ICAR
NETWORK PROGRAMME ON MICRONUTRIENTS IN ANIMAL NUTRITION AND PRODUCTION

THRISSUR CENTRE

ANNUAL PROGRESS REPORT
(1.4.2000 To 31.3.2001)

DEPARTMENT OF ANIMAL NUTRITION
COLLEGE OF VETERINARY AND ANIMAL SCIENCES
KERALA AGRICULTURAL UNIVERSITY
MANNUTHY-680 651, THRISSUR

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PROGRESS REPORT

1.	**Project Title**	:	Network Programme on Micronutrients in Animal Nutrition and Production.
2.	**Sanction No. & Date**	:	F.No. 29-1/93 ASR II dt. 30th May 1994 F.No. 29-1/97 ASR II dt. 1st October 1997 F.No. 29-1/97 ASR II dt. 15th May 1998 F.No. 29-1/97 ASR II dt. 17th August 1998 and F.No. 29-1/97 ASR II dt. 6th May 1999 of ICAR
3.	**Report Period**	:	**1-4-2000 to 31-3-2001** [VIII Plan- 4-11-94 to 31-3-97 and IX Plan 1-4-97 to 31-3-2000]
4.	**Date of Start**	:	4-11-1994
5.	**Date of Termination**	:	Sanction has been accorded by the ICAR for the continuance of the Project for the IX th plan period (From 1-4-97 to 31-3-2002)
6.	**a) Name of Institution**	:	College of Veterinary and Animal Sciences, Kerala Agricultural University, Mannuthy, Thrissur.
	b) Division/ Department/ Section	:	Department of Animal Nutrition, College of Veterinary and Animal Sciences, Kerala Agricultural University, Mannuthy, Thrissur.
	c) Location of Work	:	Department of Animal Nutrition, College of Veterinary and Animal Sciences, Mannuthy, Thrissur.

7. Technical Personnels

Name	Post sanctioned	Date of Joining	Date of lean
1. Dr. P. Gangadevi Associate Professor and P.I	Assistant Scientist	9-11-94	Till date
2. Smt. P.N. Madhavi (Farm Assistant)	Lab Technician	20-6-96	23-6-99
Mr. N. M. Surendran (Farm Assistant)		24-6-99	Till date
3. Smt. K.V. Thressia	Lab Attendant	4-11-94	31-5-95
Smt. P.K. Rosy		1-06-95	Till date
4. Sri. K.V. Kumaran	Jeep Driver	17-3-95	Till date
5. Sri. Dileep Kumar P.	Junior Research Fellow	4.10.2000	Till date

8. Total Outlay : VIII plan 31.32 lakhs
IX plan 73.39 lakhs

9. Fund allocation and Expenditure

Period- 8th Plan Period [4-11-94 to 31-3-97]

The allocation of fund to plan period are as follows (Rs in lakhs)

Period	ICAR Share	KAU Share	Total	Amount Released (Rs in Lakhs) from ICAR
1994-'95	13.18	4.39	17.57	3.6
1995-'96	4.69	1.56	6.25	10.25
1996-'97	5.62	1.88	7.50	3.63
Total	23.49	7.83	31.32	17.48

Total amount spent (Rs. in Lakhs)

Item	1994-'95	1995-'96	1996-'97	Total
Pay and Allowances	0.07057	1.79325	2.26336	4.12718
Travelling Allowances	—	—	0.05854	0.05854
Recurring contin-Gencies	0.06410	1.63892	0.85009	2.55311
Non-recurring contingencies	—	12.18697*	—	12.18697
Total	0.13467	15.61914	3.17199	18.9258

* Amount revalidated from '94-'95 allotement.

Total amount sanctioned (Rs in Lakhs)	Amount spent (Rs. in Lakhs)
31.32	18.9258

Fund allocation and expenditure during 9th plan are as follows

Period	ICAR Share	KAU Share	Total	Amount Released (Rs. in Lakhs) from ICAR
1997-'98	8.62	2.88	11.40	4.27
1998-'99	13.12	4.38	18.00	6.75
1999-2000	15.19	5.06	20.25	
2000-2001	9.30	3.10	12.40	
2001-2002	8.80	2.94	11.74	
Total	55.03	18.36	73.39	

Item wise Allocation and Expenditure

Item	1997-1998 Sanctioned (Rs. in lakhs)	1997-1998 Spent (Rs. in lakhs)	1998-1999 Sanctioned (Rs. in lakhs) 1-4-98 to	1998-1999 Spent (Rs. in lakhs) 31-3-99
Pay and Allowances	5.00	2.97112	6.00	3.61340
T.A.	0.40	0.05298	1.00	0.14465
Recurring - contingencies	6.00	1.39796	11.0	2.75899
Total	11.40	4.42206	18.00	6.51704

Item wise allocation and expenditure

Item	1999-2000 Sanctioned Amount (Rs. in Lakhs) 1-4-99 to 31-3-2000	Spent Amount (Rs. in Lakhs) 1-4-99 to 31-3-2000
Pay & Allowances	6.00	4.65543
T.A	0.50	0.36045
Recurring Contingencies	11.00	2.11959
* Non recurring contingencies		
Equipments	4.75	-
Works	1.00	-
Total	20.25	7.13547

* Since the amount of Rs 5.75 sanctioned under NRC could not be utilized request has been made to ICAR for the revalidation to 2000-2001. In addition as per letter No. 29-2/94-ASR II dt.11/9/2000 of ADG (AN&P) ICAR approval was given for the purchase of two units of block digestion system and computer at a total cost of Rs 2.5 lakhs during the year 2000-2001 by meeting the expenditure from the overall savings available during the year 1999 - 2000 and action has been initiated for effecting the purchase before 31st March 2001. Accordingly one MMPC with accessories including Scanner and CDRW, and two units of block digestion systems were purchased during the year 2000-2001.

Item	2000-2001 Sanctioned Amount (Rs. in Lakhs) 1-4-2000 to 31-3-2001	Spent Amount (Rs. in Lakhs) 1-4-2000 to 31-3-2001
Pay & Allowances	4.00	7.58068
T.A	0.40	0.01170
Recurring Contingencies	8.00+2.5	7.30762
*Non recurring contingencies		
Equipments	4.75	-
Works	1.00	-
Total	20.65	14.90000

*Revalidated to 2001-2002

10. Total number of man months : 9.33

11. Objectives of 8th Five Year Plan

1. Survey of trace element deficiencies in different regions of the country.

2. To estimate the requirements of certain trace elements for different livestock and poultry
for which the standards are unknown.

3. To record clinical or subclinical syndromes through balance studies or experimenting
on production traits.

4. Estimating the levels of certain anti-metabolites in feeds and fodder such as oxalic acid, tannic acid etc.

5. To record the toxicity in certain areas as a result of certain trace elements excesses and investigating antidote treatments for the same.

12. Approved technical programme for each centre during VIIIth plan.
(Vide annexure IV of ICAR Order No. 29-1/93 ASR II dt. 30th May 1994)

i) Each centre will carry out a bench mark survey to assess the situation and the present condition of the live stock feeding. This should help in collecting feed and fodders and concentrate samples. In addition to this, the blood and tissue samples from various slaughter houses will be collected to estimate the mineral level in respect of sample. The deficiency symptoms, if any, would be recorded.

ii) Estimation of trace elements in feeds and fodders obtained by random sampling from organised and private farms located in different parts of the regions should be done.

iii) Estimation of total dietary intake of minerals by livestock and relationship with soil types and feed and fodder should be conducted.

iv) Estimation of Ca, P, PBI, Haemoglobin, Fe, Mg. Cu, Zn, Mb in the whole blood or plasma and liver sample (if possible) of growing and lactating cows and buffaloes, sheep and pigs from organised/ private farms obtained by random sampling from different agroclimatic areas shall be made.

v) Estimation of some trace minerals in tissues obtained from slaughter houses shall also be made. Analysis of wool and hair for Zn and Se shall be made.

vi) Estimation of tannins and oxalates in unconventional feeds shall be made.

vii) Estimations of availability of different minerals to growing and lactating cattle and buffaloes using common rations should be studied.

viii) Based on the information collected in the previous years, specific metabolic trials should be conducted to examine the effect of trace elements on specific clinical and sub-clinical problems. This should include the slaughter experiments to examine various tissues like liver and other organs for the distribution of the trace elements.

ix) Suitable mineral mixtures should be developed for specific regions depending on the various existing problems and extensive trials should be conducted on various farms for wide scale use.of such elements.

x) The interaction of various minerals with respect to their metabolic activity should be examined with various categories of animals with special reference to their physiological status. The effort should be made to study the absorption of minerals from the soil and their utilization by the animals and their distribution in various organs in their body including milk and meat.

13. Technical Programme set for 8th Five Year plan

Vide F.No.29-1/96-ASR-II dated 3rd March 1999 of ICAR

1. To carry out bench mark survey.
2. To estimate trace elements in feeds and fodders.
3. Estimation of total dietary intake of minerals.
4. Estimation of Ca, P, PBI, haemoglobin, iron, Mg, Cu, Zn in whole blood/plasma, liver and tissue samples of live stock.
5. Estimation of trace elements in tissues, wool and hair.
6. Estimation of tannins and oxalate in unconventional feeds.

14. Objectives of the 9th Five Year Plan

Following objectives for the 9th plan were finalized in the Review Meeting held on 23rd October 1998 at Bombay Veterinary College, Mumbai.

1. To assess the micronutrient availability to Livestock in various agroclimatic zones of India.

2. Qualitative and quantitative assessment of the micronutrient status in the rural situations.

3. To formulate mineral and trace element supplements and also to suggest alternate sources of minerals in different categories of animals.

4. To assess the bioavailability of micronutrients in relation to milk, meat, egg production and reproduction in different categories of livestock under different eco-regions of the country.

15. Progress of Work

The State of Kerala has a total geographical area of 38.86 Lakhs hectares which is located between 8°-18' and 12°-48' North latitude and between 74°-52' and 77°-22' East longitude. The total area has been arbitrarily divided into Low land area which covers about 3.98 Lakh hectares, Midland area (16.23 Lakh hectares) and High land area of 18.65 Lakh hectares. Average annual rain fall in Kerala is 3125 mm. Average livestock population as per 1996 census is 5576917 as against 5501283 in the 1987 census which shows an increase of 1.38 % over the previous census. The average milk production (93-94) is 20.01 Lakh tonnes which has increased to 22.58 lakh tonnes in 1996-1997. According to 1996-1997 census, the main species of livestock found in the State are Cattle, Buffaloes, Goats and Pig. Among the livestock Cattle formed the largest share with 60.90 %, buffaloes- 2.96 % and goats 33.36 % and other livestock - 2.79 %.

The cattle population in 1996 - 1997 census has a slight decline of 0.81 % against the increase of 10.57 % noticed in 1987. Total number of buffaloes decreased to 49.82 % where as the goats increased by 17.71%. The largest number of livestock is found in Palakkad district followed by Malappuram and the least in wayanad. The average density of livestock population in the state is 143 with the highest livestock density in Thiruvananthapuram (214) and the lowest in Idukki. It is seen that more than 91% of the total livestock is concentrated in the rural areas of the state and the highest concentration of livestock in rural areas is noted in Wayanad-(99%). [Livestock census - 1996-1997].

The project entitled "Network programme on micronutrients in Animal nutrition and production" meant for the 8th plan period (1992-97) started functioning in the Department of Nutrition, College of Veterinary and Animal Sciences, Kerala Agricultural University, with effect from 4-11-1994. There was much delay in the filling up of sanctioned posts . Though the post of Assistant Scientist was filled up in time a Farm Assistant was posted against the post of Lab Technician only with effect from

20-6-1996 (over one and half years). A jeep was provided to the scheme with effect from 25-4-1995. All the sanctioned equipments were purchased without much delay. As regards the equipments sanctioned to the scheme, modification of the existing Atomic Absorption Spectrophotometer (Model 2380) with new Model No. AAS-3110 and accessories could be effected in February 96 and purchase of Fluorine analyser in August 1996. Later a Computer (Model - 486) with Printer and UPS was sanctioned to the Project and purchased in 1997 March.

The equipment Atomic Absorption Spectrophotometer Model-AAS-3110 of the project had gone out of function since November 1998. Action had been initiated for the repair work through the office of Dean, College of Veterinary and Animal Sciences, Mannuthy by importing spares from PERKIN ELMER since its repair is inevitable for carrying out the project work.

