tr>
<td>171</td>
</tr>
<tr>
<td>142</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(Kg)</td>
</tr>
<tr>
<td>11</td>
</tr>
</tbody>
</table>

---
more than during unsupplemented feeding period. The mild astringent action of dicalcium phosphate also may be responsible for increasing the dry matter percentage.

Comparing the unsupplemented and supplemented periods it was noticed that in the later period calves showed a tendency to excrete more dry matter in faeces. This was due apparently to the variation in digestibility. Since there was no change in the concentrate mixture between these two periods, change in digestibility of concentrate is ruled out. The only varying factor being green roughage, this variation in dry matter excreted may probably due to the difference in the digestibility of roughage due to its likely variation in quality as a result of different cuttings from different fields.

**RELATION OF WATER ELIMINATION IN URINE AND FAECES**

From perusal to table nos: 4.4, 4.5, 4.6 and 4.7 it can be noted that there was a negative correlation between water excretion in the urine and the moisture content of the faeces. For example, between the unsupplemented and feeding period and supplemented feeding period all calves showed a tendency to excrete more urine. At the same time all calves recorded an increase in the dry matter percentage of the faeces. This shows irrespective of an increase in the excretion of urine the calves maintained
a balance in the excretion of water by reducing the moisture content of the faeces.

**BALANCE TRIALS:**

**Unsupplemented Period:**

**CALCIUM:** The intake, excretion in faeces, in urine, retention and percentage of retention of calcium for all the sub periods of the unsupplemented feeding period is shown in Table No: 4.6. In Table No: 4.7 comparison of percentage retention of calcium for the three sub periods is given. Calcium balance for the whole of the unsupplemented period (9 days) is given in Table No: 4.8.

**First Sub Period:**

**INTAKE:** Intake of calcium varied according to the dry matter intake which in turn varied according to the body weight of the calves. As said earlier the intake of calcium varied from 12.95 to 22.02 gms. between calves.

**Faecal Calcium Excretion:** During the first sub period, on an average calves excreted nearly 30.6 percent of calcium in faeces. The range being 69 to 92 percent. Calf No: 171 excreted minimum calcium in faeces and calf No: 111 excreted the maximum amount other calves viz., 78.16, 94 and 142 excreted 83, 85, 75 and 79 percent of
**TABLE NO: 4-8.**

**TABLE SHOWING THE CALCIUM BALANCE FOR THE THREE SUB PERIODS (3 DAYS EACH) OF THE UNSUPPLEMENTED FEEDING PERIOD (gms. per day).**

<table>
<thead>
<tr>
<th>Intake</th>
<th>1st sub-period</th>
<th>Reten</th>
<th>Percent</th>
<th>2nd sub-period</th>
<th>Reten</th>
<th>Percent</th>
<th>3rd sub-period</th>
<th>Reten</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.</td>
<td>3.</td>
<td>4.</td>
<td>5.</td>
<td>6.</td>
<td>7.</td>
<td>8.</td>
<td>9.</td>
<td>10.</td>
</tr>
<tr>
<td>8</td>
<td>22.38</td>
<td>17.22</td>
<td>0.069</td>
<td>17.9</td>
<td>+3.48</td>
<td>-16.46</td>
<td>-17.71</td>
<td>-0.061</td>
<td>-17.79</td>
</tr>
<tr>
<td>9</td>
<td>22.02</td>
<td>18.88</td>
<td>0.094</td>
<td>18.94</td>
<td>+3.06</td>
<td>-13.66</td>
<td>-19.97</td>
<td>-0.084</td>
<td>-20.05</td>
</tr>
<tr>
<td>10</td>
<td>19.30</td>
<td>17.72</td>
<td>0.097</td>
<td>17.81</td>
<td>+1.39</td>
<td>-7.24</td>
<td>-17.28</td>
<td>-0.069</td>
<td>-17.40</td>
</tr>
<tr>
<td>11</td>
<td>15.34</td>
<td>14.34</td>
<td>0.089</td>
<td>14.43</td>
<td>+4.82</td>
<td>-23.30</td>
<td>-16.72</td>
<td>-0.073</td>
<td>-16.80</td>
</tr>
<tr>
<td>12</td>
<td>20.77</td>
<td>14.43</td>
<td>0.13</td>
<td>14.56</td>
<td>+6.21</td>
<td>-29.30</td>
<td>-17.71</td>
<td>-0.132</td>
<td>-17.85</td>
</tr>
<tr>
<td>13</td>
<td>21.34</td>
<td>16.94</td>
<td>0.064</td>
<td>17.02</td>
<td>+4.32</td>
<td>-20.20</td>
<td>-17.38</td>
<td>-0.097</td>
<td>-18.08</td>
</tr>
</tbody>
</table>
calcium in the faeces, respectively. The actual amount excreted varied from 14.34 to 18.88 kgs. There was some correlation between the intake and excretion of calcium in faeces. Between animals not much of variation was noticed in the excretion of calcium in faeces. The maximum excretion was 18.8 gms. in calf no: 16 whose intake was 22.02 gms., the maximum in the group and calf no: 94 excreted minimum of calcium and this calf was having minimum amount of intake.

**Urinary Calcium Excretion:** In all the calves the calcium was excreted only to a negligible extent in urine. The amount varied from 84 to 130 mg. The percentage of excretion varied approximately from 0.4 to 0.6 percent. Variation between calves in the urinary calcium excretion was limited to narrow bands. On the basis of this observation only, many authors have commented that the exclusion of urinary calcium excretion from a balance trial data will not affect the results of any appreciable extent.

**Amount of Retention:** The actual amount of retention during this sub period varied from 1.39 to 6.21 gms. All the calves showed a positive calcium balance. From perusal to Table No: 4-6 it can be noticed that retention was not related to intake. For calf no: 16 with 23.02 gms. of intake retained only 3.06 gms. of
calcium. Whereas calf no: 171 with 20.77 gms. of calcium intake retained as much as 6.21 gms. of calcium. Likewise calf no: 78 and 142 had the same amount of intake of 21.34 gms. of calcium but retained 3.48 and 4.32 gms. of calcium respectively.

From perusal to Table No: 4-1 the experimental calves can be divided into two groups according to their age. One group includes calf nos: 94, 171 and 142 of 1 year 6 months, 1 year 8 months and 1 year seven months of age respectively. The other group consist of calf nos: 78, 16 and 111 of two years 4 months, two years three months and two years of age respectively. On the basis of this grouping it can be seen that the calves of first group retained more of calcium than the other group. Within the group variation in the retention of calcium was not in accordance with the difference in age. In the second group calf no: 111 of 2 year old, having an intake of 19.2 gms. of calcium retained only 1.32 gms. This figure was lowest in the group. Throughout the unsupplemented period this calf retained the minimum of calcium.

From the data of this sub period there seems to exist a negative correlation between retention and body weight. Calf nos: 78, 16, 171 and 142 have more or
less similar body weight of 154, 155, 150 and 152 Kgm. But their retention values were 3.42, 3.06, 6.21 and 4.32 gms. But as a group, the calves of the younger group retained more calcium than that of the older group indicating that retention of calcium and age is positively correlated.

Percentage of Retention—During this sub period percentage retention varied from 7.24 to 29.90 percent. The minimum percentage retention was recorded by calf no: 111 and maximum recorded by calf no: 171. As in the case of actual retention percentage retention also varied according to age rather than intake of calcium and body weight. In the calves of younger age group percentage retention was maximum for calf no: 171 and in the other group calf no: 78 showed a maximum percentage retention.

Second Sub Period:

During the second sub period the intake of calcium remained the same as the daily intake of dry matter was the average of the total intake for nine days collection period.

Excretion in Faeces—During the second sub period the excretion of calcium in faeces varied from
19.97 to 16.72 gms. The percentage excretion of calcium in faeces varied from 90.7 to 83 percent. In this sub period, compared to the first sub period, the lower excretion limit was more and the upper limit remained the same. Except for calf no: 78 the older group excreted more calcium in faeces than the younger group. This fact was noticed in first sub period also.

In second sub period all calves showed a tendency to excrete more calcium in the faeces compared to the first sub period. This was probably due to the increased dry matter excretion in faeces. The trend in the variation in the excretion of calcium in faeces was same as that of the first sub period.

**Urinary Excretion:** Urinary calcium excretion in the second sub period remained as negligible as in the first sub period. There was not much variation in the excretion of calcium between sub periods. Between animal variation was also limited to narrow range.

**Retention:** In second sub period four calves out of the six showed reduced retention due to increased dry matter excretion, compared to that of the first sub period. Calves nos: 78 and 111 did not show any increase in excretion of calcium inspite of there increased dry matter excretion. This may be due to individual physiological difference. But the general
observations made from the datas of first sub period, like positive correlation between age and retention, remained unchanged in this sub period also. Datas of this sub period also did not give any proof to believe that the retention of calcium was proportional to intake. But for the reduction in retention in this sub period, variation between calves retained the same trend as that for the first sub period. In this sub period calves of the younger group more clearly showed the positive correlation between retention of calcium and age. The reduced retention of calcium, caused by increased and faecal excretion was reflected in the percentage retention also.

Third Sub Period:

**Faecal Calcium Excretion:** During this sub period with few exceptions the amount of calcium excreted showed a decline but generally more than that of the first sub period. Calves of the younger group of age excreted more calcium in the faeces than that of the first sub period.

**Urinary Calcium Excretion:** In this sub period calf no: 16 and 34 showed an increase in the excretion of calcium in urine alongwith calf no: 171 which was continuously excreting more throughout the unsupplemented
feeding period. This increased excretion in urine was not followed by an increase in the amount of liquid urine voided. But for this variation, variation between calves was as that for other sub periods.

Retention: The retention of calcium did not show much variation except for calf no: 16 which retained maximum calcium in this sub period among all other calves. Except for this deviation, variation between calves showed the same trend as in the previous sub period. The percentage of retention of calcium for the calves of the younger age group as a whole was more than that for the older age group. Percentage retention between calves also varied according to that of the Retention. This sub period also indicated that younger calves retained more calcium than older group. The trend of between sub period variation was similar to that of the other sub periods except for an individual increase recorded by calf no:16.

PERCENTAGE RETENTION FOR THE THREE SUB PERIODS:

From Table No: 4 it can be seen that the percentage retention for these three sub periods varied from 7.25 to 29.90. Except for calf no: 16 and 111 all other calves showed maximum percentage retention during first sub period. From perusal to Table No: 4-5 it can be
**TABLE NO: 4-9**

Comparison of the percentage retention of calcium in three sub-periods of unsupplemented feeding period.