Repair of AAS 3110 of the project was effected by the end of January 2000 by replacing the transformer and blower assembly imported from PERKIN ELMER.

The IV th review meeting of the project was held on March 11th and 12th 2000 at WBUAFS, Calcutta. It was decided that more work on bioavailability studies will be undertaken in different centres. It was also informed that one Research Associate will be sanctioned to all centres and two Research Associates for the centres where Assistant Scientist are not available, Minutes of the meeting has not been received from the ICAR. Later as per sanction received from ICAR one Junior Research Fellow(JRF) was posted with effect from 4.10.2000 in the project.

WORK DONE AND ALREADY REPORTED

1994-2000

I. Nutritional Survey

II. Mineral Bioavailability Studies in Cattle

1. Maintenance (Paddy Straw)
2. Maintenance (Green Grass)
3. Growth
4. Pregnancy
5. Lactation

15(a) Work done so far and already reported

I. Survey work to assess the present feeding conditions and mineral status of animals

As per the approved technical programme survey work and analytical studies to assess the present feeding conditions and mineral status of animals in Kerala covering all the 14 districts under the five agroclimatic zones have been completed. For survey work, from each districts 50% of the Taluks and from each Taluk two Villages were selected. Details of the agroclimatic conditions of Kerala, soil type, normal rainfall, livestock population and details of area covered for survey work as to the name of Villages and Taluks covered from each District were reported already (Progress Report 98-99). Data on the feeding status of animals in the respective areas were collected through a proforma supplied to each farmer, taking nine households from each Village, three from each type of farmers (large, medium and marginal) divided as per socio-economic conditions. A copy of the proforma is given below.

PROFORMA FOR SURVEY UNDER NETWORK PROGRAMME ON MICRONUTRIENTS IN ANIMAL NUTRITION AND PRODUCTION

1. Name and Address of the Farmer :

   Name

   House Name

   Village

   Post Office

   District

2. Details of the Farmer :

   a) Large (1 hectare and above) | Medium (50 cents to 1 hect) | Marginal (Less than 50 cents)

   b) Type of fodder cultivated: Grass/Legume/Mixed

   c) Irrigated/ Non-irrigated

   d) Area under cultivation

3. Details of Animals

	Cows	Buffalo	Goat	Pig	Bullock
No. of Animals					
Milking					
Milk yield (1/day)					
Dry					

4. Pattern of feeding

a) Concentrate Brand Name Quantity

b) Ingredients given

Sl. No.	Name	Quantity
1.		
2.		
3.		
4.		
5.		

C) Unconventional feeds if any used.

Sl. No.	Name	Quantity
1.		
2.		
3.		
4.		
5.		

B. Roughage:

Type of roughage	(Name)	Quantity
1. Natural grass		
2. Cultivated fodder		
3. Conserved fodder		
4. Grass legumme (Mixed fodder)		
5. Straw		

6. Unconventional fodder
   (Tree leaves/ weeds)
7. Grazing/ stall fed

C. Mineral mixture used:

a) Separate / with feed
b) Brand name of Mineral mixture used
c) Quantity given daily

5. a) Incidence of Infertility if any
   b) Long inter-calving period
   c) Unthrifty condition
   d) Poor growth
6. Biological / feed / soil/ samples collected
7. Results and Remarks.

The clinical cases of mineral deficiency conditions, if any in the areas surveyed were also ascertained from Veterinary Hospitals in the concerned areas. Proforma supplied to the Veterinary Surgeons for this purpose is as given below.

REPORT OF INFERTILITY / OTHER CASES SUSPECTED OF MINERAL DEFICIENCY

Name of Hospital

Case No.	Name of owner	Type of animal	Symptoms observed	Treatment offered/ results	Remarks/ comments of the Veterinarian.

From the households surveyed a minimum of nine samples of blood each for different species and classes of animals maintained by three categories of farmers (large, medium and marginal) were collected and estimated the concentration of various major as

well as trace elements (Ca, P, Mg, Cu, Zn and Fe) and haemoglobin as envisaged in the scheme.

From each village surveyed, a minimum of nine samples of soil (from a depth of 10 to 15 cm from the surface) were properly collected and prepared for analysis of extractable cations (Ca, Mg, Cu, Fe and Zn) by using 0.1 N HCl and estimated by AAS. Soil P was estimated by colorimetric method.

During the survey of individual households, representative samples of compound feed, feed ingredients, fodder samples, both cultivated as well as natural and paddy straw fed to animals were collected for the analysis of mineral contents. A minimum of nine samples of feeds and fodders collected from each Village were used for analysis. Samples for analysis were prepared by wet digestion using a mixture of perchloric acid and nitric acid, the estimation being carried out by AAS except phosphorus, for which colorimetric method was used. Mineral content in soil, feeds and fodders as well as biological materials collected from the organised and private farms in different regions were also analysed. Various conventional and unconventional feeds and fodders were also analysed for antinutritional factors such as tannins and oxalates. Tissue samples (Liver) collected from slaughter houses in the regions surveyed were also subjected to mineral analysis. Deficiency condition in the form of clinical cases or reproductive problems reported by farmers during survey were recorded. Information with respect to the incidence of deficiency conditions as recorded in the veterinary institutions in the concerned districts were also recorded.

From the information gathered during the survey of individual households in different regions of the State on the total quantities of the feed consumed (both concentrates and roughages) by lactating cows and from the mineral analysis of the respective feeds and fodders average daily dietary intake of minerals were also calculated.

Table 1(a). Details of area covered for survey work and collection of samples in Kerala state

Sl. No.	Districts	Taluks covered	Villages covered	
1.	Kasargode	1. Kasargode	Kodakade	Kottikol
2.	Kannur	1. Kannur	Pallikkunnu	Edayavur
3.	Wayanad	1. Kalpetta	Panamaram	Ambalavayal
4.	Kozhikode	1. Vadakara	Villyappally	Chombala
		2. Kozhikode	Kuttikottoor	Perruvayal
5.	Malappuram	1. Thirur	Thanallur	Purathur
		2. Eranade	Uppada	Pookotumpadum
6.	Palakkad	1. Chittur	Nenmara	Muthalamada
		2. Alathur	Vadakkencherry	Kannambra
7.	Thrissur	1. Thrissur	Nadathara	Madakkathara
		2. Mukundapuram	Kodakara	Irinjalakkuda
8.	Ernakulam	1. Aluva	Chengamanade	Manjapra
		2. Kunnathunadu	Vengola	Poonjassery
9.	Idukki	1. Thodupuzha	Karimannoor	Purapuzha
		2. Udumbanchola	Elappara	Ayyappankovil
10.	Kottayam	1. Kottayam	Pampady	Kumarakom
		2. Changanacherry	Kurichy	Thrikkodithanam
11.	Alleppey	1. Kuttanadu	Mancompu	Nedumudy
		2. Ambalapuzha	Punnapra	Arattuvazhy
12.	Pathanamthitta	1. Kozhenchery	Naranganum	Elanthoor
		2. Adoor	Erathu	Ezhamkulam
13.	Kollam	1. Kottarakkara	Nilamel	Kulakade
		2. Kollam	Thrikkaruva	Thekkevila
14.	Thriuvananthapuram	1. Thiruvananthapuram	Andoorkonam	Sreekariam
		2. Nedumangad	Pangode	Kallara

Result obtained on survey and analytical studies

Nutritional survey

Detailed report on the survey work with respect to each district were already reported (Annual progress report, 1994-95, 1995-96, 1996-97, 1997-98) . Summarised report on survey work are presented in Table 6 in annual report (1998-99). On reviewing the various data on the survey in all the 14 districts of Kerala with respect to present feeding conditions, the following conclusions can be drawn. Lactating cows are mostly crossbred with an average milk yield ranging from 6 to 8 litres per day with a total average of 7.24 litres per day. It was further observed that some of the households were also having animals such as goats and buffaloes in addition to cows. 19.79% of the family households surveyed were found to rear goats. 6.54% of the households surveyed were found to maintain buffaloes also. Most of the cows are stall fed. There are no established pasture lands in the different districts surveyed excepting the limited facilities as natural grass available on vacant lands, paddy fields, road sides etc. Very few farmers nearly 10.1% allot lands for separate fodder cultivation and in most of the cases cut grasses are procured and fed to animals. During rainy season majority of the farmers feed grass in addition to straw to animals. This situation may change during dry season, when animals will have to depend mostly on paddy straw. Out of the total households surveyed in all the 14 districts surveyed 25.93% of the farmers were found to give only grass as roughage, 62.33 % of farmers feed grass in addition to straw, while 8.96% were feeding paddy straw alone as the roughage.

Unconventional feeds such as tree leaves, banana leaves and stems, kitchen wastes, jack fruit waste, tapioca leaves and stem and tamarind seed are seen utilised by 8.33% of farmers surveyed.

As regard to concentrate feeding 52.35% of the farmers studied were found to provide various concentrate feed ingredients such as oil cakes and brans, rice etc. In addition to the ready made compound feeds available in the market, while 17.78% households were feeding different feed ingredients alone and 15.17% were using compounded cattle feeds only as concentrate. The feed ingredients commonly used were mainly groundnut cake, gingelly oil cake, coconut oil cake, rice bran, wheat bran etc. On assessment of the quantities provided to heifers as well as lactating cows it was found that the farmers were not following any definite pattern or schedule of feeding either with regard to concentrate or roughages. But in most cases quantities provided were found to be more since compounded feeds were supplemented with feed ingredients also. The practice of feeding rice gruel to lactating cows was practised by many farmers in Palakkad and Thrissur districts.

The results of the survey also reveal that feeding of separate mineral mixture was practiced by farmers in all the districts, though the percentage of such farmers ranged from 17 to 58 with a total average of 34.55% , the lowest percentage were noticed in Kottayam and the highest in Pathanamthitta district. Nearly 40% (39.61%) of the households surveyed reported reproductive / nutritional disorders in their animals. with an average range of 16.5 to 67% in different districts, the lowest being reported from Palakkad and the highest from Kollam.

Table showing the consolidated report on survey work to assess the present feeding condition is given below.

Table – 1(b)

Consolidated report on survey work to assess the present feeding condition of animals

District	Breed	Average milk yeild l/day	In addition to cows percentage of households rearing		Percentage of house holds having fodder cultivation	Percentage of households using			Percentage of house-holds using unconventional feeds	Concentrate feeding percentage of households giving			Percentage of household giving mineral mixture separately	Percentage of house hold reported reproductive or deficiency conditions
			Goats	Buffalo		Straw alone as rough-age	Grass alone as rough-age	Grass + straw as rough-age		Compound feed ingredients	Ingredients alone	Compound feed alone		
PALAKKAD	C B	7.5	Low Population	Low Population	14	-	30	70	-	55	45	-	24	16.5
THRISSUR	C B	7	17	14	-	-	-	100	-	44	31	22	25	28
KASARGOD	C B	6	16	-	6	28	28	44	-	61	33	-	33	61
IDUKKI	C B	6.6	14	-	11	-	22	78	-	63	18	19	28	28
KOTTAYAM	C B	7	17	-	6	5	28	67	-	72	14	14	17	44
PATHANAMTHITTA	C B	8	14	8	16	-	16.7	83.3	36	-	25	-	58	44
KOLLAM	C B	7.9	19	14	-	5.6	47	47.4	5.6	69.4	5.6	25	36	67
THIRUVANANTHAPURAM	C B	6.9	28	8	19	14	47	39	19	67	11	22	44	33
WAYANAD	C B	7	22	11	16.7	-	28	72	-	78	-	-	39	44
KANNUR	C B	7.3	11	17.6	11	34	22	44	-	67	-	33	44	33
KOSHIKODE	C B	7.6	50	11	2.8	11	50	39	-	44.6	13.9	41.7	33	52.8
MALAPPURAM	C B	6.5	50	-	13.9	27.8	33.3	38.9	-	63.9	19.4	16.7	27.8	47
ERNAKULAM	C B	8	11	8	8	-	-	78	-	-	-	-	38.9	42
ALAPUZHA	C B	8	8		17	-	11	72	56	48	33	19	36	17
AVERAGE		7.24	19.79	6.54	10.1	8.96	25.93	62.33	8.33	52.35	17.78	15.17	34.55	39.81