<table>
<thead>
<tr>
<th>Ani. No.</th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
<th>4th</th>
</tr>
</thead>
<tbody>
<tr>
<td>78</td>
<td>16.46</td>
<td>16.79</td>
<td>11.3</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>13.86</td>
<td>13.86</td>
<td>20.48</td>
<td></td>
</tr>
<tr>
<td>111</td>
<td>7.24</td>
<td>9.36</td>
<td>8.76</td>
<td></td>
</tr>
<tr>
<td>94</td>
<td>23.80</td>
<td>11.34</td>
<td>14.34</td>
<td></td>
</tr>
<tr>
<td>171</td>
<td>29.90</td>
<td>14.06</td>
<td>19.10</td>
<td></td>
</tr>
<tr>
<td>142</td>
<td>20.20</td>
<td>16.27</td>
<td>14.66</td>
<td></td>
</tr>
</tbody>
</table>

**TABLE NO: 4-10.**

Calcium balance for the whole of the unsupplemented period (9 days).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>78</td>
<td>192.42</td>
<td>163.2</td>
<td>0.77</td>
<td>163.97</td>
<td>28.45</td>
<td>14.78</td>
</tr>
<tr>
<td>16</td>
<td>198.18</td>
<td>168.85</td>
<td>0.86</td>
<td>169.61</td>
<td>28.57</td>
<td>14.92</td>
</tr>
<tr>
<td>111</td>
<td>172.80</td>
<td>157.71</td>
<td>0.78</td>
<td>158.50</td>
<td>14.50</td>
<td>8.27</td>
</tr>
<tr>
<td>94</td>
<td>170.55</td>
<td>142.57</td>
<td>0.79</td>
<td>141.40</td>
<td>29.15</td>
<td>17.0</td>
</tr>
<tr>
<td>171</td>
<td>186.93</td>
<td>146.51</td>
<td>1.26</td>
<td>147.67</td>
<td>39.26</td>
<td>21.0</td>
</tr>
<tr>
<td>142</td>
<td>192.06</td>
<td>142.12</td>
<td>0.82</td>
<td>162.94</td>
<td>29.12</td>
<td>15.2</td>
</tr>
</tbody>
</table>
noted that all calves except calf no: 111 excreted lowest dry matters in faeces in this sub period, compared to that of other sub periods, of the unsupplemented feeding period. But for few exceptions it could be presumed that retention of calcium and excretion of dry matter in faeces was negatively correlated. The variation in the retention of calcium due to age was more clear from this table with few exceptions. All the calves of the younger group recorded a higher percentage retention. If the average percentage retention of the three sub periods were taken, it could be seen that the calves of older group recorded a percentage retention of 14.8, 14.49 percent in first, second and third periods. Whereas calves of the lesser age group recorded 16.49, 21.02 and 17.04 percent of retention during the same period. This strengthens the belief that age had positively some influence in the retention of calcium.

Whole Period:- Table No: 4-9 shows the actual amount of intake, excretion in urine, and faeces, retention and percentage retention of each calf for whole of the unsupplemented feeding period. Since this table deals with the balance of calcium for the whole of the unsupplemented period, had to some extent remove the exception shown by individual calves during sub periods about excretion and retention. Except calf nos: 171 and
Ill all other calves recorded that excretion was proportional to intake.

**Urinary Excretion:** Except for calf no: 171 all other calves showed only little variation. There was no reason to believe that urinary calcium excretion was related calcium intake, age and weight of the animal or to the amount of urine voided. The percentage of calcium excreted in urine by individual calves varied from 0.4 to 0.67 percent. This extent variation in the sub periods was also of the same order.

**Retention:** Retention of calcium varied from 14.30 to 39.26 gms. amongst the calves for the whole of the unsupplemented period of nine days. Younger group as a whole, had lesser intake of calcium than the other group except for calf no: 142 in younger age group and Ill in older age group. Calf Nos: 73 and 142 had similar intake of calcium and more or less similar body weight. From the retention data it could be seen that calf no:142 irrespective of the similarity with calf no: 73 in weight and intake could retain 0.67 gms. of calcium more than that of the other. This can be attributed mainly to the difference in their age. This presumption was further strengthened due to the fact calf nos: 171 and 94 even though had lesser intake of calcium and lesser body weight.
retained more calcium than calves of other group. Thus it could be assumed that in our experimental animals, age forms a major factor in the absorption of calcium. Older calves even when the intake were more detained only to a lesser extent than younger calves having lower intake.

Variations in the excretion of calcium in faeces and urine and also in the retention of calcium recorded was in complete agreement with the observations made by Meigs et al (1919), Fober et al (1929), Lindsey et al (1931) and Talapatra (1950). Their observations are tabulated in Table Nos: 4-10, 2-1, 2-2, 2-4, 11. Meigs et al (1919) on three adults recorded that total liquid urine excretion varied 3274 to 5153 and total were faeces excretion varied from 12 to 18 kg. He had not recorded the amount of dry matter voided in the faeces. They had also recorded the variation between animals in the excretion of calcium in urine. The actual figures varied 0.03 to 0.8 gms. From these dates minimum excretion of calcium was found in the animal which consumed minimum amount of calcium. But it cannot be concluded that the urinary excretion and intake of calcium in positively correlated due to the fact that difference in the intake was negligible compared to the wide variation shown in the urinary calcium excretion. These results are tabulated in Table No: 4. Talapatra (1950) recorded 0.3
TABLE SHOWING CALCIUM & PHOSPHORUS IN ADULT HOLSTEIN COWS.

**Table No: 4-11.**

**CALCIUM BALANCE**

<table>
<thead>
<tr>
<th>No</th>
<th>Intake</th>
<th>Excretion</th>
<th>Retention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>gm.</td>
<td>Faeces</td>
<td>Urine</td>
</tr>
<tr>
<td>1</td>
<td>38.81</td>
<td>34.43</td>
<td>0.88</td>
</tr>
<tr>
<td>2</td>
<td>32.42</td>
<td>31.48</td>
<td>0.03</td>
</tr>
<tr>
<td>3</td>
<td>35.47</td>
<td>29.99</td>
<td>0.50</td>
</tr>
</tbody>
</table>

**PHOSPHORUS BALANCE**

<table>
<thead>
<tr>
<th>Intake</th>
<th>Excretion Gm.</th>
<th>Retention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>gms.</td>
<td>Faeces</td>
</tr>
<tr>
<td>22.39</td>
<td>19.91</td>
<td>0.09</td>
</tr>
<tr>
<td>30.37</td>
<td>26.04</td>
<td>0.90</td>
</tr>
<tr>
<td>30.51</td>
<td>25.89</td>
<td>0.87</td>
</tr>
</tbody>
</table>
TABLE SHOWING CALCIUM & PHOSPHORUS IN 
ADULT HOLSTEIN COWS.

**TABLE NO: 4-11.**

- **CALCIUM BALANCE** -

<table>
<thead>
<tr>
<th>Ani.</th>
<th>Intake</th>
<th>Excretion</th>
<th>Urine</th>
<th>Retention</th>
</tr>
</thead>
<tbody>
<tr>
<td>No:</td>
<td>gm.</td>
<td>Facees</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>51</td>
<td>38.81</td>
<td>34.43</td>
<td>0.88</td>
<td>3.51</td>
</tr>
<tr>
<td>63</td>
<td>32.42</td>
<td>31.48</td>
<td>0.03</td>
<td>0.91</td>
</tr>
<tr>
<td>66</td>
<td>35.47</td>
<td>29.99</td>
<td>0.50</td>
<td>4.98</td>
</tr>
</tbody>
</table>

- **PHOSPHORUS BALANCE** -

<table>
<thead>
<tr>
<th>Ani.</th>
<th>Intake</th>
<th>Excretion Gm.</th>
<th>Urine</th>
<th>Retention</th>
</tr>
</thead>
<tbody>
<tr>
<td>No:</td>
<td>gm.</td>
<td>Facees</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>51</td>
<td>23.39</td>
<td>19.91</td>
<td>0.09</td>
<td>3.39</td>
</tr>
<tr>
<td>63</td>
<td>30.37</td>
<td>26.04</td>
<td>0.80</td>
<td>3.34</td>
</tr>
<tr>
<td>66</td>
<td>30.51</td>
<td>25.89</td>
<td>0.87</td>
<td>3.75</td>
</tr>
</tbody>
</table>
to 0.6 gms. of urinary calcium excretion in calves, when the intake was more or less similar in all cases. Nearly with the same intake, urinary calcium excretion varied nearly two fold between animals. On the basis of intake and urinary excretion values it was seen that, with decrease of 0.01 to 0.11 gms. of calcium there was a difference of about 0.17 to 0.27 gms. excess excretion in the urine.

He has also recorded that younger calves showed greater efficiency in the utilization of calcium. Adult animals when fed with 8.82 to 13.50 gms. of calcium showed a negative balance of 0.25 to 1.63 gms., whereas young calves fed with 10.54 to 10.64 gms. of calcium recorded a clear positive balance varying from 3.54 to 4.22 gms. The adult animal excreted as much as 1.80 to 2.1 gms. of calcium in urine while calves excreted only 0.3 to 0.6 gms. of calcium in urine. Talapatra explained the much higher excretion in adult animals as due to the fact that the young calves should have a chance to utilize more calcium for skeletal formation whereas adult animals require little calcium for calcification and the major portion of the absorbed calcium was excreted in the urine by adults.

Lindsey et al. (1931) studied calcium and
### Table 4-12

**S.K. TALMPTA - 1950.**

**Ind. J. Vety. Sc. An. Hu. 20-247.**

**Calcium and Phosphorus Balance.**

#### Calcium

<table>
<thead>
<tr>
<th>Animal No</th>
<th>Intake (Gm)</th>
<th>Excretion (Gm)</th>
<th>Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10.69</td>
<td>6.08 0.33 6.4</td>
<td>+4.22</td>
</tr>
<tr>
<td>2</td>
<td>10.64</td>
<td>6.40 0.60 7.1</td>
<td>+3.54</td>
</tr>
<tr>
<td>3</td>
<td>10.62</td>
<td>6.21 0.60 6.8</td>
<td>+3.81</td>
</tr>
<tr>
<td>4</td>
<td>10.54</td>
<td>6.09 0.50 6.39</td>
<td>+3.95</td>
</tr>
</tbody>
</table>

#### Phosphorus

<table>
<thead>
<tr>
<th>Animal No</th>
<th>Intake (Gm)</th>
<th>Excretion (Gm)</th>
<th>Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-4.54</td>
<td>11.26 0.44 -11.7</td>
<td>2.84</td>
</tr>
<tr>
<td>2</td>
<td>-4.55</td>
<td>9.15 0.50 9.65</td>
<td>+4.90</td>
</tr>
<tr>
<td>3</td>
<td>-4.53</td>
<td>9.81 0.21 10.02</td>
<td>+4.51</td>
</tr>
<tr>
<td>4</td>
<td>-4.44</td>
<td>8.57 0.34 8.91</td>
<td>+5.53</td>
</tr>
</tbody>
</table>
### TABLE NO: 4-12


**CALCIUM AND PHOSPHORUS BALANCE.**

#### CALCIUM

<table>
<thead>
<tr>
<th>Ani. No</th>
<th>Intake Gm.</th>
<th>Excretion Gm.</th>
<th>Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>3, 4, 5</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>10.69</td>
<td>6.08, 0.33, 6.4</td>
<td>+4.22</td>
</tr>
<tr>
<td>2</td>
<td>10.64</td>
<td>6.50, 0.60, 7.1</td>
<td>+3.54</td>
</tr>
<tr>
<td>3</td>
<td>10.62</td>
<td>6.21, 0.60, 6.8</td>
<td>+3.81</td>
</tr>
<tr>
<td>4</td>
<td>10.54</td>
<td>6.09, 0.50, 6.39</td>
<td>+3.95</td>
</tr>
</tbody>
</table>

#### PHOSPHORUS

<table>
<thead>
<tr>
<th>Ani. No</th>
<th>Intake Gm.</th>
<th>Excretion Gm.</th>
<th>Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>3, 4, 5</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>-14.54</td>
<td>11.26, 0.44, 11.7</td>
<td>+2.84</td>
</tr>
<tr>
<td>2</td>
<td>-14.55</td>
<td>9.15, 0.50, 9.65</td>
<td>+4.90</td>
</tr>
<tr>
<td>3</td>
<td>-14.53</td>
<td>9.81, 0.21, 10.02</td>
<td>+4.51</td>
</tr>
<tr>
<td>4</td>
<td>-14.44</td>
<td>8.57, 0.34, 8.91</td>
<td>+5.53</td>
</tr>
</tbody>
</table>
### Table No: 4-13