Table - 2. No. Of samples analysed *

Sl. No.	Districts	No. Of Taluks	No. Of Villages	No. Of Samples									
				Soil	Grass	Straw	Compound feed	Ingredients (each type)	Growing cattle	Lactating cattle	Buffaloes lactating	Adult Goat	Cattle Liver
1.	Kasargod	1	2	18	18	18	18	18	18	18	18	18	18
2.	Kannur	1	2	18	18	18	18	18	18	18	18	18	18
3.	Wayanad	1	2	18	18	18	18	18	18	18	18	18	18
4.	Kozhikode	2	4	36	36	36	36	36	36	36	36	36	36
5.	Malappuram	2	4	36	36	36	36	36	36	36	36	36	36
6.	Palakkad	2	4	36	36	36	36	36	36	36	36	36	36
7.	Thrissur	2	4	36	36	36	36	36	36	36	36	36	36
8.	Ernakulam	2	4	36	36	36	36	36	36	36	36	36	36
9.	Idukki	2	4	36	36	36	36	36	36	36	36	36	36
10.	Kottayam	2	4	36	36	36	36	36	36	36	36	36	36
11.	Alleppey	2	4	36	36	36	36	36	36	36	36	36	36
12.	Pathanamthitta	2	4	36	36	36	36	36	36	36	36	36	36
13.	Kollam	2	4	36	36	36	36	36	36	36	36	36	36
14.	Thiruvananthapuram	2	4	36	36	36	36	36	36	36	36	36	36
Total	14	25	50	450	450	450	450	450	450	450	450	450	450

* 9 samples from each village

Results of Analytical studies

Results of analysis of soil, feed, fodders and biological materials (blood and liver tissue) collected from the surveyed areas with respect to each district were already reported in detail (Progress report 1994-95, 1995-96 and 1996-97).

Consolidated data on the mineral concentrations of soil, feeds, fodders, blood samples of different species, tannin and oxalate content of feeds and fodders used, mineral content of liver sample, data on recorded cases in the Veterinary Institutions and mean dietary intake of minerals by lactating cows of the surveyed areas were already reported. and from a critical evaluation of the data results can be summarised as follows.

Soil analysis

Characteristics

Soil characteristics of different districts of Kerala revealed that the texture of surface layers of soil in Kerala covers a wide range of sandy to clayi, their relative proportion being 4% sandy, 59% loamy and 30% clayi. About 82% of the area in Kerala has moderately or well drained soil.

Analysis

Data on the pH and mineral concentration of soil from the surveyed areas of all the 14 districts of Kerala were already reported. pH of the soil from different regions are found to be mainly acidic to neutral ranging from 5.19 to 7.15 with an average of 6.47±0.13.

Results of mineral analysis of soil samples revealed that the levels of all the minerals except for calcium were within the normal range. Relatively lower concentration of calcium, below the critical level was obtained for most of the districts of the state, the lowest value recorded being 0.03% for Wayanad, 0.04% for Kannur and Malappuram, 0.05% for Pathanamthitta and Kollam and 0.06% for Thiruvananthapuram districts as

against the critical level of 0.1% reported by Kanwar (1979). Iron content of the soil from all the districts were found to be very high on comparing the critical level.

Natural grass and Paddy straw

The results of mineral analysis of natural grass collected from different districts and comparison of the same with that of the critical limit revealed that the concentrations of all the minerals were with in the normal range except for the scattered deficiency of copper and phosphorous in certain districts. Lower values for copper were recorded in the samples of natural grass collected from Kasargod (4.68ppm), Kannur (5.42ppm) Kozhikode (4.19ppm) and Ernakulam (5.21ppm) as against the critical level of 10ppm suggested by Mc Dowell (1983). Marginal deficiency of P was observed in the grass samples collected from Malappuram, Palakkad, Ernakulam, Idukki, Kottayam, Pathanamthitta and Thiruvananthapuram districts the values being 0.19, 0.22, 0.21, 0.21, 0.2, 0.22 and 0.19 respectively as against the critical level of 0.25. Statistical analysis revealed significant difference ($p<0.01$) of all minerals between the 14 districts. Soil samples collected from these districts were also found to have a comparatively lower P levels , though the values were within the normal range.

The values in respect of paddy straw were similar to those reported in the literature. Wide variations were observed in the mineral concentrations of the paddy straw collected from different districts, the variations being mainly attributable to the differences in the variety of straw fed to the animals. As reflected in grass samples paddy straw collected from Kasargod, Kannur, Kozhikode and Ernakulam districts also recorded lower copper values. The variations observed in the mineral concentration in the natural grass collected from different districts are attributable to the type of soil , season during which the survey and collection of fodder were carried out, plant genus, species and variety, stage of maturity of the plant at the time of collection, agroclimatic influences, manurial practices followed and soil characteristics such as acidity/ alkalinity and drainage conditions.

Concentrate mixtures and feed ingredients

Data on the mineral content of various compound feeds used by the households in the regions surveyed revealed that the levels of Ca, P, Mg, Cu, Zn and Fe were all within the normal range, when assessed in terms of requirements of these minerals for cattle. Wide variation existed between the samples collected from different districts.

Values obtained on the mineral contents of the commonly used feed ingredients viz ground nut cake, gingelly cake, coconut cake , rice bran , wheat bran, rice and tamarind seed were within the range reported in the literature. Rice and tamarind seed were found to be lower in Mg and Cu when compared to other feeds.

Mineral mixtures

Data obtained from the analysis of mineral mixtures collected from the different regions during survey work depicted in table below, revealed that wide variations exist in the mineral concentration of various mineral mixtures marketed in the State. None of the mineral mixtures analysed were found to conform fully to the BIS standard, the content of most of the minerals being either high or low in comparison to the standard. On comparing the mineral concentrations of the mineral mixtures obtained with those of BIS standard, it could be seen that about 23% of the samples are low in Ca, 38.46% are deficient in P, 15.4% deficient in Cu, 53.8% deficient in Zn and 30.77% are deficient in Fe and Mn apart from a higher content of acid insoluble ash in 23% of samples. Regarding the fluorine content of the mineral mixtures analysed 38.46% of the samples were found to have higher concentrations of fluorine than the permissible levels, the lowest and highest concentration being 0.08% and 0.68% respectively.

Table 3. Percentage mineral composition of various mineral mixtures collected from different districts

	with salt									without salt				BIS standard	
Sample No.	1	2	3	4	5	6	7	8	9	1	2	3	4	with salt salt	without
Dry matter	93.30	95.90	97.30	96.80	97.50	97.30	96.70	95.70	96.20	96.3	95.20	93.30	92.80	95.00	95.10
Acid insoluble ash	3.50	1.70	2.60	2.80	2.01	1.89	1.76	2.90	2.70	5.35	0.57	2.75	3.70	3.00	2.50
Calcium	26.73	17.62	17.83	20.90	22.24	21.99	22.64	25.28	26.73	32.34	27.36	32.11	31.27	18.00	23.00
Phosphorus	9.63	11.41	10.93	11.22	8.01	12.88	9.70	7.37	10.36	12.68	6.14	8.55	8.16	9.00	12.00
Magnesium	5.89	0.33	1.34	2.02	0.67	0.97	0.70	4.18	3.49	1.12	0.98	2.61	1.47	5.00	6.50
Copper	0.07	0.02	0.09	0.13	0.09	0.06	0.09	0.43	0.11	0.05	0.11	0.26	0.09	0.06	0.077
Zinc	0.06	0.23	0.31	0.28	0.16	0.11	0.16	0.03	0.04	0.17	0.05	0.09	0.19	0.30	0.38
Iron	0.93	0.32	0.63	0.45	0.70	0.38	0.93	0.65	0.24	0.82	0.72	0.43	1.23	0.40	0.50
Manganese	0.10	0.11	0.26	0.09	0.15	0.10	0.08	0.39	0.56	0.07	0.11	0.02	0.41	0.10	0.12
Fluorine	0.41	0.17	0.16	0.08	0.31	0.16	0.27	0.36	0.68	0.51	0.29	0.45	0.37	0.05	0.07

Antinutritional factors

Antinutritional factors such as tannins and oxalate content of common feeds and unconventional feeds had been estimated and the data were already reported. Salseed meal and tree leaves like subabul, jack, kainy and venga are found to have high tannin content. Regarding oxalate content, paddy straw, napier, setaria, and water hyacianth are found to have comparatively more oxalates.

Blood values

Results of analysis of blood samples collected from growing and lactating cattle, adult buffaloes and adult goats of the surveyed areas of all the districts were already reported and the data revealed a normal mineral status among all the animals. Concentrations of Hb, Ca, Mg, P, Cu, Zn and Fe obtained for different animals were within the normal range reported for the species. However, marginally lower blood Mg levels were observed in certain areas such as growing cattle in Kottayam (1.64mg/100ml), Pathanamthitta (1.76mg/100ml) and Kozhikode (1.62mg/100ml), the normal values reported being 1.8 to 3.2mg /100ml (Mc Dowell, 1992), though no specific deficiency condition was reported from these areas. Lower values of 1.41 and 1.28mg/100ml were also obtained in buffaloes in Kottayam and Kasargod districts and 1.29, 1.36, 1.63 and 1.62 mg/100ml respectively in goats of Kottayam, Kasargod, Ernakulam and Kozhikode districts in spite of adequate Mg concentration in soil, fodder and feeds of these areas. Lower copper levels of 0.43±0.08 ppm were recorded in the blood serum of buffaloes in Kozhikode district, though no specific clinical conditions of copper deficiency was reported by the surveyed households.

Liver mineral concentration

Results of mineral analysis of liver samples of cattle collected from slaughter houses in the regions surveyed revealed that the liver concentrations of P, Ca, Mg, Zn, Cu and Fe were all within the normal range and did not indicate any mineral deficiency.

Dietary intake of minerals

Average daily dietary intake of minerals by lactating cows in the surveyed areas of all the 14 districts calculated from the total quantity of feeds consumed and their corresponding mineral concentration obtained by analysis are presented in table below and the data did not indicate any specific mineral deficiency. On comparing the requirements for different minerals for lactating cows for particular body weight, milk production and dry matter consumption (NRC, 1989), the calculated dietary intake were all found to be adequate except for a slightly lower intake of Ca in Kasargod, Kannur, Kottayam, Malappuram and Idukki districts. The lower dietary intake of Ca in these areas is attributable to the differences in the type of feeds and quality of mineral mixtures provided to the animals in these areas. Ca content of soil in these areas were also found to be low except in Kasargod. However, fodder samples collected from these areas are found to contain adequate level of Calcium. A perusal of the serum Ca levels of animals in different districts indicate that all the animals maintain a normal range of serum Ca level in spite of the lower intake of Ca in certain districts. The reason for a normal serum Ca concentration in animals maintained in districts with a lesser Ca intake is that of a lower Ca intake especially for a short period need not result in a low serum Ca level because of Ca homeostasis of the animal. An underestimation of the feed intake and thereby the dietary mineral intake due to the error which occurs in converting the quantity of a feed fed from a measure into a weight which is the usual practice followed by farmers in households, instead of the actual weighing of the feed might also partly account for the variation observed in this regard.