**Calcium and Phosphorus Balance of Dairy Heifers.**

*(Lindsey, J.B. Archipald J.G. & Nelson P.R., 1931)*

*J: Agri.: Res. 42.683.*

<table>
<thead>
<tr>
<th>Group</th>
<th>Calcium Intake (gm)</th>
<th>Calcium Retained (gms.)</th>
<th>Phosphorus Intake (gms.)</th>
<th>Phosphorus Retained (gms.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Ca.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 yr. calves</td>
<td>35</td>
<td>9.5</td>
<td>27.2</td>
<td>10</td>
</tr>
<tr>
<td>2 yrs. calves</td>
<td>43</td>
<td>7.3</td>
<td>16.5</td>
<td>13</td>
</tr>
<tr>
<td>3 yrs. calves</td>
<td>57</td>
<td>7.1</td>
<td>12.5</td>
<td>17</td>
</tr>
<tr>
<td>Low Ca.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 yr. calves</td>
<td>17</td>
<td>4.8</td>
<td>27.6</td>
<td>11</td>
</tr>
<tr>
<td>2 yrs. calves</td>
<td>20</td>
<td>4.1</td>
<td>20.5</td>
<td>16</td>
</tr>
<tr>
<td>3 yrs. calves</td>
<td>27</td>
<td>4.7</td>
<td>17.5</td>
<td>19</td>
</tr>
</tbody>
</table>
### TABLE NO. 4-12-B

**MEAN DAILY CALCIUM AND PHOSPHORUS BALANCE OF DAIRY HEIFERS**


<table>
<thead>
<tr>
<th>AGE</th>
<th>Number of trials</th>
<th>Mean weight intake per 100 Lb.</th>
<th>Calcium per liveweight</th>
<th>Calcium Phosphate retention per 100 Lb. live weight</th>
<th>Phosphate retention per 100 Lb. live weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Phosphorus group:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calves, first year</td>
<td>16</td>
<td>464</td>
<td>3.8</td>
<td>1.4</td>
<td>36.3</td>
</tr>
<tr>
<td>Calves second year</td>
<td>21</td>
<td>772</td>
<td>3.0</td>
<td>0.8</td>
<td>26.4</td>
</tr>
<tr>
<td>In calf, third year</td>
<td>5</td>
<td>1103</td>
<td>3.1</td>
<td>0.8</td>
<td>27.0</td>
</tr>
<tr>
<td>Low Phosphorus group:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calves, first year</td>
<td>17</td>
<td>472</td>
<td>3.6</td>
<td>1.2</td>
<td>31.9</td>
</tr>
<tr>
<td>Calves, second year</td>
<td>13</td>
<td>640</td>
<td>3.3</td>
<td>0.8</td>
<td>24.5</td>
</tr>
<tr>
<td>In calf, third year</td>
<td>5</td>
<td>1054</td>
<td>3.1</td>
<td>0.9</td>
<td>23.0</td>
</tr>
</tbody>
</table>
phosphorus balance in heifers of different age group and is tabulated in Table No 4-13. They have shown that one year calves retained more calcium than two years and three year. Two year calves retained more calcium than three year calves. The amount of intake of calcium was proportional to age that is one year calves took less calcium than 2 year calves, which in turn took less calcium than third year calves. This shows that age was more important a factor in calcium retention than intake.

Summing up the results it can be fairly concluded that very little relationship was there between intake of calcium and its excretion, at least when the intake was sufficient to satisfy the apparent requirements. There was some positive correlation between faecal excretion of calcium and dry matter excreted in the faeces. Urinary calcium excretion was not related to the amount of the intake of calcium. Definite indications were lacking to believe that urinary calcium excretion was positively correlated to body weight. This experiment failed to show any relationship between urinary calcium excretion and age of the animal. Calcium retention was positively correlated with the age of the animal.
PHOSPHORUS.

Phosphorus balance for three sub-periods are given in Table No: 4-14.

INTAKE:

Intake of phosphorus varied as in the case of calcium depending upon the amount of dry matter intake. Phosphorus intake varied from 8.15 to 9.60 gm. The calcium phosphorus ratio was 1 : 2.3. The intake was same for all the calves throughout the unsupplemented feeding period.

EXCRETION IN FAECES:

The amount of phosphorus excreted in faeces varied in the first sub-period from 5.50 to 7.08 gms. The percentage of excretion in faeces varied from 92 to 96.7 percent of the intake and 91.8 to 94.4 percent of the total excretion. The results showed that the excretion of phosphorus was to some extent correlated positively to intake and also to some extent for body weight with the exception of calf No: 171 and 78. Calf No: 78 excreted maximum amount of phosphorus. In intake as well as in body weight this calf was slightly less than calf No: 16. Calf No: 16 excreted 6.72 gms. phosphorus in faeces when its intake was 9.60 gms. Calf No: 171 even though consumed 9.01 gm. of phosphorus in faeces when its intake was 9.60 gms. of phosphorus excreted only 5.50 gms.
TABLE SHOWING THE PHOSPHORUS BALANCE FOR THE THREE SUB-PERIODS (9 3 DAYS EACH) OF THE UNSUPPLEMENTED FEEDING PERIOD (GMS. PER DAY)

<table>
<thead>
<tr>
<th>Intake</th>
<th>1st. sub-period</th>
<th>Excretion gms.</th>
<th>Retention %</th>
<th>2nd. sub-period</th>
<th>Excretion gms.</th>
<th>Retention %</th>
<th>3rd. sub-period</th>
<th>Excretion gms.</th>
<th>Retention %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faeces</td>
<td>Urine Total</td>
<td></td>
<td></td>
<td>Faeces</td>
<td>Urine Total</td>
<td></td>
<td>Faeces</td>
<td>Urine Total</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>10.32</td>
<td>7.08</td>
<td>0.63</td>
<td>7.71</td>
<td>1.61</td>
<td>17.27</td>
<td>1.44</td>
<td>15.45</td>
<td>7.40</td>
<td>0.52</td>
</tr>
<tr>
<td>9.60</td>
<td>6.72</td>
<td>0.34</td>
<td>7.06</td>
<td>2.54</td>
<td>26.46</td>
<td>2.50</td>
<td>26.04</td>
<td>7.20</td>
<td>0.19</td>
</tr>
<tr>
<td>8.25</td>
<td>6.22</td>
<td>0.43</td>
<td>6.65</td>
<td>2.63</td>
<td>19.68</td>
<td>2.26</td>
<td>27.27</td>
<td>6.50</td>
<td>0.28</td>
</tr>
<tr>
<td>8.15</td>
<td>5.68</td>
<td>0.27</td>
<td>5.95</td>
<td>2.20</td>
<td>27.00</td>
<td>2.20</td>
<td>27.0</td>
<td>6.16</td>
<td>0.26</td>
</tr>
<tr>
<td>9.01</td>
<td>5.50</td>
<td>0.27</td>
<td>5.77</td>
<td>3.24</td>
<td>35.60</td>
<td>2.31</td>
<td>25.62</td>
<td>6.13</td>
<td>0.26</td>
</tr>
<tr>
<td>9.25</td>
<td>6.60</td>
<td>0.40</td>
<td>7.00</td>
<td>2.25</td>
<td>24.32</td>
<td>2.45</td>
<td>26.5</td>
<td>6.97</td>
<td>0.35</td>
</tr>
</tbody>
</table>
which was less than that for calf No: 111 and 94. They excreted 6.22 and 5.6 gm. when there intake was 8.25 and 8.15 gms. For calf nos: 111, 94 and 171 the excretion of phosphorus was related to dry matter excretion. For calf no: 78 and 142 even though the intake was similar, variation in excretion of phosphorus in faeces was due to their variation in dry matter excretion. During this sub period calf no: 78 excreted 1.37 Kg. of dry matter and calf no: 142 excreted 1.10 kg. in faeces. Calf No: 16 had an intake of 9.60 gm. of phosphorus, and during this sub period it excreted 1.60 Kg. of dry matter in faeces. This figure was the highest for this sub-period. The excretion of phosphorus is thus governed by both intake and excretion of dry matter in faeces. The excretion of phosphorus showed no correlation with the excretion of calcium in faeces.

**Excretion in Urine:**

Phosphorus was excreted in urine in more quantities compared to that of calcium. The urinary phosphorus excretion varied from 0.27 to 0.63 gms. There was no relation between intake and excretion of phosphorus in urine. Calf No: 78 had the maximum urinary phosphorus excretion and the minimum was recorded by Calf Nos: 171 and 94. Their respective intake was 9.32, 9.01 and 8.15 gms. Urinary phosphorus excretion seems to
be related to the amount of liquid urine voided. In the first sub period calf No: 78 had the maximum urine output and the amount of phosphorus voided with urine was maximum in this sub period compared to all other calves. Calf No: 171 with minimum amount of urinary excretion voided minimum phosphorus in urine. This clearly indicated the relationship between total urine output and the amount of phosphorus excreted. The percentage of phosphorus excreted in urine varied from 33 to 57 percent of intake and 4.4 to 8.2 percent of the total excretion in this sub period. As seems to be a factor in limiting the excretion of phosphorus as in the case with calcium. Even with variation in intake calves of the younger group excreted less phosphorus than the other group. In the 1st sub period excretion of calcium and excretion of phosphorus did not show any correlation.

**RETENTION:**

In the first sub period of the unsupplemented feeding period the retention showed no relation to intake of dry matter, intake of phosphorus or to the body weight of calves. The actual retention varied from 1.61 to 3.24 gm. All calves showed a positive phosphorus balance. As in calcium balance calf nos: 94, 171 and 142 showed a better retention than calf of older age group.
except calf No: 16. Calf No: 111 recorded better retention in Phosphorus than that for calcium. The amount of retention was more than that for animal No: 78. In calcium balance Calf No: 111 always retained less than Calf No: 78. Calf No: 16 retained more Phosphorus than Calf No: 94. The average retention of calves of older group was about 1.93 gms. and that for the calves of the younger group was about 2.56 gms. But as in the case of calcium younger calves on an average retained more Phosphorus than older ones. This was more clear from percentage retention of phosphorus. Percentage retention the varied between 17.27 and 35 percent. The minimum percentage was recorded by calf No: 78 and maximum percentage was recorded by calf No: 171. Contrary to calcium balance where calf No: 78 recorded maximum percentage retention, in Phosphorus this Calf recorded minimum retention among calves of older age group. These
Second sub-period

Excretion in faeces: In the second sub-period the variation in excretion of Phosphorus was more between animals and also compared to that of the first sub-period. Excretion in faeces varied from 5.65 to 7.32. This sub-period also relied to recorded any positive correlation between the
except calf No: 16. Calf No: 111 recorded better retention in Phosphorus than that for calcium. The amount of retention was more than that for animal No: 78. In calcium balance Calf No: 111 always retained less than Calf No: 78. Calf No: 16 retained more Phosphorus than Calf No: 94. The average retention of calves of older group was about 1.93 gms. and that for the calves of the younger group was about 2.56 gms. But as in the case of calcium younger calves on an average retained more Phosphorus than older ones. This was more clear from percentage retention of phosphorus. Percentage retention varied between 17.27 and 35 percent. The minimum percentage was recorded by calf No: 78 and maximum percentage was recorded by calf No: 171. Contrary to calcium balance where calf No: 78 recorded maximum percentage retention, in Phosphorus this Calf recorded minimum retention among calves of older age group. These Second sub-period.

Excretion in faeces: In the second subperiod the variation in excretion of Phosphorus was more between animals and also compared to that of the first sub-period. Excretion in faeces varied from 5.65 to 7.32. This sub-period also relied to recorded any positive correlation between the
the excretion of phosphorus and body weight. In second sub-period the excretion of Phosphorus failed to show any relation to age. Between sub-periods in the second sub-period many calves showed only a negligible increase in excretion than that of the first sub-period despite of the fact that dry matter excretion was more in this sub-period. Except for calf No: 111 and 94 the trend of excretion of phosphorus remained the same between sub-periods.

Excretion in Urine: In the second sub-period also the trend of excretion of Phosphorus in urine showed a positive correlation to the amount of Urine voided. There was some variation in the Urinary excretion of Phosphorus by the same animal between sub-periods. But the trend shown by different calves in the first sub-period was maintained in this sub-period also.

Retention: Three out of six calves recorded reduction in the retention and other two calves viz. 111 and 142 recorded a slight increase and calf No: 94 showed the same retention. During this sub-period there was an increase in the dry matter excretion in faeces. Irrespective of this fact three out of six calves did not record any reduction in the excretion of Phosphorus. This indicates as in the first sub-period, that the retention of Phosphorus depends more upon the physiological differences of
the body rather than to dry matter excretion. Age seems to influence the retention of Phosphorus as in case of first sub period. When the average retention of three calves of the older age group for this sub-period was 2.08 gms, that for the calves of the younger age group was 2.32 gms with nearly the same intake.

Percentage retention: The variations shown in the amount retention was reflected in percentage retention also. Except for 111 and 171, the trend of variations between animals and that by same animal between sub period remained unchanged.

Third sub-Period.

Excretion in faeces: In this sub period all calves showed a tendency to excrete more Phosphorus even though the dry matter excretion was less than that of the second sub-period and more than that of the first sub-period. In this sub-period also all calves showed a positive correlation between dry matter excretion and excretion of Phosphorus in faeces.

Urinary excretion:

Except for a negligible reduction in urinary excretion the trend of variation in urinary phosphorus excretion was same as that for other sub-periods.
The average retention during the three sub-periods was as follows:

<table>
<thead>
<tr>
<th>Sub-periods</th>
<th>$1^\text{st}$</th>
<th>$2^\text{nd}$</th>
<th>$3^\text{rd}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>27</td>
<td>15.45</td>
<td>15.02</td>
</tr>
<tr>
<td>2</td>
<td>24.46</td>
<td>26.04</td>
<td>23.24</td>
</tr>
<tr>
<td>3</td>
<td>29.68</td>
<td>27.27</td>
<td>18.13</td>
</tr>
<tr>
<td>4</td>
<td>27.00</td>
<td>27.00</td>
<td>21.22</td>
</tr>
<tr>
<td>5</td>
<td>28.60</td>
<td>25.62</td>
<td>28.85</td>
</tr>
<tr>
<td>6</td>
<td>24.32</td>
<td>26.50</td>
<td>20.86</td>
</tr>
</tbody>
</table>

This variation was generally correlated with the dietary values.

The retention of Phosphorus varied from 15.02 to 28.85 due to differences in growth rates. The retention results, therefore, indicate that the body retains a portion of the ingested Phosphorus for metabolism and synthesis. The table clearly shows only the average values for each sub-period.
Retention:

The increased excretion of Phosphorus was reflected in the retention also, showing a reduction in retention of Phosphorus. The younger group retained more phosphorus than the older group. The average retention for younger group in this sub-period was 2.08 gm. and that for older calves was 1.7 gm. The average percentage retention was 23.64 and 18.79% respectively.

Percentage retention of the three sub-periods:

The comparative percentage retention of Phosphorus of the three sub-periods is given in Table No: 4-11. The percentage retention for all the three sub-periods varied from 15.45 to 35.60 percent. The variation between sub-periods for the same animal was within narrow limit. Phosphorus was better utilized by all calves compared to calcium. Probably due to lower intake.

As with calcium, calves of the younger group recorded a better percentage retention with Phosphorus. On an average the calves of older group retained 21.13, 22.32 and 18.79 percent respectively for first, second and third sub-periods and that for the calves of the younger age group was 22.97, 26.07
TABLE NO: 40-15.

COMPARISON OF PERCENTAGE RETENTION OF PHOSPHORUS IN THE THREE SUB-PERIODS OF UNSUPPLEMENTED FEEDING PERIOD.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Percentage retention during sub-periods</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>1st.</td>
</tr>
<tr>
<td>78</td>
<td>17.27</td>
</tr>
<tr>
<td>16</td>
<td>26.46</td>
</tr>
<tr>
<td>111</td>
<td>19.68</td>
</tr>
<tr>
<td>94</td>
<td>27.00</td>
</tr>
<tr>
<td>171</td>
<td>0.560</td>
</tr>
<tr>
<td>142</td>
<td>24.32</td>
</tr>
</tbody>
</table>

The trend in this variation was generally associated with higher urinary values.

Relation - Retention of Phosphorus varied from 12.66 to 26.06 cc. This variation was not related to dry matter intake, intake of Phosphorus or to the body weight of the calves. But the table clearly shows that the calves of the younger age retained more phosphorus.
and 23.64% respectively.

**Whole period:**

The intake, excretion in faeces and urine, retention and percentage of phosphorus for the whole of the unsupplemented feeding period is shown in Table No: 4-16.

**Faecal excretion:**

Faecal phosphorus excretion was not always correlated with intake. Except calf No: 16 and 171 all other calves showed a positive correlation between dry matter excretion of phosphorus in faeces.

**Urinary excretion:**

There was considerable variation between animals in the excretion of phosphorus in urine. Calf No: 16, 94 and 171 excreted only 2.31, 2.6 and 2.43 gms of phosphorus in urine, whereas an calf No: 78, 111 and 142 excreted 5.13, 3.23 and 3.60 gms. of phosphorus. The trend in this variation was generally correlated with higher urinary volume.

**Retention:** Retention of phosphorus varied from 13.35 to 24.46 gms. This variation was not related to dry matter intake, intake of phosphorus or to the body weight of the calves. But the table clearly shows that the calves of the younger age retained more phosphorus
**Table No: 4-16.**

**Phosphorus Balance for the Whole of the Unsupplemented Feeding Period.**

<table>
<thead>
<tr>
<th>Animal No.</th>
<th>Intake (gms.)</th>
<th>Excretion (gms.)</th>
<th>Retention (gms.)</th>
<th>% Retention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Faeces</td>
<td>Urine</td>
<td>Total</td>
</tr>
<tr>
<td>78</td>
<td>83.88</td>
<td>65.40</td>
<td>5.13</td>
<td>70.53</td>
</tr>
<tr>
<td>16</td>
<td>66.40</td>
<td>62.34</td>
<td>2.31</td>
<td>64.65</td>
</tr>
<tr>
<td>101</td>
<td>74.52</td>
<td>55.11</td>
<td>3.23</td>
<td>58.34</td>
</tr>
<tr>
<td>94</td>
<td>73.39</td>
<td>52.53</td>
<td>2.43</td>
<td>54.96</td>
</tr>
<tr>
<td>171</td>
<td>81.09</td>
<td>54.03</td>
<td>2.60</td>
<td>56.63</td>
</tr>
<tr>
<td>142</td>
<td>83.25</td>
<td>59.70</td>
<td>3.60</td>
<td>63.30</td>
</tr>
</tbody>
</table>
compared to that of the older groups except for calf No: 16. The average retention of Phosphorus for the calves of the younger age group was 20.98 gms. and that for older age group was 17.09. This clearly indicates that age is a limiting factor in deciding the retention of Phosphorus.

Observations recorded by Neigs et al. (1913), Lindsey et al. (1931) and Talapatra (1950) about Phosphorus balance is shown in Table No: 4-11, 2.2, and 4-12 for comparison.

Neigs et al. (1913) recorded 19.91, 26.04 and 25.89 gms. of faecal phosphorus excretion and 0.09, 0.90 and 0.87 gms. of urinary excretion when the intake was 23.39, 30.37 and 30.51 gms. He recorded retention of 3.39, 3.34 and 3.75 gms.

Talapatra (1950) while studying Phosphorus balance in growing calves recorded fecal phosphorus excretion varying between 8.57 and 11.26 gms. and urinary Phosphorus excretion between 0.34 and 0.5 gms. when the intake varied from 14.44 and 14.54. The retention of Phosphorus varied between 2.84 to 5.53 gms. This data shows a wide variation in excretion of Phosphorus in faeces and urine and also in retention of Phosphorus when the intake varied between such narrow limits as 14.44 and 14.54. Neither of the authors have recorded the age or body weight of the calves and as
such the effect of age on absorption or retention could not be compared.

Lindsey et al. (1981) whose data are tabulated in Table No: 2-2 showed that the retention of Phosphorus was related to age. They showed that young calves retained more Phosphorus and that the efficiency of Phosphorus utilization was more in young calves.

The observations made in the present study about the excretion of Phosphorus in faeces, and urine and extent of retention showed much similarity to the observations made by the authors shown above.

**Carotene:**

The intake, excretion, retention and percentage retention of carotene for all calves for the three periods is given in Table No: 4-17.

**Intake:**

The intake of carotene varied between 118.2 to 171.6 mg. This variation was due to variation in the intake of green roughage. Throughout the unsupplemented period the intake of carotene for the same animal remained the same.

**Excretion:**

Since carotene is known to be not excreted through urine the values shown below are of excretion in
### Table No. 4-17

**Table Showing the Caroten Balance for the Three Sub-Periods (Three day each) of the Unsupplemented Feeding Period (mg. per day).**

<table>
<thead>
<tr>
<th>No.</th>
<th>Intake</th>
<th>1st. Sub-Period</th>
<th>2nd Sub-Period</th>
<th>3rd Sub-Period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mg.</td>
<td>Excretion</td>
<td>Retention</td>
<td>Excretion</td>
</tr>
<tr>
<td>1</td>
<td>160.6</td>
<td>.94.98</td>
<td>65.62</td>
<td>40.85</td>
</tr>
<tr>
<td>2</td>
<td>171.1</td>
<td>.126.42</td>
<td>44.68</td>
<td>.26.10</td>
</tr>
<tr>
<td>3</td>
<td>123.84</td>
<td>31.36</td>
<td>.31.36</td>
<td>25.45</td>
</tr>
<tr>
<td>4</td>
<td>118.2</td>
<td>.92.63</td>
<td>25.57</td>
<td>.21.63</td>
</tr>
<tr>
<td>5</td>
<td>145.94</td>
<td>114.94</td>
<td>30.66</td>
<td>.21.10</td>
</tr>
<tr>
<td>6</td>
<td>157.25</td>
<td>108.25</td>
<td>48.85</td>
<td>.31.09</td>
</tr>
</tbody>
</table>
faeces. Carotene excretion varied from 91.94 to 126.42 mg. There seems to be relation between excretion of carotene and age of the animal or the weight. For Calf No: 16 which took 171.1 mg. of carotene excreted 126.42 mg. This was the maximum amount of intake and excretion on 1y 94.98 mg. Calf No: 142 having more or less similar body weight and intake to that of calf No: 78, excreted 108.26 mg. of carotene. Calf No: 171 excreted 114.94 mg. of carotene even though the drymatter excretion in faeces was on ly 0.88 Kgs. The date indicates that there was no relation between excretion of carotene and excretion of dry matter.

Retention: The retention of carotene varied between 25.57 to 65.62 mg. There was considerable variation in the retention of carotene between calves. Contrary to the retention of calcium and Phosphorus, Carotene retention was un-affected by age in this experiment. Body weight also did not seem to be related in any way to the retention of carotene.

Percentage retention:

Percentage retention varied between 21.10 to 40.85%. Except for calf No: 142, calves of the older age group recorded a higher percentage retention than that for the younger age groups. The variation noticed in the retention and percentage retention of the animal of
may perhaps be due to the individual physiological difference.

Second sub-period:

Excretion: In this sub-period excretion varied between 85.34 to 117.80. The calf which excreted maximum carotene in the first sub-period, excreted maximum in this sub-period also. In this sub-period except Calf No: 78 all other calves showed a tendency to excrete lesser amount of carotene compared to the first sub-period, irrespective of the fact that the dry matter excretion was more during this sub-period. But for this, excretion between calves remained unchanged in this sub-period also.