Table 4. Mean daily dietary intake of minerals by lactating cows in suveyed area in different districts of Kerala

Districts	Daily DMI	Minerals**						
		Average milk yield (L/day)	Ca(g)	P(g)	Mg(g)	Cu(mg)	Zn(mg)	Fe(mg)
1. Kasargode	9.06 ±0.25	5.96 ±0.46	26.83 ±1.35	28.54 ±2.27	28.21 ±1.34	133.00 ±19.01	433.00 ±25.00	8160 ±395
2. Kannur	8.31 ±0.21	7.22 ±0.37	30.88 ±1.29	35.05 ±2.24	23.20 ±0.96	115.00 ±13.51	536.00 ±16.83	7260 ±239
3. Wayanad	8.85 ±0.17	7.22 ±0.63	37.47 ±1.74	39.87 ±2.24	31.31 ±1.45	195.00 ±22.40	546.00 ±14.51	7207 ±254
4. Kozikode	8.97 ±0.10	7.54 ±0.23	38.81 ±1.54	40.48 ±1.82	36.19 ±6.62	117.00 ±10.00	405.00 ±13.73	7416 ±213
5. Malappuram	8.87 ±0.11	6.95 ±0.41	33.13 ±1.61	41.25 ±2.03	39.38 ±7.73	145.00 ±6.98	592.00 ±11.11	4963 ±147
6. Palakkad	9.30 ±0.17	6.44 ±0.39	37.50 ±1.89	42.93 ±2.61	37.21 ±5.52	183.51 ±14.77	504.00 ±15.34	6051 ±239
7. Thrissur	9.85 ±0.18	6.51 ±0.30	41.46 ±1.89	42.61 ±1.50	29.86 ±0.90	190.65 ±12.72	497.00 ±10.51	5930 ±156
8. Ernakulam	9.08 ±0.13	7.20 ±0.32	38.97 ±1.31	43.52 ±1.82	34.11 ±0.92	113.00 ±6.63	485.00 ±10.21	6317 ±157
9. Idukki	9.12 ±0.19	6.88 ±0.38	35.90 ±0.84	35.08 ±1.88	28.26 ±1.01	190.89 ±13.71	546.97 ±10.99	8221 ±300
10. Kottayam	8.97 ±0.21	6.85 ±0.42	30.45 ±1.67	35.47 ±1.91	24.70 ±0.94	120.68 ±8.57	376.00 ±93.00	8796 ±330
11. Alappuzha	8.65 ±0.32	8.10 ±0.56	45.58 ±3.30	40.32 ±2.25	29.43 ±1.76	204.00 ±16.70	531.00 ±22.43	6958 ±293
12. Pathanam-thitta	10.35 ±0.24	8.17 ±0.37	41.00 ±1.15	43.07 ±2.00	34.40 ±1.30	233.00 ±14.38	615.72 ±14.77	10073 ±334
13. Kollam	9.82 ±0.21	7.72 ±0.25	46.85 ±1.23	54.08 ±2.50	33.46 ±1.07	145.00 ±8.08	594.00 ±14.28	6935 ±218
14. Thiruvananthapuram	8.60 ±0.12	7.06 ±0.27	48.79 ±2.01	42.49 ±1.59	27.53 ±0.69	149.70 ±14.10	436.00 ±7.98	4933 ±147
Average ±SE	9.13 ±0.14	7.13 ±0.16	38.12 ±1.65	40.33 ±1.50	31.23 ±1.23	159.72 ±10.08	506.97 ±18.88	7087.14 ±368.71

** - $p<0.01$ between districts with respect to each mineral

Recorded cases of Nutritional deficiency/Reproductive disorders

Data on the recorded cases of different nature in cattle, buffaloes and goats at the Veterinary Institutions were collected and reported already. Regarding the clinical cases, the cases were either metabolic (milk fever) or reproductive problems (delayed sexual maturity, anoestrum, long inter-calving period etc.). The recorded cases are mostly suspected cases of deficiency of minerals /vitamins or even major nutrients. The reason for the higher incidence of low production or reproductive disorders may be due to either marginal deficiencies of minerals / vitamins which may go undetected, lower utilization of minerals due to interaction or imbalances or mainly deficiencies of major nutrients particularly energy.

From a critical evaluation of the overall results obtained in the present study, it can be inferred that the animals in the surveyed areas maintained a satisfactory mineral status as evidenced by normal serum mineral concentrations except for a marginal deficiency of Mg in certain areas and scattered deficiency of Ca in soil samples and Cu and P levels in a few fodder samples. The lower dietary intake of Ca in certain areas probably is due to the differences in the type of feeds and quality of mineral mixture provided to them. Over all evaluation of the results of survey and analysis of soil, feeds, fodders and biological materials in all the 14 districts of the state did not reveal any specific mineral deficiency. Regarding the reported cases of the Veterinary Institutions and by the farmers at the household, higher incidence of low production and reproductive disorders may be due to either marginal deficiencies of minerals/vitamins which may go undetected, lower utilization of minerals due to interaction or imbalances or mainly deficiencies of major nutrients particularly energy.

II. STUDIES ON THE BIOAVAILABILITY OF MINERALS IN CATTLE

As per the approved technical programme studies on the bioavailability of minerals in cattle using common rations during different stages are going on. Studies on the mineral bioavailability in cattle during maintenance, growth, pregnancy, lactation and two feeding trials in calves were completed already and reported in detail in Progress Report-1996-97, 1997-98, 1998-1999 and 1999-2000 respectively.

Consolidated report of the various work conducted so far and already reported are summarised in this report under separate headings.

1. Mineral Balance studies in adult cattle for maintenance

Six adult cross bred non producing cows were maintained on the farm ration consisting of a basal concentrate mixture prepared as per standards and paddy straw as roughage. The ingredient composition and percentage chemical composition of the concentrate mixture , mineral mixture used were already reported . Towards the end of the feeding experiment, a metabolism trial was carried out with quantitative collection of dung and urine voided. Representative samples of dung and urine collected during metabolism trial were analysed for different mineral contents. From the data on the total intake in feed and total outgo through dung and urine, the balance with respect to each mineral was calculated. The data on mineral balance for Ca, P, Mg, Cu, Zn and Fe indicated that the average mineral balances with respect to Phosphorous, Magnesium, Copper, Zinc and Iron were all positive. However , marginally lower negative balance was seen with regard to Ca. Poor availability of Ca due to higher oxalate content in paddy straw may be the reason for the slightly negative balance for Ca. Mg balances were also marginally negative in majority of animals though the average values were on the positive side. All the experimental animals maintained their body weights during the period of experiment.

Overall result of the study indicated that the mineral mixture used in the ration was well utilised as evidenced by the body weights and balances for individual minerals. Negative balances obtained for Ca indicated the need for Ca supplementation when paddy straw alone is used as the roughage. Similar study using grass as the roughage is being carried out instead of paddy straw to rule out the adverse effect of oxalate or any other factors on Ca availability.

Table 5 a. Studies on Bioavailability of Minerals in Cattle for Maintenence (Percentage ingredient and chemical composition of the concentrate mixture used (When paddy straw is used as roughage)

Ingredients		Chemical composition	
Yellow maize	18.00	Dry matter	88.90
Ground nut cake (expeller)	19.00	Crude protein	19.40
Coconut cake (expeller)	10.00	Ether extract	5.40
Wheat bran	50.00	Crude fibre	8.20
Mineral mixture*	2.00	Total ash	8.30
Common salt	1.00	Nitrogen free extract	58.70

* Keyes forte manufactured by Kerala Solvent Extraction Ltd. Irinjalakuda.

Table 5b. Mineral composition of concentrate mixture, paddy straw and mineral mixture used for the study on bioavailability of minerals in cattle for maintenance (on Dry matter basis)

Sample	Calcium (%)	Phosphorous (%)	Magnesium (%)	Copper (ppm)	Zinc (ppm)	Iron (ppm)
Concentrate mixture	0.90	0.64	0.32	44.38	69.85	447.34
Paddy straw	0.47	0.09	0.15	51.08	103.21	2867
Mineral mixture*	21.99	12.88	0.97	600	1100	3800

* Keyes forte manufactured by Kerala Solvent Extraction Ltd. Irinjalakuda.

Table 5c. Data on total dry matter intake and dung and urine voided during the metabolism trial on bioavailability of minerals in cattle for maintenance

Animal No.	Body Wt. (Kg)	DM intake from concentrate (Kg)	DM intake from paddy straw (Kg)	Total DM intake 7 days (Kg)	Total dung output (DM basis) (Kg)	Total qty. of urine voided (Lit.)
987	476.00	12.45	30.26	42.71	19.41	44.10
934	392.00	12.42	29.10	41.52	19.18	43.22
967	437.00	12.45	30.20	42.65	20.08	40.40
T-140	399.00	12.42	21.02	33.44	15.80	41.05
927	480.00	12.42	29.54	41.96	19.02	45.45
935	394.00	12.42	30.26	42.68	18.46	41.85
Average	429.67	12.43	28.40	40.83	18.66	42.73
±SE	±16.70	±0.01	±1.49	±1.49	±0.61	±0.81

Table-5d. Average data on mineral balances of cattle for maintenance using paddy straw as roughage

Minerals	Intake of Minerals per 7 days			Outgo of Minerals per 7 days			Balance		Percentage retention
	Conc. Mixture	Paddy Straw	Total	Dung	Urine	Total	per 7 days	per day	
Calcium(g)	111.87 ±0.06	133.45 ±6.99	245.33 ±7.01	274.46 ±17.78	0.55 ±0.22	275.01 ±17.88	-29.65 ±16.80	-4.24 ±2.40	-12.19 ±6.01
Phosphorus(g)	79.55 ±0.01	25.56 ±1.34	105.11 ±1.35	90.35 ±8.03	2.215 ±1.08	92.57 ±8.14	12.54 ±7.40	1.79 ±1.06	12.17 ±6.48
Magnesium(g)	39.78 ±0.02	42.60 ±0.23	82.38 ±2.23	68.73 ±4.82	13.42 ±3.71	82.16 ±4.15	0.21 ±3.95	0.03 ±0.56	0.125 ±4.25
Copper(mg)	551.67 ±0.42	1450.67 ±75.97	2002.33 ±70.39	380.50 ±24.50	4.32 ±1.35	384.83 ±27.04	1617.50 ±70.30	231.16 ±9.99	80.73 ±1.12
Zinc(mg)	868.67 ±0.38	2930.67 ±140.37	3799.33 ±140.37	3203.67 ±962.19	23.50 ±1.98	3227.17 ±1053.00	572.16 ±1185.00	81.74 ±169.00	8.66 ±31.65
Iron(mg)	5560.67 ±275.00	81410.00 ±4664.85	86973.67 ±4266.00	26897.33 ±7638.38	100.00 ±9.00	26997.33 ±7633.00	59976.00 ±8920.00	8568.00 ±1274.00	68.43 ±7.99

2. Mineral Balance Studies in cattle for growth

Six HF cross bred heifers weighing on an average 200 kg body weight selected from Cattle Breeding Farm, Thumburmuzhi formed the experimental animals for the growth study. The experimental animals were fed on a basal concentrate mixture containing mineral mixture at 2% level and Napier grass as roughage for a period of 4 months. Drinking water was provided *ad libitum*. All the animals were maintained individually on identical conditions of feeding and management throughout the period of study. The percentage ingredient composition and mineral composition of diets used were reported. Records on feed intake and fortnightly body weights of animals were maintained. A metabolism trial of five days duration was carried out at 2 months after the beginning of the study with quantitative collection of dung and urine voided. Representative samples of feed, dung and urine were analysed for mineral contents. From the data on the total intake in feed and outgo in dung and urine, the balance with respect to each mineral was calculated. Data on total dry matter intake and quantities of dung and urine voided during the metabolism trial and the data on balance of different minerals under study were reported previously. Results obtained on the mineral balance studies in cattle during growth are presented in table below.

Regarding the Ca utilization, average Ca retention g/day ranged from 4.47 to 17.77 with an average of 7.19±2.19 and an average percentage retention of 26.40 ± 6.56. The data on phosphorus balance revealed that average Phosphorous retention (g/day) is 2.7±1.95 and retention as percentage of intake is 16.06 ± 3.26. Regarding the utilization of Mg, by growing animals the values ranged from 0.32 to 2.99 g/day with an average of 1.61 ± 0.37 which comes to 9.75 ± 1.95 as percentage of intake. As regards to the utilization of trace elements the experimental animals showed positive balances, the average retention being 35.15 ± 4.82 (mg/day) and 31.76 ± 3.14, as percentage of intake for Copper and 0.86 ± 22.11 mg/day for Zn while the value for Iron being 1.55 mg/day and 21.20 as % of intake.

All the experimental animals were gaining in body weight as revealed from body condition and fortnightly body weights. Data on balances of different minerals revealed positive balances for all the minerals studied, as expected in growing animals. The balance study indicated that all the minerals were will utilised in cattle for growth.

Table - 6a. Percentage ingredient composition of the concentrate mixture used for the mineral balance studies in cattle for growth.

Groundnut cake	30
Yellow maize	33
Rice polish	33
*Mineral mixture	2
Common salt	2

* Keys forte manufactured by Kerala Solvent Extraction Ltd., Irinjalakuda.