Retention:

Since the excretion of carotene was less than that for the first sub-period the retention recorded a slight increase. The retention varied from 28.77 to 63.77 mg. Except for calf No: 78 the trend of retention was same as that for the first sub-period. Calf No: 78 recorded a slight reduction in the retention.

Percentage retention: Varied between 24.35 and 39.70%. The variation between calves seen in the first sub-period in percentage retention was slightly reduced and between sub-period no marked variation was noticed.
may perhaps be due to the individual physiological difference.

Second sub-period:

Excretion: In this sub-period excretion varied between 85.94 to 117.30. The calf which excreted maximum carotene in the first sub-period, excreted maximum in this sub-period also. In this sub-period except Calf No: 78 all other calves showed a tendency to excrete lesser amount of carotene compared to the first sub-period, irrespective of the fact that the dry matter excretion was more during this sub-period. But for this, excretion between calves remained unchanged in this sub-period also.

Retention:

Since the excretion of carotene was less than that for the first sub-period the retention recorded a slight increase. The retention varied from 28.77 to 63.77 mg. Except for calf No: 78 the trend of retention was same as that for the first sub-period. Calf No: 78 recorded a slight reduction in the retention.

Percentage retention: Varied between 24.35 and 39.70%. The variation between calves seen in the first sub-period in percentage retention was slightly reduced and between sub-period no marked variation was noticed.
Third sub-period:

Excretion: Excretion of carotene in this sub period varied from 30.23 to 112.39 mg. Calf No: 73 and 111 excreted more carotene in this sub-period. Excretion in other calves was less than first sub-period and more than second sub-period. The trend of variation between calves remained unchanged in all the three sub-periods.

Retention:

Retention in this sub-period varied between 27.66 to 58.71 mg. Retention was least in this sub-period for calf nos: 73 and 111, compared to other sub-periods. As in the case of excretion rest of the calves showed an increase in retention compared to 1st sub-period except calf No: 142 and a reduction compared to the retention in second sub-period. Between calf variation and between sub period variation for the most part were similar to that for other sub-periods. Percentage retention varied between 21.12 to 34.31%. The trend of variation between calves remained the same as for other sub-periods.

Comparative percentage retention:

Comparison of the percentage retention for
the three sub-periods is given in Table No: 4-18. Percentage retention varied from 21.12 to 40.83 percent. For calf No: 16 for which the percentage retention was 26.10, 31.15 and 34.31% for first, second and third sub-period respectively. In all the sub-period individual calves recorded some variation in the percentage retention. But the trend of variation between sub-periods remained same.

**WHOLE PERIOD:**

Table No: 4-19 shows the carotene balance for the whole of the unsupplemented feeding period.

**RETENTION:**

Retention percentage varied from 23.21 to 37.68%. The variation in retention of carotene by individual animal may be done to individual physiological variation. For want of readily available figures of other workers no comparison could be made on this point.

**SUPPLEMENTED FEEDING PERIOD.**

**CALCIUM:**

In-take, excretion in faeces, in urine, retention and percentage retention of calcium is tabulated in Table No: 4-20.

**First Sub-period:**

**Intake:** The intake of calcium varied between 49.74 gm to 51.12 gm. This intake remained same for both the sub-periods. In this period for the last sub-period, since
<table>
<thead>
<tr>
<th>Animal</th>
<th>Percentage retention in three sub-periods</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st.</td>
</tr>
<tr>
<td>78</td>
<td>40.89</td>
</tr>
<tr>
<td>16</td>
<td>26.10</td>
</tr>
<tr>
<td>111</td>
<td>25.45</td>
</tr>
<tr>
<td>171</td>
<td>21.16</td>
</tr>
<tr>
<td>142</td>
<td>31.09</td>
</tr>
</tbody>
</table>
the three sub-periods is given in Table No: 4-18. Percentage retention varied from 21.12 to 40.83 percent. For calf No:16 for which the percentage retention was 26.10, 31.15 and 34.31% for first, second and third sub-period respectively. In all the sub-period individual calves recorded some variation in the percentage retention. But the trend of variation between sub-periods remained same.

**WHOLE PERIOD:**

Table No:4-19 shows the carotene balance for the whole of the unsupplemented feeding period.

**RETENTION:**

Retention percentage varied from 23.21 to 37.68%. The variation in retention of carotene by individual animal may be done to individual physiological variation. For want of readily available figures of other workers no comparison could be made on this point.

**SUPPLEMENTED FEEDING PERIOD.**

**CALCIUM:**

In-take, excretion in faeces, in urine, retention and percentage retention of calcium is tabulated in Table No: 4-20.

**First Sub-period:**

**Intake:** The intake of calcium varied between 49.74 gm. to 51.12 gm. This intake remained same for both the sub-periods. In this period for the last sub-period, since
**TABLE NO: 4-19.**

**CAROTENE BALANCE FOR THE WHOLE OF THE UNSUPPLEMENTED FEEDING PERIOD**

(9 days)

<table>
<thead>
<tr>
<th>No.</th>
<th>Intake mg.</th>
<th>Excretion mg.</th>
<th>Retention mg.</th>
<th>% Retention</th>
</tr>
</thead>
<tbody>
<tr>
<td>78</td>
<td>1445.4</td>
<td>900.6</td>
<td>544.8</td>
<td>37.68</td>
</tr>
<tr>
<td>16</td>
<td>1539.9</td>
<td>1069.93</td>
<td>476.97</td>
<td>30.52</td>
</tr>
<tr>
<td>111</td>
<td>1108.8</td>
<td>919.96</td>
<td>288.04</td>
<td>26.04</td>
</tr>
<tr>
<td>94</td>
<td>1312.2</td>
<td>983.01</td>
<td>329.01</td>
<td>925.16</td>
</tr>
<tr>
<td>171</td>
<td>1312.2</td>
<td>983.01</td>
<td>329.01</td>
<td>925.16</td>
</tr>
<tr>
<td>142</td>
<td>1413.9</td>
<td>965.28</td>
<td>448.62</td>
<td>31.73</td>
</tr>
</tbody>
</table>
supplementation was stopped the intake remained as that for unsupplemented feeding period.

**Excretion in Faeces:** During this sub-period the excretion of calcium in faeces varied from 44.58 to 46.80 gms. between individual calves. In this sub-period the average faecal calcium excretion was about 99% of the total excretion. The variation in excretion of calcium was positively correlated to drymatter excretion. Calf No 16 which was having 1.95Kg. of drymatter in the faeces, excreted 46.80 gms. of calcium in faeces. This was the maximum excretion of drymatter and calcium in faeces among all the calves in this sub-period. All other calves excreted less drymatter and less calcium in faeces than calf No 16. Between calves the variation was limited to narrow bounds.

Compared to the unsupplemented feeding period excretion of calcium was more in the supplemented feeding period. The percentage excretion of calcium recorded a slight increase in this sub-period.

**Excretion in Urine:** The excretion of calcium in urine varied between 0.22 to 0.35 gm. The excretion of calcium in urine recorded an increase in this sub-period. This may be due to increase in the intake of calcium. The percentage excretion of calcium varied between 0.4 to 0.67 percent. Even though the actual excretion, recorded an increase the percentage excretion remained the same as that for the first sub-period. From perusal to Table No 4-6 it...
TABLE NO: 4-20.

**TABLE SHOWING THE BALANCE OF CALCIUM FOR THE TWO SUB-PERIODS (3 days each)**

<table>
<thead>
<tr>
<th>Sub-period</th>
<th>Intake</th>
<th>5th Sub-period</th>
<th>6th Sub-period</th>
<th>Total</th>
<th>Gms.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Sub-period</td>
<td>78.50</td>
<td>49.64</td>
<td>20.36</td>
<td>15.14</td>
<td>46.00</td>
</tr>
<tr>
<td>2nd Sub-period</td>
<td>51.22</td>
<td>46.60</td>
<td>0.28</td>
<td>7.90</td>
<td>10.65</td>
</tr>
<tr>
<td>3rd Sub-period</td>
<td>94.74</td>
<td>42.00</td>
<td>4.00</td>
<td>9.29</td>
<td>44.30</td>
</tr>
<tr>
<td>4th Sub-period</td>
<td>71.50</td>
<td>46.82</td>
<td>0.22</td>
<td>9.19</td>
<td>45.92</td>
</tr>
<tr>
<td>5th Sub-period</td>
<td>42.00</td>
<td>4.62</td>
<td>0.31</td>
<td>6.17</td>
<td>50.00</td>
</tr>
</tbody>
</table>
can be seen that in this sub-period the excretion of calcium in urine and the amount of liquid urine voided recorded a positive correlation. Calves of the younger age group in general showed a tendency to excrete less calcium in the urine compared to that of older group. The average excretion of the three calves of the younger age group was 0.25 gm. and that for older age group was 0.31 gm. Between groups the excretion of calcium was not related intake.

Retention: Retention of calcium in this sub period varied from 3.09 to 5.40 gm. As in the unsupplemented feeding period all calves showed a positive calcium balance. As in the unsupplemented period in this period also retention of calcium was not related to intake. Calf No:16 which is having the maximum intake of 51.12 gms. retained only 4.04 gms. whereas calf No:94 which was having the least intake of 49.74 gm. of calcium retained 4.93 gms. Calf No:78 and 142 retained 5.34 and 3.09 gm. of calcium when their respective intake of calcium was 50.45 and 50.02.

Contrary to the unsupplemented period the retention of calcium did not show any relation to age. The average retention of the calves of the younger age group was 4.23 gms. and that for the older group was 4.93 gms. The amount of retention in this period recorded an increase to that of the unsupplemented feeding period except for calf
nos: 171 and 142.

Percentage retention: The percentage retention of calcium for the first sub period varied from 6.17 to 10.62 percent. All calves recorded a reduction in percentage retention compared to the unsupplemented period indicating that added extra calcium reduced the efficiency of utilization. Individual calves did not show much variation in the percentage retention of calcium.

Second Sub-Period:

During this sub-period the intake remained same as that for the first sub-period.

Excretion in Faeces: In this sub period faecal calcium excretion varied between 42.24 and 46.37 gms. Calf No: 111 excreted maximum amount of calcium in faeces and calf No: 171 excreted least amount of 42.24 gms. The trend of variation remained the same as that for the first sub period.

Urinary Excretion: Urinary excretion varied between 0.21 to 0.42. Except for calf no: 78 and 142 increased excretion was not followed by corresponding increase in excretion of liquid urine. Excretion of calcium in the urine by individual calves was of same order as that for the previous sub-period.

Retention: Retention in this sub period varied between 3.00 to 5.25 gms. Calf Nos: 96, 171 and 142 retained more calcium in this sub-period than the first sub-period.
But calf Nos: 78, 111 and 94 showed a reduction in retention. Between sub-periods the variation in excretion remained between narrow limits. In this sub-period also age seems not to be in any way related to retention. Difference in retention may be due to individual physiological difference.

Percentage retention varied between 6.03 to 16.27% variations seen in the retention of calcium is seen in percentage retention also.

**COMPARATIVE PERCENTAGE RETENTION FOR BOTH SUB-PERIODS:**

The percentage retention of calcium in both sub periods is given in Table Nos: 4-21. During supplemented feeding period percentage retention varied from 6.03 to 11.10%. There was some variation between sub-period in the same calf.

**Whole Period:** Intake, excretion in faeces, in urine, retention and percentage retention for whole of the supplemented period (6 days) was given in Table Nos: 4-22. The date for whole sub-period eliminates the individual variation seen between sub-periods.