Table - 6b. Mineral composition of concentrate mixture, napier grass and mineral. mixture used for the study on bioavailability of minerals in cattle for growth

Sample	Calcium (%)	Phosphorous (%)	Magnesium (%)	Copper (ppm)	Zinc (ppm)	Iron (ppm)
Concentrate mixture	0.50	0.96	0.33	25.62	69.36	1186.00
Napier grass	0.50	0.30	0.29	17.64	47.05	1395.00
*Mineral mixture	21.99	12.88	0.97	600.00	1100.00	3800.00

* Keys forte manufactured by Kerala Solvent Extraction Ltd., Irinjalakuda

Table 6c. Data on fortnightly body Weights(Kg) of cattle used for the mineral balance studies for growth

Anim. No.	Fortnights						
	1	2	3	4	5	6	7
334	220.00	227.00	232.00	238.00	247.00	256.00	264.00
354	191.00	200.00	211.00	222.00	234.00	245.00	252.00
357	185.00	198.00	209.00	220.00	231.00	242.00	250.00
337	189.00	198.00	206.00	214.00	220.00	228.00	237.00
332	195.00	202.00	211.00	219.00	225.00	230.00	236.00
349	210.00	219.00	228.00	236.00	245.00	253.00	260.00
Average ± S.E.	198.00 ±5.58	207.30 ±5.10	216.20 ±4.47	248.83 ±4.00	233.67 ±4.38	242.33 ±4.71	247.17 ±3.87

Table 6d. Data on total dry matter intake and dung and urine voided during the metabolism trial on bioavailabity of minerals in cattle for growth

Anim. No.	Body weight (Kg)	DM intake from concentrate (Kg)	DM intake from grass (Kg)	Total DM intake (Kg)	Total dung output (DM basis) (Kg)	Total quantity of urine voided (Litres)
334	240.00	9.26	19.35	28.61	13.97	40.37
354	225.00	9.26	15.80	25.06	9.18	46.45
357	223.00	9.26	19.10	28.36	11.13	54.26
337	216.00	9.26	17.57	26.83	13.21	44.42
332	221.00	9.26	14.58	23.84	9.86	44.88
349	239.00	9.26	18.66	27.92	9.40	55.84
Aver. ± S.E.	227.33 ±4.04	9.26 ±0.00	17.51 ±0.79	26.77 ±0.79	11.13 ±0.83	47.70 ±2.47

Table-6e. Average mineral balances of cattle for maintenance during growth

Minerals	Intake of Minerals/5 days			Outgo of Minerals/5 days			Balance	
	From concentrate	From grass	Total intake	Through dung	Through urine	Total	% of intake	per day
Ca(g)	46.30 ±0.00	87.55 ±3.95	133.85 ±3.95	95.11 ±9.22	2.76 ±0.51	97.88 ±9.27	26.40 ±6.56	7.19 ±2.19
P(g)	88.90 ±0.00	52.53 ±2.37	141.43 ±2.37	122.85 ±7.92	5.67 ±1.69	127.94 ±8.52	16.06 ±3.26	2.70 ±1.95
Mg(g)	30.56 ±0.00	50.78 ±2.29	81.34 ±2.29	66.16 ±1.49	7.11 ±1.57	73.27 ±1.83	9.75 ±1.97	1.61 ±0.37
Cu(mg)	237.24 ±0.00	308.88 ±12.73	546.00 ±13.99	366.52 ±12.86	3.687 ±0.415	370.20 ±12.88	31.76 ±3.14	35.15 ±4.82
Zn(mg)	642.27 ±0.00	823.85 ±37.19	1466.12 ±37.19	1433.00 ±73.03	29.11 ±2.45	1461.83 ±79.82	0.29 ±7.38	0.86 ±22.11
Fe(mg)	10982.00 ±0.00	24414.50 ±1097.12	35396.50 ±1097.12	27350.00 ±1866.00	285.00 ±66.44	27635.00 ±1818.00	21.20 ±6.07	1552.40 ±499.43

3. Mineral Bioavailability Studies in Cattle during Pregnancy

Six adult cross bred dry pregnant cows at about three months of pregnancy selected from the cattle breeding station, Thumburmuzhi formed the subjects for the experiment.

The experimental animals were maintained on a basal concentrate mixture containing mineral mixture at 2% level and Napier grass as roughage. The animals were fed individually and daily dry matter intake were recorded. Fresh wholesome water was provided *ad libitum*. All the animals were maintained on identical conditions of feeding and management throughout the period of study. The percentage ingredient and chemical composition of the concentrate mixture and mineral concentrations of the concentrate mixture, Napier grass and mineral mixture used for the study were reported already . Two metabolism trials each involving a collection period of 7 days duration were conducted one at five to five and half months of pregnancy (first trial) and other at six to six and half months of pregnancy (2nd trial) at 2 months and 3 months after the beginning of the study with quantitative collection of dung and urine voided. Representative samples of feed, dung and urine were analysed for the various major as well as trace elements. From the data on the total intake in feed and outgo in dung and urine, the balance with respect to each mineral was calculated. Data on the total dry matter intake and quantities of dung and urine voided in the first and second metabolism trials and the data on daily mineral balance and retention as percentage of intake for Ca, P, Mg, Cu, Zn and Fe were reported already in Annual report 98-99 and consolidated data on mineral balances during pregnancy are presented in table 1a & 1b.

Results of study during pregnancy

Consolidated data on mineral balances of cattle collected from the first and second trial during pregnancy are presented in table below.

From data on Ca balance it can be seen that the average Ca retention (g/day) was 11.61 and 14.63 for the first and second trials with an average value of 13.12 ± 2.69 g/day corresponding percentage retention being 35.02 ± 15.08, 40.69 ± 4.94 and 37.85 ± 7.99 while slightly negative balance (g/day) of -4.24 ±2.40 and a positive balance of 7.19 ± 2.19 were obtained for maintenance and growth respectively . Regarding the utilization of

P by pregnant animals data indicated an average percentage retention of 22.19 ±5.78 for first trial and 18.65 ± 7.73 for second trial with a total average of 20.42 ± 1.85. From the consolidated data on mineral balance it can be seen that balance of P is more during pregnancy than maintenance and growth.

Mg balance (g/day) by the pregnant cows were found to be 3.97 ± 0.83 for first trial, 11.47 ± 0.65 for second trial with a total average of 7.72 ± 1.21 and the corresponding percentage retention being 21.38 ± 4.49, 56.76 ± 3.22 and 39.07 ± 5.81 respectively. On comparison, the Mg retention was found to be very poor during maintenance and low during growth, the retention as % of intake being 0.125 ± 4.25 and 9.75 ±1.97 respectively.

Regarding the utilization of copper result revealed that the average copper balance as Cu retention (mg/day) by pregnant cows were 104.88 ± 2.96 during first trial and 37.30 ± 5.75 during second trial with an average of 71.09 ± 10.29 and the corresponding percentage retention as percentage of intake being 62.31 ± 1.76, 19.23 ± 2.96 and 40.77 ± 6.46% respectively. On comparing the copper balance during maintenance, growth and pregnancy, cattle showed a higher percentage retention of 80.73 ± 1.12 during maintenance and lower value of 31.76 ± 3.14 during growth.

Regarding the utilization of zinc by pregnant cows as revealed from the data the average daily retention (mg/day) and percentage of intake were 116.69 ± 8.45 and 39.76 ± 2.88 for first trial, 69.52 ± 7.89 and 21.14 ± 2.4 for the second trial with a total average of 93.11 ± 8.94 and 30.45 ± 3.28 respectively whereas the average percentage retention of Zn obtained for maintenance was 8.66 ± 31.65.

Data on iron balance of pregnant animals indicated positive balances in both trials, the values of retention as % of iron intake being 45.36 ± 3.24 and 55.36 ± 1.22 for first and second trials respectively with an average value of 50.37 ± 2.26.

All the experimental animals were gaining weight as revealed from the body condition. Results of the balance study indicated that all the minerals were well utilised by the animals.

Table 7 a : Studies on bioavallability of minerals in cattle for Pregnancy and Lactation

Percentage ingredient and chemical composition of the concentrate mixture used

Ingredients		Chemical composition	
Ground nut cake (Expeller)	30	Dry matter	90.04
Yellow maize	37	Crude protein	19.42
Rice polish	30	Crude fibre	7.30
* Mineral mixture	2	Ether extract	7.32
Common salt	1	Total ash	8.42
		Nitrogen free extract	57.54

* Keyes forte manufactured by Kerala Solvent Extraction Ltd., Irinjalakuda, Trissur

Table 7 b : Mineral composition of concentrate mixture, green grass and mineral mixture used for the study on bioavailability of minerals in cattle for pregnancy (on DM basis) and lactation

Samples	Calcium g%	Phosphorus g%	Magnesium g%	Copper ppm	Zinc ppm	Iron ppm
Concentrate Mixture	0.62	1.05	0.37	56.98	78.35	1075.50
Green grass	0.50	0.30	0.27	14.95	34.66	939.31
Mineral Mixture	24.09	9.07	0.33	1632	3264	2342.93

Table 7 c. Data on total dry matter intake and dung and urine voided during the metabolish trial on bioavailability of minerals in dry-pregnant cows (First trial)

Animal No	Body wt (Kg)	DM intake from concentrate (Kg)	DM intake from grass	Total DM intake (Kg)	Total dung output (DM basis) Kg	Total quantity of urine voided (Litres)
368	281	1.8	4.4	6.2	2.3907	9.6330
437	342	1.8	4.4	6.2	3.1592	5.8500
290	321	1.8	4.4	6.2	2.8329	6.1000
564	279	1.8	4.4	6.2	3.0304	8.1667
303	267	1.8	4.4	6.2	2.4063	10.5000
277	290	1.8	4.4	6.2	2.9525	9.5700
Average ± S E	297 ±10.71	1.8 ±0.00	4.4 ±0.00	6.2 ±.00	2.7953 ±0.1212	8.30 ±0.73

Table 7d: Data on total dry matter intake and dung and urine voided during the metabolism trial on bioavailability of minerals in dry-pregnant cows (second trial)

Animal No	DM intake from concentrate (Kg)	DM intake from grass	Total DM intake (Kg)	Total dung output (DM basis) Kg	Total quantity of urine voided (Litres)
368	2.25	4.4	6.65	2.0262	14.833
437	2.25	4.4	6.65	2.5762	8.500
290	2.25	4.4	6.65	2.4619	9.667
564	2.25	4.4	6.65	2.3931	10.333
303	2.25	4.4	6.65	2.3604	11.300
277	2.25	4.4	6.65	2.2556	20.833
Average ± S E	2.25 ±0.00	4.4 ±0.00	6.65 ±0.00	2.35 ±0.071	12.58 ±1.71

Tabel - 8 a. Consolidated data on average mineral balance collected from the first and second metabolism trials during Pregnancy in cattle (Major minerals)

Particulars	Intake of Minerals (g/day)			Outgo of Minerals (g/day)			Balance of minerals	
	Concentrate	Grass	Total	Dung	Urine	Total	Retention (g/day)	Retention (% of intake)
Calcium								
First trial	11.16 ±0.00	22 ±0.00	33.16 ±0.00	21.04 ±5.11	0.512 ±0.23	21.55 ±5.0	11.61 ±5.00	35.02 ±15.08
Second trial	13.95 ±0.00	22 ±0.00	35.95 ±0.00	20.93 ±1.82	0.39 ±0.21	21.32 ±1.78	14.63 ±1.78	40.69 ±4.94
Average ± S E	12.56 ±0.40	22 ±0.0	34.56 ±0.40	20.98 ±2.72	0.45 ±0.16	21.44 ±2.66	13.12 ±2.69	37.85 ±7.99
Phosphorus								
First trial	18.9 ±0.0	13.2 ±0.0	32.10 ±0.0	24.47 ±1.88	0.51 ±0.28	24.98 ±1.85	7.12 ±1.85	22.19 ±5.78
Second trial	23.63 ±0.00	13.2 ±0.00	36.83 ±0.00	25.39 ±0.84	4.58 ±2.73	29.96 ±2.85	6.87 ±2.85	18.65 ±7.73
Average ± S E	21.27 ±0.40	13.2 ±0.0	34.47 ±0.68	24.93 ±1.04	2.54 ±1.50	27.47 ±1.85	7.00 ±1.70	20.42 ±4.86
Magnesium								
First trial	6.6 ±0.0	11.88 ±0.0	18.54 ±0.0	12.46 ±0.84	2.12 ±0.31	14.58 ±0.83	3.97 ±0.83	21.38 ±4.49
Second trial	8.33 ±0.0	11.88 ±0.0	20.21 ±0.0	6.38 ±0.95	2.36 ±0.46	8.74 ±0.65	11.47 ±0.65	56.76 ±3.22
Average ± S E	7.50 ±0.24	11.88 ±0.0	19.38 ±0.24	9.42 ±1.08	2.24 ±0.28	11.66 ±1.00	7.72 ±1.21	39.07 ±5.81

Tabel - 8 b. Consolidated data on average mineral balance collected from the first and second metabolism trials during Pregnancy in cattle (Trace Minerals)

Particulars	Intake of Minerals (mg/day)			Outgo of Minerals (mg/day)			Balance of Minerals	
	Concentrate	Grass	Total	Dung	Urine	Total	Retention (mg/day)	Retention (% of intake)
Copper								
First trial	102.56 ±0.00	65.78 ±0.00	168.34 ±0.00	62.87 ±2.93	0.59 ±0.08	63.46 ±2.96	104.88 ±2.96	62.31 ±1.76
Second trial	128.21 ±0.00	65.78 ±0.00	193.99 ±0.00	155.76 ±5.69	0.93 ±0.16	156.69 ±5.75	37.30 ±5.75	19.23 ±2.96
Average ± S E	115.39 ±3.71	65.78 ±0.00	181.17 ±3.71	109.32 ±13.80	0.76 ±0.10	110.07 ±13.86	71.09 ±10.29	40.77 ±6.46
Zinc								
First trial	141.03 ±0.00	152.50 ±0.00	293.53 ±0.00	172.30 ±7.90	4.54 ±3.90	176.84 ±8.45	116.69 ±8.45	39.76 ±2.88
Second trial	176.29 ±0.00	152.50 ±0.00	328.80 ±0.00	248.58 ±6.93	10.70 ±5.02	259.28 ±7.89	69.52 ±7.89	21.14 ±2.40
Average ± S E	158.66 ±5.10	152.50 ±0.00	311.17 ±5.10	210.44 ±12.22	7.62 ±3.08	218.06 ±3.08	93.11 ±8.94	30.45 ±3.28
Iron(g/day)								
First trial	1.94 ±0.00	4.13 ±0.00	6.07 ±0.0	3.31 ±0.20	0.002 ±0.0005	3.31 ±0.20	2.75 ±0.20	45.36 ±3.24
Second trial	2.42 ±0.00	4.13 ±0.00	6.55 ±0.00	2.92 ±0.08	0.0019 ±0.001	2.92 ±0.008	3.629 ±0.008	55.38 ±1.22
Average ± S E	2.18 ±0.29	4.13 ±0.00	6.31 ±0.07	3.12 ±0.12	0.0021 ±0.0004	3.12 ±0.12	3.19 ±0.17	50.37 ±2.26

4. Mineral Bioavailability Studies in Cattle during Lactation

Six adult cross bred lactating cows at 8th week of lactation maintained at University Cattle Breeding Farm, Thumburmuzhi, were selected for the study on bioavailability of minerals in cattle during lactation. The experimental animals were maintained on a basal concentrate mixture containing mineral mixture at 2% level and Napier grass as roughage. The animals were fed individually based on their requirement and daily dry matter intake were recorded. Wholesome water was provided *ad libitum* . All the experimental animals were maintained on identical conditions of feeding and management through out the course of the study. The percentage ingredient and chemical composition of the concentrate mixture are given in Annual Report(98-99).

Two metabolism trials each involving a collection period of 7 days duration were conducted, one at 14th week of lactation (first trial) and other at 18th week of lactation (2nd trial) with quantitative collection of dung and urine voided. Representative samples of feed, milk, dung and urine were analysed for mineral contents. From the data on the total intake in feed and outgo in dung, urine and milk, the balance with respect to each mineral was calculated. Data on average milk yield, dry matter intake and quantities of dung and urine voided during the first and second metabolism trials and the data on the balance (g/day) and retention as % of intake for Ca, P, Mg, Cu, Zn and Fe from the first and second metabolism trials were reported already (Annual Report 1998-99). Consolidated data on mineral balance in cattle during lactation are presented in table 1a & 1b.

Data showing in the mineral balances in cattle collected from the first and second trials during lactation are presented in table below.

From the data on calcium balance, it was seen that the average calcium retention is 16.29g/day during the first trial, the percentage retention being 32.60±7.00 and 34.33± 3.01 g/day during the second trial with % retention of 62.15 with the total average of the two trials being 25.31 ± 3.01g/day or 47.37 ± 6.04 as % of intake , where as the calcium retention as % of intake obtained in cattle during pregnancy, growth and maintenance are 37.85± 7.99, 26.4 ± 6.56 and -12.19± 6.01 respectively. As regards to the availability of P during lactation balance of P (g/day) obtained in the first and second trials are

15.76 ± 1.72 and 32.16 ± 2.49 with an average of 23.96 ± 2.81 and the corresponding retention as percentage of P intake being 23.14 ± 2.80 and 47.39 ± 3.07 with total average of 35.27%. The values obtained for % retention during maintenance, growth and pregnancy were 12.17 ± 6.48, 16.06± 3.26 and 20.42 ± 4.86 respectively. Balance of Mg (g/day) in lactating cows during the first and second metabolism trials are 11.36, 17.06 with the average of 14.21 g/day, the corresponding % retention are 39.25, 53.78 and 46.52 respectively. Average % Mg retention for maintenance, growth and pregnancy were 0.125 ± 4.25, 9.75 ± 1.97 and 39.07 ± 5.81 respectively

The average copper balance as copper retention (mg/day) by lactating cows are 243.90 ±10.93 during the first trial and 212.70 ± 11.26 during the second trial with an average of 228.30 ± 9.06 and the corresponding percentage retention being 66.02 ± 2.28, 58.87 ± 2.23 and 62.44 ± 1.90 respectively. On comparing the copper balance during maintenance, growth and pregnancy in cattle, the results showed a higher percentage retention of 80.73 ± 1.12 during maintenance then 40.77 ± 6.46 during pregnancy and the lowest value of 31.76 ± 3.14 during growth.

Regarding the utilization of zinc by lactating cows as revealed from the two trials the average daily retention (mg/day) and percentage of intake are 160.50 ± 26.23 and 29.45 ± 5.02% respectively for the first trial; 246.87 ± 23.80 and 43.64 ± 3.53% for the second trial with a total average of 203.69 ± 21.69 mg/day and 36.54 ± 3.70 % where as the average percentage retention of Zinc obtained for maintenance, growth and pregnancy were 8.66 ± 31.65, 0.29 ± 7.38 and 30.45 ± 3.28 respectively.

Regarding the utilization of iron by lactating cattle, positive balance was obtained in both trials, the iron retention as percentage of intake being 48.69 ± 3.38 and 40.71 ± 8.10 for the first and second trials respectively with an average value of 44.70 ± 4.54. The average percentage retention of iron for pregnancy, growth and maintenance were 50.37 ± 2.26, 21.20 ± 6.07 and 68.43 ± 7.99.

All the experimental animals were gaining in weight as revealed from the body condition. Results of the balance study indicated that all the minerals were well utilised by the animals.

Table - 9 a. Data on average daily dry matter intake and dung and urine voided during the metabolism trials on bioavailability of minerals in lactating cows (first trial)

Animal No.	Body Wt. (Kg)	DM intake from concentrate (Kg)	DM intake from grass (Kg)	Total DM intake (Kg)	Milk yield per day (Kg/day)	Total dung Output (DM basis) (Kg)	Total Qty. of urine voided (L)
383	313.00	5.70	3.25	8.95	8.60	3.303	13.967
484	303.00	5.90	2.25	8.15	8.53	4.174	13.333
354	333.00	5.85	3.25	9.10	7.83	3.686	19.133
394	293.00	5.10	3.00	8.10	5.23	2.841	15.667
307	357.00	5.80	3.50	9.30	8.67	4.870	11.033
326	310.00	5.58	3.50	9.08	5.60	4.768	11.333
Average ± SE	318.17 ± 8.63	5.66 ±0.11	3.13 ±0.17	8.78 ±0.19	7.41 ± 0.59	3.94 ± 0.30	14.08 ± 1.12

Table - 9 b. Data on average daily dry matter intake and dung and urine voided during the metabolism trials on bioavailability of minerals in lactating cows (second trial)

Animal No.	DM intake from concentrate (Kg)	DM intake from grass (Kg)	Total DM intake (Kg)	Milk yield per day (Kg/day)	Total dung Output (DM basis) (Kg)	Total Qty. of urine voided (L)
383	5.40	5.20	10.60	8.33	3.856	12.333
484	4.95	5.60	10.55	7.17	3.687	11.500
354	4.90	4.50	9.40	8.10	3.768	17.833
394	5.10	4.50	9.60	4.93	3.204	19.600
307	4.90	4.00	8.90	9.03	3.817	17.000
326	5.25	4.50	9.75	5.50	3.207	13.833
Average ± SE	5.08 ± 0.08	4.72 ± 0.22	9.80 ± 0.25	7.18 ± 0.61	3.59 ± 0.11	15.35 ±1.22

Table - 10 a. **Consolidated data on average mineral balance collected from the First and Second metabolism trials during lactation in Cattle Major minerals**

Particulars	Intake of minerals(g/day)			Outgo of minerals (g/day)				mineral balance	
	Concentrate	Grass	Total	Dung	Urine	Milk	Total	Retention (g/day)	Retention (% of intake)
Calcium									
Ist trial	35.06 ± 0.68	15.63 ± 0.87	50.69 ± 1.03	25.26 ± 3.88	0.25 ± 0.13	8.89 ± 0.71	34.40 ±4.07	16.29 ±3.50	32.60 ±7.00
IInd trial	31.52 ± 0.48	23.58 ± 1.08	55.10 ± 1.29	11.80 ± 2.51	0.35 ± 0.26	8.61 ±0.73	20.77 ±2.68	34.33 ±3.01	62.15 ±4.89
Average	33.29 ± 0.66	19.60 ±1.34	52.89 ±1.05	18.53 ±3.02	0.30 ±0.14	8.75 ±0.51	27.59 ±3.14	25.31 ±3.49	47.37 ±6.04
Phosphorus									
Ist trial	59.38 ±1.15	9.38 ± 0.52	68.75 ±1.20	44.62 ± 2.77	0.97 ± 0.47	7.41 ±0.59	53.00 ± 2.65	15.76 ±1.72	23.14 ±2.80
IInd trial	53.38 ± 0.81	14.15 ± 0.65	67.53 ±1.17	27.50. ± 1.36	0.69 ± 0.18	7.18 ± 0.61	35.37 ± 1.66	32.16 ±2.49	47.39 ±3.07
Average ± SE	56.38 ±1.12	11.76 ±0.81	68.14 ±0.86	36.06 ±2.92	0.83 ±0.25	7.29 ±0.43	44.18 ±2.99	23.96 ±2.81	35.27 ±4.08
Magnesium									
Ist trial	20.93 ± 0.41	8.44 ± 0.47	29.37 ± 0.58	14.32 ± 2.40	3.02 ± 0.54	0.67 ± 0.06	18.01 ± 2.40	11.36 ± 2.03	39.25 ± 7.56
IInd trial	18.81 ± 0.28	12.74 ± 0.58	31.55 ± 0.72	11.60 ±1.90	2.16 ± 0.48	0.72 ± 0.06	14.48 ± 2.11	17.06 ± 2.35	53.78 ± 6.93
Average ± SE	19.87 ± 0.39	10.59 ±0.72	30.46 ±0.56	12.96 ±1.58	2.59 ±0.38	0.69 ±0.04	16.25 ±1.68	14.21 ±1.76	46.52 ±5.55

Table - 10b. Consolidated data on average mineral balance collected from the first and second metabolism trials during lactation in cattle (Trace Minerals)