**Excretion in Faeces:** Excretion of calcium in faeces varied from 264.18 to 276.06 gms. Maximum amount of calcium was excreted by calf No: 111. This calf excreted 276.06 gms. when the intake of this calf was 305.04 gms. The excretion of dry matter in this calf for this period 3.52 Kg. Calf No: 16 excreted maximum dry matter of 3.30 Kg.
and in the faeces this calf excreted 275.32 slightly less than that of the calf No:111. In the supplemented feeding period calcium excretion in faeces did not seem to be related to the body weight or age.

**Excretion in Urine:** Urinary calcium excretion varied from 1.29 to 2.31 gms. Calf Nos: 78, 111 and 142 excreted 2.31, 2.07 and 2.16 gms., and calf Nos: 16, 94 and 171 excreted 1.72, 1.41 and 1.29 gms. of calcium. Except for calf No: 16 and 142 the decreased excretion in the later calves indicates that younger calves excreted slightly less amount of calcium in urine even when the intake was 298.44 and 304.2 gms.

**Retention:** Retention of calcium varied from 23.79 to 38.73 gms. Except for calf no: 78 and 171, the retention of calcium showed a positive relation with the amount of intake. Except for calf no: 171 all calves showed some degree of correlation between body weight and retention.

Calf No: 171 retained 38.73 gms. of calcium. This retention did not show any positive correlation to age, body weight or intake of calcium. This increased excretion of calcium may be due to physiological difference of the animal during this stage.

**Percentage Retention:** Percentage retention varied between 7.97 to 12.73 percent. Except for calf No:
TABLE NO: 4-21.

COMPARISON OF PERCENTAGE RETENTION OF CALCIUM IN THE TWO SUB-PERIODS OF THE SUPPLEMENTED FEEDING PERIOD

<table>
<thead>
<tr>
<th>Animal No:</th>
<th>Percentage retention during sub-periods</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First sub-period</td>
<td>Second sub-period</td>
</tr>
<tr>
<td>78</td>
<td>10.58</td>
<td>9.15</td>
</tr>
<tr>
<td>16</td>
<td>7.90</td>
<td>11.10</td>
</tr>
<tr>
<td>111</td>
<td>10.62</td>
<td>7.02</td>
</tr>
<tr>
<td>94</td>
<td>9.91</td>
<td>6.03</td>
</tr>
<tr>
<td>142</td>
<td>6.17</td>
<td>10.01</td>
</tr>
<tr>
<td>No.</td>
<td>Intake (gms.)</td>
<td>Excretion (gms.)</td>
</tr>
<tr>
<td>-----</td>
<td>---------------</td>
<td>------------------</td>
</tr>
<tr>
<td>1</td>
<td>302.7</td>
<td>270.51</td>
</tr>
<tr>
<td>16</td>
<td>306.72</td>
<td>275.82</td>
</tr>
<tr>
<td>11</td>
<td>305.04</td>
<td>276.06</td>
</tr>
<tr>
<td>94</td>
<td>298.44</td>
<td>273.24</td>
</tr>
<tr>
<td>171</td>
<td>304.20</td>
<td>264.18</td>
</tr>
<tr>
<td>142</td>
<td>300.12</td>
<td>273.66</td>
</tr>
</tbody>
</table>

TABLE NO: 4-22.

CALCIUM BALANCE FOR THE WHOLE OF THE SUPPLEMENTED FEEDING PERIOD (6 days).
all other calves showed only very little variation in percentage retention. The data indicates that the percentage retention is positively correlated to body weight.

These data when compared with that for the unsupplemented feeding period it can be noticed that irrespective of body weight and age calcium from unsupplemented feeding period was better utilized by calves. In unsupplemented period younger calves showed a better efficiency in the utilization. With increased intake of calcium even though the amount of excretion in faeces and urine was increased the percentage excretion remained the same. Increased excretion of calcium in urine in this period compared to unsupplemented feeding period indicates that with increased calcium intake, even though absorption was slightly increased the extent of absorption was reduced by the increased excretion of calcium in urine. Intake of calcium much above the requirement considerably reduces the efficiency of utilization and is merely excreted in the faeces or in the urine. Lindsey et al (1931) reported that with high calcium diet the percentage of retention and efficiency of utilization is reduced.

**PHOSPHORUS**

**First Sub-Period**

**Intake:** The phosphorus balance for the supplemented period is given in Table No:4-23. Intake of
phosphorus varied from 30.55 to 31.15 gms. Calf No: 94 had the minimum amount of phosphorus intake and calf No: 16 had the maximum amount of intake. The variation in intake was due to variation in the amount of drymater consumed. This intake remained same for both sub-periods of the supplemented feeding period.

**Excretion in Feces:** Excretion of phosphorus in faeces varied between 22.17 to 27.53 gms. The percentage of phosphorus excreted varied from 77.5 to 86%. Unlike excretion of calcium in faeces in supplemented feeding period phosphorus excretion in faeces is positively correlated to the body weight except for calf No: 111. The data indicates that excretion of phosphorus was also correlated to drymater excretion except for calf No: 111. Calf No: 111 with 31.09 gms. of intake and 1.66 kg. of drymater excretion excreted 24.90 gm. of phosphorus in faeces. Whereas drymater excretion excreted only 23.94 gms. of phosphorus in faeces.

Unlike calcium, as in unsupplemented feeding period here also calves of the younger age excreted less phosphorus in faeces compared to that of the older age group. The average excretion for the younger age group was 23.34 gms. and that for calves of the older age group was 25.5 gms.

**Excretion in Urine:** Excretion of phosphorus showed wide variation in the excretion in urine. The amount
TABLE NO: 4-23.

TABLE SHOWING THE BALANCE OF PHOSPHORUS FOR THE TWO SUB-PERIODS (THREE DAYS EACH) OF THE SUPPLEMENTED FEEDING PERIOD (gm. per day)

<table>
<thead>
<tr>
<th>Ani No:</th>
<th>Intake (gms)</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>% Retention</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>% Retention</th>
</tr>
</thead>
<tbody>
<tr>
<td>78</td>
<td>30.80</td>
<td>24.03</td>
<td>2.54</td>
<td>26.57</td>
<td>4.23</td>
<td>13.7</td>
<td>24.12</td>
<td>2.44</td>
<td>26.56</td>
<td>4.24</td>
<td>13.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>31.15</td>
<td>27.53</td>
<td>0.38</td>
<td>27.91</td>
<td>3.24</td>
<td>10.4</td>
<td>26.04</td>
<td>0.33</td>
<td>26.37</td>
<td>5.13</td>
<td>16.46</td>
<td></td>
<td></td>
</tr>
<tr>
<td>111</td>
<td>31.09</td>
<td>24.90</td>
<td>2.36</td>
<td>27.26</td>
<td>3.83</td>
<td>12.3</td>
<td>27.53</td>
<td>1.70</td>
<td>29.23</td>
<td>1.86</td>
<td>5.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>94</td>
<td>30.55</td>
<td>22.17</td>
<td>0.40</td>
<td>22.57</td>
<td>9.98</td>
<td>26.1</td>
<td>24.61</td>
<td>0.40</td>
<td>25.01</td>
<td>5.54</td>
<td>18.13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>171</td>
<td>31.00</td>
<td>23.94</td>
<td>1.35</td>
<td>25.29</td>
<td>5.71</td>
<td>18.4</td>
<td>25.54</td>
<td>1.24</td>
<td>26.78</td>
<td>4.22</td>
<td>13.61</td>
<td></td>
<td></td>
</tr>
<tr>
<td>142</td>
<td>30.64</td>
<td>24.82</td>
<td>2.37</td>
<td>27.19</td>
<td>3.45</td>
<td>11.2</td>
<td>25.86</td>
<td>2.40</td>
<td>28.26</td>
<td>2.38</td>
<td>7.76</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---
varied between 0.38 to 2.54 gms. The percentage of phosphorus excretion in urine varied from 1.5 to 8.3. This wide variation could not be accounted in the variation in the excretion of liquid urine for calf no: 16 and 111 excreted 4963 and 4963 of urine in this period but the urinary phosphorus showed a wide variation at 0.38 and 2.36 gms. respectively. Age also seems to have not reduced the amount of phosphorus excretion in urine for calf no: 94 and 142 both are in the younger age group excreted 0.40 and 2.37 gms. in the urine.

Retention:- Compared to the unsupplemented feeding period, in this period a slight increase in the retention was recorded by all calves. The retention varied between 3.24 and 7.98 gms. Unlike calcium retention for the supplemented period, phosphorus retention was correlated with age. On an average calves of the younger age group retained more phosphorus. The average retention for younger age group was 5.71 gms. and that for calves of the older age group was 3.76 gms. Calf No: 171 retained maximum amount of phosphorus. The retention of phosphorus in this period does not seem to be related with the body weight of the calves or their phosphorus intake.

Percentage Retention:- Percentage retention of phosphorus varied from 11.2 to 26.1%. In unsupplemented feeding period the percentage retention varied from 15.45
to 35.60 percent. This reduced percentage retention indicates the reduced efficiency of utilization of phosphorus. This shows that considering the intake, more phosphorus is excreted unabsorbed in this period.

**Second Sub-Period:**

**Fecal Excretion:** In this sub period, excretion of phosphorus varied from 24.12 to 27.53 gms. Except for calf no:111 all calves showed the same trend of excretion as that for the first sub-period. Calf No:111 excreted 26.04 gms. of phosphorus. This calf during this sub-period excreted more dry matter than that for the first sub-period. Calf No:78 and 142 also showed a negligible increase in the excretion of dry matter. They also showed some increase in faecal phosphorus excretion.

**Urinary Excretion:** In this sub-period also, urinary excretion varied from 0.33 to 2.44 gms. As in the previous sub-period animal No:78 excreted maximum amount of phosphorus in urine and calf No: 15 excreted minimum amount. The trend of variation remained the same as that for the first sub-period.

**Retention:** Retention of phosphorus varied from 1.36 to 5.54 gms. Calf Nos: 111, 94, 171 and 142 showed lesser in retention. In this sub period also calves of the younger age group recorded a slight increase in the retention compared to that of the calves of the older age.
group. The average retention for younger calves was 4.05 gms. and that for older calves was 3.74 gms.

**Percentage Retention:** Percentage retention of phosphorus was from 5.66 to 18.13 percent. The trend of variation remained the same as that for the first sub period.

**COMPARISON OF PERCENTAGE RETENTION FOR BOTH SUB PERIODS:**

The comparison of percentage retention of phosphorus is given in Table No: 4-24. In supplemented feeding period the percentage retention varied from 5.66 to 26.1 percent. Except calf No: 78 all other calves showed some variation, varying from 3.5 to 8.00 gms. in percentage retention between sub-periods. The average percentage retention for calves of the younger age group was 15.7, that for older group was 12.02 percent.

**Whole Period:** Phosphorus balance for the whole period of the supplemented feeding period is given in Table No: 4-25.

**Excretion in Faeces:** Excretion in faeces varied from 140.34 to 160.71 gms. Except for calf no: 111 the phosphorus retention was related to drymatter excretion.

**Excretion in Urine:** Excretion in urine varied from 2.13 to 14.94 gms. The trend of variation seen in urinary phosphorus excretion was same as that for the other sub period.
TABLE NO: 4-24.

COMPARISON OF THE PERCENTAGE RETENTION OF PHOSPHORUS FOR BOTH THE SUB-PERIODS OF THE SUPPLEMENTED FEEDING PERIOD.

<table>
<thead>
<tr>
<th>Ani. No.:</th>
<th>% Retention during sub - periods</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>First sub period</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td>78</td>
<td>13.7</td>
</tr>
<tr>
<td>16</td>
<td>10.4</td>
</tr>
<tr>
<td>111</td>
<td>12.3</td>
</tr>
<tr>
<td>94</td>
<td>26.1</td>
</tr>
<tr>
<td>171</td>
<td>18.4</td>
</tr>
<tr>
<td>142</td>
<td>11.2</td>
</tr>
</tbody>
</table>
### TABLE NO: 4-25

**PHOSPHORUS BALANCE FOR THE WHOLE OF THE SUPPLEMENTED PERIOD**

*(6 days)*

<table>
<thead>
<tr>
<th>Ani. No</th>
<th>Intake (gms)</th>
<th>Excretion (gms)</th>
<th>Retention</th>
<th>Percentage Retention</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Faeces</td>
<td>Urine</td>
<td>Total</td>
</tr>
<tr>
<td>1 78</td>
<td>184.80</td>
<td>144.45</td>
<td>14.94</td>
<td>159.39</td>
</tr>
<tr>
<td>16</td>
<td>186.90</td>
<td>160.71</td>
<td>2.13</td>
<td>162.84</td>
</tr>
<tr>
<td>11</td>
<td>186.54</td>
<td>157.29</td>
<td>12.18</td>
<td>169.47</td>
</tr>
<tr>
<td>194</td>
<td>183.30</td>
<td>149.30</td>
<td>2.40</td>
<td>142.74</td>
</tr>
<tr>
<td>171</td>
<td>186.00</td>
<td>148.44</td>
<td>7.77</td>
<td>156.21</td>
</tr>
<tr>
<td>142</td>
<td>183.84</td>
<td>152.04</td>
<td>14.31</td>
<td>166.35</td>
</tr>
</tbody>
</table>
Retention:— The retention of phosphorus varied from 17.49 to 40.56 gms. The calves of the younger age group retained more phosphorus than that of the older age group. The average retention for the younger age group was 29.28 gms. and that for the older age group was 22.11 gms. for six days. Compared to the supplemented unsupplemented feeding period all calves recorded an increase in phosphorus retention in this period.

Percentage Retention:— Percentage retention of phosphorus varied from 9.50 to 22.10 percent. In the unsupplemented feeding period percentage retention varied from 15.91 to 30.18 percent. This clearly shows that the extra phosphorus added to the ration was less well utilized, by all calves as in the case of calcium.

CAROTENE:—

First Sub. Period:—

Intake:— Intake of carotene varied from 193.2 to 246.1 mg. This variation was due to variation in the intake of green roughage.

Excretion:— Excretion of carotene varied from 155.95 to 189.74 mgr. Except in calf no: 111 all other calves showed a positive relation between excretion of carotene and excretion of dry matter. For example calf no: 16 had the maximum amount of dry matter excretion in this sub-period and this calf excreted 189.74 mg. of carotene in faeces. This
**TABLE NO: 4-26.**

**TABLE SHOWING THE BALANCE OF CAROTENE FOR TWO SUB-PERIODS (3 day each) OF THE SUPPLEMENTED FEEDING PERIOD (mg. per day).**

<table>
<thead>
<tr>
<th>Ani: No.</th>
<th>First sub-period</th>
<th>Second sub-period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intake</td>
<td>Excretion</td>
</tr>
<tr>
<td></td>
<td>mg.</td>
<td>(mg.)</td>
</tr>
<tr>
<td>78</td>
<td>235.6</td>
<td>165.00</td>
</tr>
<tr>
<td>16</td>
<td>246.1</td>
<td>189.74</td>
</tr>
<tr>
<td>11</td>
<td>198.2</td>
<td>155.95</td>
</tr>
<tr>
<td>94</td>
<td>193.2</td>
<td>158.32</td>
</tr>
<tr>
<td>42</td>
<td>232.1</td>
<td>175.75</td>
</tr>
<tr>
<td>171</td>
<td>220.8</td>
<td>176.06</td>
</tr>
</tbody>
</table>
was the maximum amount.

**Retention:** In this sub period retention varied from 34.33 to 70.60 mg. Between calves there was much variation in the retention. Compared to unsupplemented feeding period calves recorded an increase in retention with supplemented feeding. But the percentage retention was much lower than that for the unsupplemented feeding period. The percentage retention varied from 18.05 to 29.96.

**Second SubPeriod:**

The intake of carotene was the same as that for other sub-period.

**Excretion:** Excretion in this period varied from 153.73 to 195.79 gms. The trend of between calves variation was same for the other period.

**Retention:** The amount of retention in this sub period showed similar variations as in the other sub period and not much variation was recorded between sub periods. Retention varied from 36.45 to 67.47 mg. Percentage retention also showed the same trend of variation between sub periods and between animals as that for the first sub period.

Carotene balance whole of the period is given in Table No:4-28. This Table clearly shows that even though retention was more than that for unsupplemented
<table>
<thead>
<tr>
<th>Period</th>
<th>1st sub-period</th>
<th>2nd sub-period</th>
</tr>
</thead>
<tbody>
<tr>
<td>No: 1</td>
<td>78 96</td>
<td>66 58</td>
</tr>
<tr>
<td>No: 2</td>
<td>76 21.32</td>
<td>94 18.05</td>
</tr>
<tr>
<td>No: 3</td>
<td>94 24.30</td>
<td>26 08</td>
</tr>
</tbody>
</table>
feeding period, all the calves utilized only less amount of carotene provided as supplement, reducing the efficiency of utilization. This indicates that smaller amounts of carotene will be better utilized by animals.

Percentage Retention of Supplemented Nutrients:

Table Nos: 4-32, 33 and 34 shows the amount of supplementation, retention without and with supplement, excess retention due to supplementation and also the percentage retention from the supplements with calcium, phosphorus and carotene respectively.

All the three nutrients showed a less percentage retention from supplements when compared to unsupplemented period. This reinstates the previous contention that the extra nutrients provided to the animal were less utilized.

Lindsey et al (1931) showed that with high calcium diet, when the intake was 35, 43 and 57 gms. of calcium, one year calves retained 27.2%, two year calves 16.6% and three years calves retained 12.5% respectively. The amount of retention was 9.5, 7.3 and 7.1 gms. respectively. Whereas with low calcium diet the same calves retained 27.6, 20.5 and 17.5% of calcium when the intake was 17, 20 and 27 gms. respectively. The amount of calcium retained was 4.8, 4.1 and 4.7 gms. These results show that efficiency of utilization was increased with
lesser amount of dietary calcium than with greater amounts. The observations made in this experiment agrees with the observation made by Lindsey et al.

Archibald and Bennet (1935) reported the same observation with phosphorus. With high dietary phosphorus first, second and third year calves retained 31.1, 24.5 and 15.3% of phosphorus. But with low phosphorus diet the same calves retained 40.6, 32.1 and 27.1%.

Baumann and Riising (1934) showed that small amounts of Provitamin A was better utilized by calves than large amounts. Nyardes et al (1954) reported that the efficiency of utilization was less when carotene was supplied in excessive amounts. All these observations indicate that the efficiency of utilization of calcium phosphorus and carotene was reduced when they are supplied in excessive quantities.

The observations made in this study shows complete agreement with the conclusions made by various authors shown above.

**Balance of Calcium, Phosphorus and Carotene During Supplemented Feeding Period After Discontinuing the Supplementation**

A further three days collection of faeces and urine was made after discontinuing supplementation to study the carry over or residual effect of these
### TABLE No: 4-29.

**Calcium Balance for the Third Sub-Period of the Supplemented Feeding Period After with Holding Supplementation (gm. per day)**

<table>
<thead>
<tr>
<th>Ani. No.</th>
<th>Intake (gms)</th>
<th>Excretion (gms.)</th>
<th>Total</th>
<th>Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Faeces</td>
<td>Urine</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>78</td>
<td>21.38</td>
<td>37.04</td>
<td>0.30</td>
</tr>
<tr>
<td>16</td>
<td>22.02</td>
<td>40.40</td>
<td>0.23</td>
<td>40.63</td>
</tr>
<tr>
<td>111</td>
<td>19.20</td>
<td>43.10</td>
<td>0.31</td>
<td>43.41</td>
</tr>
<tr>
<td>94</td>
<td>18.95</td>
<td>39.00</td>
<td>0.23</td>
<td>39.23</td>
</tr>
<tr>
<td>171</td>
<td>20.77</td>
<td>35.04</td>
<td>0.24</td>
<td>35.29</td>
</tr>
<tr>
<td>142</td>
<td>21.34</td>
<td>40.70</td>
<td>0.31</td>
<td>41.01</td>
</tr>
</tbody>
</table>

### TABLE No: 4-30.

**Phosphorus Balance for the Third Sub-Period of the Supplemented Feeding Period After with Holding Supplementation.**

<table>
<thead>
<tr>
<th>Ani. No.</th>
<th>Intake (gms)</th>
<th>Excretion (gms.)</th>
<th>Total</th>
<th>Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Faeces</td>
<td>Urine</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>78</td>
<td>9.32</td>
<td>22.06</td>
<td>2.00</td>
</tr>
<tr>
<td>16</td>
<td>9.60</td>
<td>20.85</td>
<td>0.37</td>
<td>21.22</td>
</tr>
<tr>
<td>111</td>
<td>8.28</td>
<td>22.30</td>
<td>1.75</td>
<td>24.05</td>
</tr>
<tr>
<td>94</td>
<td>8.15</td>
<td>21.80</td>
<td>0.43</td>
<td>22.23</td>
</tr>
<tr>
<td>171</td>
<td>9.01</td>
<td>20.24</td>
<td>1.30</td>
<td>21.54</td>
</tr>
<tr>
<td>142</td>
<td>9.25</td>
<td>21.07</td>
<td>1.77</td>
<td>22.84</td>
</tr>
</tbody>
</table>
**TABLE NO: 4-31.**

CAROTEN BALANCE FOR THE THIRD SUB-PERIOD
OF SUPPLEMENTED FEEDING PERIOD AFTER WITH
HOLDING SUPPLEMENTATION (mg. per day).

\[
\begin{array}{cccc}
\text{Ani. No.} & \text{Intake (mg.)} & \text{Excretion (mg.)} & \text{Balance (mg.)} \\
1 & 2 & 3 & 4 \\
78 & 160.6 & 172.73 & -12.13 \\
16 & 171.1 & 185.22 & -14.12 \\
111 & 123.2 & 134.15 & -10.95 \\
94 & 118.2 & 131.54 & -13.34 \\
171 & 145.8 & 160.92 & -15.12 \\
142 & 157.1 & 171.83 & -14.73 \\
\end{array}
\]
nutrients in excretion and retention after stopping supplementation. Table Nos: 4-29, 4-30 and 4-31 shows the data of this last sub-period for calcium, phosphorus and carotene respectively.

All the calves in all the nutrients recorded a negative balance indicating that the excretion of these nutrients were more than their intake.

In the case of calcium the negative balance varied from 14.52 to 24.21 gms, that for phosphorus varied from 11.62 to 15.77 gms, and for carotene the negative balance varied from 10.85 to 15.12 mg.

The huge negative balance for all the nutrients would work out to be much lower when the total intake is corrected by taking into account, the supplementation on the sixth day of the collection period, a day before the commencement of this sub-period. It is an established physiological fact that feeds or nutrients fed on any day will be excreted during the next 36 hours or more. As such the samples of faeces collected on the first day of this sub-period would definitely reflect on the supplementation done on the previous day and even on the day before. Taking this factor into account and considering the intake of the previous day only, the recalculated balance data for calcium of an individual animal for the whole period is given below:-
<table>
<thead>
<tr>
<th>Animal</th>
<th>Corrected daily amount of</th>
<th>Excretion in (gms)</th>
<th>Balance (gms)</th>
<th>Balance/day (gms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>78</td>
<td>50.5 +</td>
<td>21.4 +</td>
<td>370 x 3</td>
<td>-17.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5.9</td>
</tr>
<tr>
<td></td>
<td>21.4</td>
<td></td>
<td></td>
<td>111.0</td>
</tr>
</tbody>
</table>

The above smaller negative (5.9 from 15.96) would even be converted to positive balance by taking 50% of the intake of the next previous day. The above reasoning holds equally well for phosphorus and carotene as well.