Particulars	Intake of Minerals (mg/day)			Outgo of Minerals (mg/day)				Mineral balance	
	Concentrate	Grass	Total	Dung	Urine	Milk	Total	Retention (mg/day)	Retention (%of intake)
Copper									
Ist trial	322.22	46.72	368.94	122.81	0.76	1.48	125.05	243.90	66.02
	± 6.26	±2.61	± 6.46	± 8.10	± 0.04	± 0.12	± 8.04	±10.93	± 2.28
IInd trial	289.65	70.52	360.17	145.32	0.71	1.44	147.47	212.70	58.87
	± 4.39	± 3.22	± 6.12	± 6.22	± 0.11	± 0.12	± 6.23	±11.26	± 2.23
Average	305.94	58.62	364.55	134.06	0.73	1.46	136.26	228.30	62.44
± SE	± 6.07	±4.02	±4.63	±6.06	±0.06	±0.09	±6.04	±9.06	±1.90
Zinc									
Ist trial	443.07	108.32	551.39	356.72	1.26	32.90	390.88	160.50	29.45
	± 8.61	± 6.04	± 9.86	± 31.13	± 0.13	± 3.87	± 32.63	± 26.23	± 5.02
IInd trial	398.28	163.48	561.76	289.64	1.32	23.93	314.89	246.87	43.64
	± 6.03	± 7.46	± 10.82	± 16.37	± 0.14	± 2.74	± 15.82	±23.80	±3.53
Average	420.68	135.90	556.57	323.18	1.29	28.41	352.89	203.69	36.54
± SE	± 8.34	±9.31	±7.48	±20.10	±0.10	±2.70	±21.22	±21.69	±3.70
Iron									
First trial	6081.95	2935.35	9017.30	4610.09	2.49	9.63	4622.22	4395.08	48.69
	± 118.17	±163.69	±189.15	± 320.95	± 0.38	± 0.76	± 320.67	± 335.38	± 3.38
Second trial	5467.13	4430.42	9897.54	5832.73	2.25	9.33	5844.31	4053.24	40.71
	± 82.77	± 202.17	± 238.90	± 798.82	± 0.43	± 0.80	± 797.78	±846.33	±8.10
Average	5774.54	3682.88	9457.42	5221.41	2.37	9.48	5233.26	4224.16	44.70
± SE	± 114.51	±252.27	±198.64	±465.85	±0.29	±0.55	±465.32	±458.48	±4.54

5. Studies on the Bioavailability of Minerals in Cattle during maintenance using grass as roughage instead of paddy straw

Mineral bioavailability study conducted in adult non pregnant, non-producing cows during maintenance using basal concentrate mixture containing 2 % mineral mixture and paddy straw as roughage revealed negative balances for Ca in all the animals . High oxalate content in paddy straw may be the reason for the poor Ca availability . Slightly negative balances were also obtained for Mg in most of the animals though the average value was on the positive side. Considering the poor availability of minerals while paddy straw was used as roughage another experiment was planned to study the mineral availability in cattle during maintenance using green grass as roughage instead of paddy straw to rule out the adverse effect of oxalate or any other factors on the availability of Ca and other minerals.

Six adult non pregnant, non producing (dry) Cross bred cows selected from the University cattle breeding farm, Thumburmuzhi formed the subjects for the experiment. The experimental animals were fed on a basal concentrate mixture containing 2 % mineral mixture and green grass as roughage for a period of three months. Percentage ingredient composition of concentrate mixture mineral composition of feed, grass and mineral mixture used for the study are given in table 89 and 90 respectively in annual report 98-99. Fresh wholesome water was provided *ad libitum* . All the experimental animals were maintained on identical conditions of feeding and management throughout the period of study. Towards the end of feeding trial a metabolism trial of seven days duration was conducted with quantitative collection of dung and urine voided. The representative samples of feed, dung and urine were analysed for the mineral contents. From the data on the total intake from concentrate and roughage and outgo through dung and urine the balance with respect to each mineral was calculated. Data on total dry matter intake, quantities of dung and urine voided during the metabolism trial and their mineral

composition and results on the balance study of Ca, P, Mg, Cu, Zn and Fe were reported in annual report (98-99) and consolidated results are presented in table 1a & 1b of the present report.

Results

Data obtained on the balance of different minerals from the present study are presented in table below.

Data on Ca balance revealed that all the experimental animals were having a positive Ca balance. The average Ca balance as retention(g/day) in the present study is 13.35±0.57 the corresponding percentage retention being 39.19%±1.68 as against a per day intake of 11.16g from concentrate and 23g from grass with a total intake of 34.16g. On comparing the results on mineral bioavailability during maintenance using paddy straw Vs grass as roughage along with the basal concentrate mixture it could be seen that bioavailability of Ca is significantly high from grass based ration, retention being 13.35±0.57g/day while that from paddy straw based ration was on the negative side, where the animals showed an average negative retention of -4.24±2.4g/day against a per day intake of 15.98g from concentrate and 19.06 g from paddy straw with a total intake of 35.05g/day. Hence Ca supplementation is necessary when paddy straw alone is being used as roughage along with the basal concentrate mixture.

As regards the utilization of phosphorous in dry animals maintained on basal concentrate mixture and grass as roughage, the experimental animals showed an average retention of 20.85±0.79g/day and 57.99±2.21% against a total P intake of 35.94g/day and on comparing the results in the present study with that in dry animals fed on paddy straw and concentrate mixture for maintenance. It can be seen that though the animals showed a positive Phosphorous balance, the per day retention was comparatively low, the value being 12.17% .

Regarding the Mg utilization, also better utilization was recorded when green grass is used as roughage. All the animals showed a positive balance. The average retention being 4.28±1.15g/day and 18.8±5.05% of intake , where as the majority of the animals showed slightly negative balance when maintained on paddy straw as roughage instead of grass though the average value was towards the positive side, retention being only 0.03g/day and 0.125±4.25% .

Regarding the bioavailability of trace elements all the experimental animals showed positive balances of Cu, Zn and Fe. The average retention of Cu registered by the experimental animals in the present study is 68.9±4.01mg/day which comes to 52.99±3.08% of the total intake. Data on balance of Zinc and Iron revealed that the average percentage retention of Zn and Fe were 54.62±2.52 and 53.54±4.42 respectively. From the comparison of data it could be seen that all the trace elements were well utilized in both trials during maintenance using grass or straw as roughage.

On comparing the data on mineral balances during maintenance, growth, pregnancy and lactation as revealed from the consolidated data presented in table -1a and 1b on daily retention of each mineral, it can be seen that the utilization and bioavailability of various major as well as trace elements were very efficient in cows during lactation, pregnancy, growth and maintenance where green grass was used as the roughage. However the bioavailability of various minerals were found to be least in cows maintained on concentrate mixture and paddy straw as roughage instead of green grass particularly for calcium which showed negative balance. Hence Calcium supplementation is required when paddy straw alone is used as roughage.

Data showing the comparison of mineral balances in cattle during maintenance using grass vs paddy straw as roughage are presented below

STUDIES ON BIOAVAILABILITY OF MINERALS IN CATTLE DURING MAINTENANCE WHEN GRASS IS USED AS THE ROUGHAGE

Table - 11 a. Percentage ingredient and chemical composition of the concentrate mixture used.

Ingredients		Chemical Composition (on DMB)	
Groundnut cake (expeller)	30	Dry matter	90.04
Yellow maize	37	Crude protein	19.42
Rice polish	30	Crude fibre	7.30
Mineral mixture *	2	Ether extract	7.32
Common salt	1	Total ash	8.42
		Nitrogen free extract	57.54

* Keys forte manufactured by Kerala Solvent Extraction Ltd. Irinjalakuda, Thrissur.

Table - 11 b. Mineral composition of concentrate mixture, grass and mineral mixture used for the study on bioavailability of minerals in cattle during maintenance (On Dry Matter Basis)

Sample	Calcium (%)	Phosphorous (%)	Magnesium (%)	Copper (ppm)	Zinc (ppm)	Iron (ppm)
Concentrate mixture	0.62	1.00	0.37	56.98	78.35	1075
Green grass	0.50	0.39	0.35	5.97	24.86	849
Mineral mixture *	24.09	9.07	0.33	1632	3264	2342

* Keys forte manufactured by Kerala Solvent Extraction Ltd. Irinjalakuda, Thrissur.

Table - 11 c. Data on total dry matter intake and quantity of dung and urine voided per day during the metabolism trial on bioavailability of minerals in cattle during maintenance using grass as roughage

Animal No.	Body Weight (kg)	DM intake from Concentrate (kg)	DM intake from grass (kg)	Total DM Intake (kg/day)	Total dung output (DM Basis) (kg/day)	Total urine voided (Lit/day)
TM - 58	303	1.8	4.6	6.4	1.53	5.24
67	302	1.8	4.6	6.4	1.74	12.20
492	264	1.8	4.6	6.4	1.48	7.33
259	283	1.8	4.6	6.4	1.67	6.58
255	286	1.8	4.6	6.4	1.89	12.28
215	267	1.8	4.6	6.4	1.72	10.18
Average	284.17	1.8	4.6	6.4	1.67	8.97
± S.E	± 6.78	± 0.0	± 0.0	± 0.0	± 0.07	± 1.23

Table - 11 d. Consolidated Data On Mineral Balance Of Cattle During Maintenance (Grass As Roughage)

Minerals	Average Intake per day			Average outgo per day			Mineral balance per day	
	Concentrate	Grass	Total	Dung	Urine	Total	Retention	Retention
	(grams)			(grams)			(g/day)	(% of intake)
Calcium	11.16	23.00	34.16	20.48	0.331	20.82	13.35	39.19
	± 0.0	± 0.0	± 0.0	±0.57	±0.08	±0.57	±0.57	±1.68
Phosphorus	18.00	17.94	35.94	14.63	0.468	15.09	20.85	57.99
	± 0.0	±0.0	± 0.0	±0.82	±0.12	±0.80	±0.79	±2.21
Magnesium	6.66	16.10	22.76	16.62	1.87	18.48	4.28	18.80
	±0.0	± 0.0	±0.0	±1.19	±0.17	±1.48	±1.15	±5.05
	Intake(mg)			Outgo (mg)			Balance per day (mg)	
Copper	102.56	27.46	130.02	60.61	0.506	61.12	68.90	52.99
	±0.0	±0.0	±0.0	±3.98	±0.07	±4.01	±4.01	±3.08
Zinc	141.03	114.36	255.39	111.85	4.04	115.89	139.50	54.62
	±0.0	±0.0	±0.0	±5.05	±1.68	±6.45	±6.45	±2.52
Iron	1935	3905.4	5840.4	2704.27	8.97	2713.24	3127.15	53.54
	±0.0	±0.0	±0.0	±257.02	±3.20	±258.36	±258.37	±4.42

Table - 12. Data Showing The Comparison Of Mineral Balances In Cattle During Maintenance Using Grass Vs Paddy Straw As Roughage

Minerals	GRASS					PADDY STRAW				
	Average Intake per day			Mineral balance per day		Average intake per day			Balance/day	
	Conc.	Grass	Total	Retention	Retention	Conc.	Paddy straw	Total	Retention	
	(grams)			(g/day)	(% of intake)	(grams)			(g/day)	(%)
Calcium	11.16	23.00	34.16	13.35	39.19	15.98	19.06	35.05	-4.24	-12.19
	± 0.0	± 0.0	±0.0	±0.57	±1.68	± 0.0	±1.00	±1.00	±2.40	±6.01
Phosphorous	18.00	17.94	35.94	20.85	57.99	11.36	3.65	15.02	1.79	12.17
	± 0.0	± 0.0	±0.0	±0.79	±2.21	±0.0	±0.19	±0.19	±1.06	±6.48
Magnesium	6.66	16.10	22.76	4.28	18.80	5.68	6.09	11.77	0.03	0.13
	±0.0	± 0.0	± 0.0	±1.15	±5.05	±0.0	±0.32	±0.32	±0.56	±4.25
	Intake(mg)			(mg/day)	(% of intake)	(mg)			(mg/day)	(%)
Copper	102.56	27.46	130.02	68.90	52.99	78.81	207.24	286.05	231.16	80.73
	± 0.0	±0.0	±0.0	±4.01	±3.08	±0.0	±10.85	±10.88	±9.99	±1.12
Zinc	141.03	114.36	255.39	139.50	54.62	124.1	418.67	542.76	81.74	8.66
	±0.0	± 0.0	±0.0	±6.45	±2.52	±0.0	±21.94	±21.97	±169.00	±31.65
Iron	1935	3905.4	5840.4	3127.15	53.54	794.38	11630.43	12424.81	8568.00	68.43
	±0.0	±0.0	±0.0	±258.37	±4.42	±0.0	±609.69	±609.43	±1274.00	±7.99