Validity of the Balance Data Observed in the First and Second Sub-Period:

The validity of the balance data could not be doubted due to the following points:

The supplements in question was fed to the animal for nine days prior to collection period and six days during collection day period. Any deposition of this nutrients in the gut would have shown a high positive balance because the excretion of these minerals will be less even though they are not absorbed. But such a phenomena was not noticed from the results.

Another effect of the deposition would be to show a reduction in the positive balance after continued
feeding of these nutrients. This is because a part of the nutrients deposited in the gut will be later on excreted along with the faeces. This increased excretion when compared with the intake will be more than that was previously observed.

The results of the supplemented period does not show any increase, between sub period giving no chance to suspect the first phenomina.

The second phenomina is also ruled out due to the fact that between sub-periods there was no reduction in retention.
### TABLE NO: 4-32.

**TABLE SHOWING THE PERCENTAGE RETENTION OF SUPPLEMENTED CALCIUM (6 days) average.**

<table>
<thead>
<tr>
<th>No.</th>
<th>Amount of Supplementation (gms.)</th>
<th>Retention without supplementation (6 days) (gms.)</th>
<th>Retention with supplementation (6 days) (gms.)</th>
<th>Excretion (gms.)</th>
<th>Percentage of retention from supplements.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2174</td>
<td>21.21</td>
<td>29.88</td>
<td>8.67</td>
<td>4.98</td>
</tr>
<tr>
<td>16</td>
<td>174</td>
<td>15.09</td>
<td>29.16</td>
<td>14.07</td>
<td>8.08</td>
</tr>
<tr>
<td>111</td>
<td>174</td>
<td>9.57</td>
<td>26.91</td>
<td>17.34</td>
<td>9.90</td>
</tr>
<tr>
<td>94</td>
<td>174</td>
<td>20.01</td>
<td>23.79</td>
<td>3.78</td>
<td>2.17</td>
</tr>
<tr>
<td>171</td>
<td>174</td>
<td>27.39</td>
<td>38.73</td>
<td>11.34</td>
<td>6.50</td>
</tr>
<tr>
<td>142</td>
<td>174</td>
<td>22.74</td>
<td>24.30</td>
<td>1.56</td>
<td>0.90</td>
</tr>
<tr>
<td>No.</td>
<td>Amount of Supplementation (gms.)</td>
<td>Retention with Supplementation</td>
<td>Excess of Retention</td>
<td>Percentage of Retention from Supplement.</td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>---------------------------------</td>
<td>-------------------------------</td>
<td>---------------------</td>
<td>------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>7.8</td>
<td>25.61</td>
<td>11.67</td>
<td>24.72</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>129.00</td>
<td>16.26</td>
<td>8.94</td>
<td>6.90</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>129.00</td>
<td>24.06</td>
<td>5.20</td>
<td>4.03</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>129.00</td>
<td>13.20</td>
<td>27.36</td>
<td>4.67</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>129.00</td>
<td>11.67</td>
<td>13.74</td>
<td>3.39</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>129.00</td>
<td>15.15</td>
<td>17.49</td>
<td>1.74</td>
<td></td>
</tr>
</tbody>
</table>

TABLE SHOWING THE PERCENTAGE RETENTION OF SUPPLEMENTED PHOSPHORUS
<table>
<thead>
<tr>
<th>Ani. No:</th>
<th>Amount of supplementation (mg.)</th>
<th>Retention without supplementation (mg.)</th>
<th>Retention with supplementation (mg.)</th>
<th>Excretion retention (mg.)</th>
<th>Percentage retention from supplement.</th>
</tr>
</thead>
<tbody>
<tr>
<td>78</td>
<td>450</td>
<td>388.17</td>
<td>414.21</td>
<td>26.04</td>
<td>5.7</td>
</tr>
<tr>
<td>16</td>
<td>450</td>
<td>293.94</td>
<td>320.01</td>
<td>26.07</td>
<td>5.70</td>
</tr>
<tr>
<td>111</td>
<td>450</td>
<td>205.86</td>
<td>260.16</td>
<td>54.30</td>
<td>12.00</td>
</tr>
<tr>
<td>94</td>
<td>450</td>
<td>163.02</td>
<td>213.99</td>
<td>50.97</td>
<td>10.1</td>
</tr>
<tr>
<td>171</td>
<td>450</td>
<td>213.93</td>
<td>276.24</td>
<td>62.31</td>
<td>13.8</td>
</tr>
<tr>
<td>142</td>
<td>450</td>
<td>304.32</td>
<td>350.67</td>
<td>46.35</td>
<td>10.3</td>
</tr>
</tbody>
</table>
To study the rate of absorption and retention of extra dietary calcium, phosphorus and carotene in Tharparkar calves, two balance experiments were conducted with six calves. One experiment was conducted to assess the normal retention of calcium, phosphorus and carotene from usual ration. The other balance trial was conducted with excess quantities of calcium, phosphorus and carotene. The supplementation was made in such a manner to provide all calves not less than twice the requirement of the calcium, phosphorus and carotene, as per Morrison Feeding Standard.

Calcium and phosphorus was estimated in feeds faeces and urine by A.O.A.C. method modified by Talapatra and carotene was estimated by the method suggested by Majumder and Gupta.

Daily samples of faeces was analysed for carotene and three days average results were treated as the data for a single day. Three days pooled samples of faeces and urine was used for estimation of calcium and phosphorus for both unsupplemented feeding period and supplemented feeding period.
In the excretion of moisture a negative correlation between the amount of urine and the drymatter in faeces voided was seen.

In the unsupplemented feeding period some variation was noticed between animals and between sub periods in the excretion of drymatter in faeces. In the supplemented feeding period all calves excreted more drymatter in faeces, compared to the other period and the excretion of urine also was more during supplemented feeding period. Dry matter excretion was about 1% of the body weight.

Major part of calcium and phosphorus was excreted in faeces and only a negligible part was excreted in urine. Compared to calcium more phosphorus was excreted in urine. Carotene was excreted through faeces only.

In the unsupplemented feeding period when the intake of calcium was between 18.95 to 22.02 gm. the retention varied between 1.39 to 6.21 gm. The percentage retention varied between 7.24 to 29.90 percent.

Younger animals showed more retention than older animals. The calves of the younger age on an average retained 3.69 gm. and older calves retained on
an average 2.64 gm. of calcium.

Phosphorus retention varied from 1.4 to 3.24 gm. and the percentage retention was between 15 to 35%.

In case of phosphorus also younger calves showed a better retention. Younger calves retained 2.21 and older calves retained 1.87 gm. of phosphorus.

Carotene retention varied from 27.44 to 60.5 mg. The retention of carotene did not show any relation to age.

In the supplemented feeding period the calcium intake varied between 49.74 to 51.12 gm. Even though the retention showed a slight increase, percentage retention was reduced in supplemented feeding period indicating a reduction in the utilization.

Younger animals did not retain more calcium compared to older ones. The retention varied between 3.96 to 6.45 gm. and the percentage retention varied between 7.07 to 16.2 percent.

Retention of phosphorus also showed the same trend. Retention varied between 1.36 to 7.9 gm. and percentage retention varied between 7.7 to 26 percent.

Younger calves showed more retention of
phosphorus than older calves as in the unsupplemented feeding period.

Carotene also recorded increased retention with supplementation but the percentage retention was reduced.

All calves recorded a reduced efficiency in utilizing the supplemented nutrients.

Evidence was obtained that the supplemented calcium and phosphorus were not precipitated and retained inertly in the rumen.
REFERENCE

Ahmad, B & Malik, K (1933)


J. Agric. Sc. 42: 337.

Bacharach, A.L. (1950)
 Analyst. 75: 568.


Basu, K.P. and De, H.N. (1945)

J. Biol. Chem. 107: 705.

J. Biol. Chem. 95: 29.


J. Dairy Sci. 27: 360.

J. Dairy Sci. 41: 514.
Brune, H. and Kudlich, J. (1959)
Nut. Abs. Rev. 29: 851
Brown, E. F. and Morgan, A. F. (1948)
Bruninghaus, C. (1935)
Ztscher. Schweinezuchet. Chem. 32: 221
Bunge, G. (1873)
Z. Bio. 2: 104.
Cayle, J. (1935)
Le Progremu de medicine 43.
Cowell (1937)
Biochem. J. 50: 95.
J. Vac. Sci. 12910.
J. Dairy Sci. 38: 627.
Crowley, J. W. and Allen, M. N. (1953)
J. Dairy Sci. 36: 156.
Dallemane, M. J., Fabry, C. and Bedson, F. (1955)
Experimentia 11: 143.
Dorothy, L. and Duncan (1958)
:: iii ::

DuToit, P.J. and Green H.H. (1932)


Dutt. B. Majumdar, B.N. and Kehar, N.D. (1959)


Eaton, H.D. and Matterson, L.D. (1951)

J. Dairy Sci. 34: 1073.

Eaton, H.D., Myers, G.S., Dicks, M.W., Debority, B.A., Grifo, A.P.,
Teichman, R. Heimboldt, E.F., Jungeheer, E.L. and
Gosslee, D.G. (1959)


Eaton, H.D. Heimboldt, C.F., Avampato, J.E., Jungeheer, E.L.
and Dolge, K.L. (1952)

J. Dairy Sci. 35: 607.


Ganguly, J., Mehl, J.W. and Dstul, H.J. (1953)

J. Nutrition. 50: 487.

Garg, R.P. (1962)

M.S. thesis submitted to Agra University.

Gilbert, H.R., Hurt, G.H. and Hughes, E.H. (1937)


Gilbert, H.R. and Hurt. (1937)


Gilbert, H.R., Miller, R.F. and Hughes, E.H. (1936)


Giri, K.V. (1940)


Goodwin, T.W. (1948)

Biochemical J. 42: XLIII.

Goodwin, T.W. and Wilson, A.A. (1951)


Haag, J.R., Jones, I.R. & Brandt, B.M. (1933)


LEIBSCHNER, W. (1932) Biologia generalis 1: 227

LENKEIT, W. and Duppe (1940) J. Landwirtsch. 87: 298.


J. Dairy. Sci. 35: 283.

Majumder, B.N. & Gupta, B.N. (1960)

Martston, H.R. and Lines, E.W.L. (1934)

Maynard, L.A. (1932)


McGillivray, W.A. (1959)
Mut. Abs. revi. 29: 1399.

Mellam by E.D. (1943)
J. Phy. 101: 408.


Majumder, B.N. and Gupta, B.N. (1960)

Meyeri, A.E. & Greenberg, J. (1949)


J. Biol. Chem. 178: 345.

Mitchell, M. (1947)
J. Ani. Sci. 6: 356.

Morgan, A.P. & Arnrich, L. (1953)

Nezvesky (1949)
Nicolaysen, R. Tunes, F. R. M., Albright, F. and Susulkowitch (1937)


Union South Africa. 703-732.


Outhouse, J; Smith, J., and Towney, J. (1938)
J. Nutrition. 15: 257.

Palmer, L. S. Eckles, C. H. and Schutte, D. J. (1928)

Reid, J. T., Pflue, K. O. Salisbury, P. L. & Bender (1946)

Repp, H. W. and Watkins, W. B. (1958)

J. Biochem. 76: 84.

Rocha, J. and Mourgue, M. (1943)

Ross, O. B. & Gallup, W. D. 1949.
J. Animal Sci. 8: 628.

Rassenburg, H. R. (1943)
Chemistry and Physiology of Vitamins by Rassenburg (1943).

Rousseau, J. E. (1954)

Rousseau, J. E. Trichman, R., Eaton, H. D., Micks, H. W., Delge, K. L.,


Wise, C.F., John, W., Mehel & Danel, R.J. (1947)