6. Studies on the Mineral bioavailability in calves using common rations

Feeding Trial I

Mineral bioavailability studies were carried out in cross bred calves of 3 to 4 months of age group maintained on different basal concentrate mixtures containing 2% mineral mixture and green grass (congosignal) as roughage. Twelve female cross bred calves of 3 to 4 months of age group selected from the University cattle breeding farm, Thumburmuzhy were randomly divided into 2 groups viz. Group I and II of six calves in each as uniformly as possible with regard to age and weight. Before the commencement of the study all the experimental calves were dewormed and sprayed against ectoparasites. Experimental calves were maintained on two different concentrate mixtures, the ingredient, chemical and mineral composition of which are already reported (AR-99-00). Group I animals were fed concentrate mixture I containing 10% meat cum bone meal (Feed A) and group II, were fed concentrate mixture II containing 10% dried unsalted fish instead of 10% meat cum bone meal (Feed B). Fresh green grass was given as the roughage. All the calves were housed individually and maintained on identical conditions of feeding and management throughout the period of study. Fresh wholesome water was provided *ad libitum*. Animals were maintained on their respective dietary regime, for a period of 3 months. Records of daily dry matter intake and monthly body weight of the experimental calves were maintained. Data on monthly weight and average daily gain and summarised data on growth rate and feed efficiency of the calves are already reported (Annual Report. 99-00)

Towards the end of the feeding trial a metabolism trial was carried out with quantitative collection of dung and urine voided. Representative samples of feed and grass given to the experimental animals and dung and urine collected during the metabolism trial were analysed for the various major and trace minerals. Estimation of Ca, Mg, Cu, Zn and

Table - 13.1 Percentage ingredient composition of concentrate mixtures used - Feeding Trial I

Ingredients	Conc. Mixture I (Feed - A)	Conc. Mixture II (Feed - B)
Yellow Maize	35.50	35.50
Groundnut cake (expeller)	35.00	35.00
Meat cum bone meal (Carcass Meal)	10.00	Nil
Unsalted dried fish	Nil	10.00
Rice polish	10.00	10.00
Wheat bran	7.00	7.00
Mineral mixture	2.00	2.00
Salt	0.50	0.50

Table - 13.2 Percentage chemical composition of concentrate mixtures on dry matter basis - Feeding Trial I

	Chemical composition	
	Conc. Mix. I (Feed - A)	Conc. Mix. II (Feed - B)
Total Ash	11.30	11.40
Acid Insoluble Ash	2.93	5.90
Crude Fibre	5.14	2.70
Ether Extract	7.10	8.84
Crude Protein	25.93	25.31
NFE	50.53	51.75

Table - 13.3 Percentage mineral composition of Concentrate mixture, Grass and Meat cum bone meal used for the study(on DMB)

Sample	Ca (g %)	P (g %)	Mg (g %)	Cu (ppm)	Zn (ppm)	Fe (ppm)
Conc. Mix. I	1.78	1.30	0.557	21.50	52.20	702.69
Con. Mix. II	1.14	1.13	0.485	20.42	51.46	600.05
Grass	0.50	0.39	0.410	5.97	24.86	849.00
Meat cum bone meal	10.63	5.36	0.510	5.80	82.00	825.07

Table -13.4 Monthly body weight and average daily gain of experimental calves maintained on different rations

(Feeding Trial I)

Group	Animal No.	Monthly body weights (Kg)				Average daily gain(g)
		0	1	2	3	
I	541	49.5	60.5	69.0	77.0	313
	553	41.5	53.0	62.0	72.0	347
	551	40.5	50.0	62.0	71..0	347
	568	32.5	40.0	50.0	57.0	278
	567	32.0	43.0	50.0	63.0	352
	566	33.0	42.5	54.5	63.0	341
	Ave. ± S.E	**38.17 ±2.84**	**48.17 ±3.18**	**57.92 ±3.13**	**67.17 ±3.02**	**329.67 ±11.79**
II	545	55.5	67.0	75.0	86.0	347
	552	43.5	56.5	62.5	72.0	324
	564	34.0	44.0	55.0	60.0	295
	555	35.0	46.0	59.0	64.0	330
	569	29.5	39.0	51.0	63.0	381
	563	32.0	41.5	50.0	68.0	409
	Ave. ± S.E	**38.25 ±3.95**	**49.00 ±4.36**	**58.75 ±3.78**	**68.83 ±3.83**	**347.67 ±16.85**

Table - 13.5 Summarised data on average daily gain and dry matter intake of calves fed two dietary treatments - Feeding Trial I

Parameters	Ration I	Ration II
Average Initial Weight (Kg)	38.17	38.25
Average Final Weight (Kg)	67.17	68.83
Average Weight Gain (Kg)	29.00	30.58
Average Daily Gain (g)	330.00	348.00
Period of experiment (days)	88.00	88.00
Average Total Dry Matter Intake (Kg)	60.71	67.23
Average Daily Dry Matter Intake (Kg)	0.69	0.76

Table - 13.6 Data on daily Dry matter intake, dung and urine voided during the metabolism trial on bioavailability of minerals in calves - Feeding Trial I

Animal No.	Body Weight (Kg)	DMI concentrate (Kg)	DMI grass (Kg)	Total DMI (Kg/day)	Total dung outgo DMB (Kg/day)	Total urine voided (L/day)
			Group I (Feed - A)			
541	77.00	0.9	1.63	2.53	0.86	2.85
553	72.00	0.9	1.49	2.39	0.86	3.85
566	63.00	0.9	1.55	2.45	0.68	4.95
551	71.00	0.9	1.45	2.35	0.82	4.20
567	63.00	0.9	1.41	2.31	0.74	2.70
568	57.00	0.9	1.36	2.26	0.63	3.00
Aver.	**67.17**	**0.9**	**1.48**	**2.38**	**0.77**	**3.59**
±S.E	±3.02	±0.0	±0.04	±0.04	±0.04	±0.36
			Group II (Feed - B)			
569	63.00	0.9	1.57	2.47	0.59	3.10
552	72.00	0.9	1.42	2.32	0.74	2.90
545	86.00	0.9	1.49	2.39	0.74	3.05
564	60.00	0.9	1.43	2.33	0.64	3.20
555	64.00	0.9	1.49	2.39	0.84	4.63
563	68.00	0.9	1.43	2.33	0.58	1.90
Aver.	**68.83**	**0.9**	**1.47**	**2.37**	**0.69**	**3.13**
±S.E	±3.83	±0.0	±0.02	±0.02	±0.04	±0.36

Fe were carried out using Atomic Absorption Spectrophotometer (AAS-3110) and P by calorimetry (AOAC-1990). From the data on the total intake of minerals from the ration and total outgo through dung and urine, the balance with respect to each mineral was calculated. Data on average daily dry matter intake, dung and urine voided by the experimental animals, during the metabolism trial are already reported (Annual Report-99-00). The data on balance of different minerals estimated viz Ca, P, Mg, Cu, Zn and Fe are already reported and the consolidated data on average mineral balances of experimental animals maintained on concentrate mixture-I containing Meat cum bone meal (Group I) and concentrate mixture-II containing dried unsalted fish (Group II) are reported in AR-99-00. Summarised data showing the mineral utilization of experimental animals belonging to group I and II are presented below.

Results of the study on bioavailability of minerals in calves Feeding Trial I

Calcium

Regarding the Ca balance of experimental calves belonging to group I receiving concentrate mixture containing meat cum bone meal (group I) ranged from 2.92 to 13.66 with an average retention of 8.61±1.98 g/day, the corresponding percentage retention being 37.05±8.67 where as the Ca balance in group II averaged 7.89±1.65 which comes to 44.64±9.33 % of the intake. Consolidated data on Ca balance in calves from two trials reveals an average Ca retention of 8.25±1.23 g/day, which corresponds to a percentage retention of 40.85±6.19 against a total intake of 20.52±0.88 g/day. On comparison of the data, it can be seen that the percentage retention is more in group II receiving the control diet containing dried unsalted fish than that receiving experimental diet containing Meat cum bone meal even though on statistical analysis no significant difference could be seen.

Phosphorus

Regarding the Phosphorus utilization by calves fed on both diet, the data reveals an average retention of 6.9±0.81g/day and a percentage retention of 39.58 ±4.69 for group I, the corresponding values for group II are 7.01±1.05g/day 44.02±6.53.69 respectively while the total average for the two groups being 6.96±0.63 g/day and a percentage of 41.80±3.90 respectively against a total intake of 16.70±0.25g/day.

Magnesium

Data presented in table below indicate that calves of group I and II recorded an average Mg retention (g/day) of 0.81±0.69 and 1.17±0.82 respectively with a total average of 0.99±0.52 and the corresponding percentage retention are 7.35±6.26; 11.29±7.88 and 9.32 ±4.84 respectively.

Copper

Regarding the utilization of trace elements positive balances were recorded by all the calves in both groups. Group I calves registered an average daily retention of 12.76±1.91mg which comes to 45.40±6.98 percentage of the daily average intake of 28.20±0.24 mg while the values for group II are 15.57±2.52mg; 57.22±9.17 % and 27.17±0.14 mg respectively with a total average retention of 14.17±1.57mg/day and 51.31±5.78 as percentage of intake for the two groups.

Zinc

Data on dietary Zn intake, retention as g/day and as percentage of intake of the experimental calves of group I & II are depicted in table below. Average daily retention of Zn recorded by the calves of group I is 32.78±7.43 mg while the percentage retention being 39.59±9.26 percentage against an average intake of 83.81±0.99mg/day; and the corresponding values for group II calves are 43.49±1.36mg; 52.50±1.79 percentage and 82.90±0.58 mg respectively. Consolidated data on Zinc balance reveals that the average retention of the calves of both group is 38.14±3.95 mg per day and 46.05 ± 4.91 mg percentage against an average daily intake of 83.36±0.57 mg.

Iron

Regarding the utilization of dietary iron experimental calves belonging to both groups recorded a positive balance, the daily average retention as percentage of intake being 49.56 ± 7.4 for group I and 53.99±5.84 for group II with a total average of 51.78±4.55.

Table - 13.7 Consolidated data on average mineral balance in calves maintained on different rations - Feeding Trial I

Minerals		Intake of minerals (g/day)			Outgo of minerals (g/day)			Mineral balance	
		Conc.	Grass	Total	Dung	Urine	Total	Retention (g/day)	Retention (% of intake)
Major Minerals									
Ca	Ist Group	16.02 ±0.00	7.41 ±0.20	23.43 ±0.20	14.69 ±2.15	0.128 ±0.030	14.82 ±2.14	8.61 ±1.98	37.05 ±8.67
	IInd Group	10.26 ±0.00	7.36 ±0.12	17.62 ±0.12	9.62 ±1.59	0.115 ±0.050	9.73 ±1.61	7.89 ±1.65	44.64 ±9.33
Average ±S.E		13.14 ±0.87	7.38 ±0.11	20.52 ±0.88	12.15 ±1.49	0.121 ±0.03	12.27 ±1.49	8.25 ±1.23	40.85 ±6.19
P	Ist Group	11.7 ±0.0	5.78 ±0.16	17.48 ±0.16	7.13 ±0.44	3.45 ±0.48	10.58 ±0.87	6.90 ±0.81	39.58 ±4.69
	IInd Group	10.17 ±0.00	5.74 ±0.09	15.91 ±0.09	5.01 ±0.23	3.90 ±0.87	8.90 ±1.03	7.01 ±1.05	44.02 ±6.53
Average ±S.E		10.94 ±0.23	5.76 ±0.09	16.70 ±0.25	6.07 ±0.40	3.68 ±0.48	9.74 ±0.69	6.96 ±0.63	41.80 ±3.90
Mg	Ist Group	5.01 ±0.00	6.08 ±0.16	11.09 ±0.16	8.90 ±0.64	1.37 ±0.10	10.28 ±0.72	0.81 ±0.69	7.35 ±6.26
	IInd Group	4.37 ±0.00	6.03 ±0.10	10.40 ±0.10	8.19 ±0.71	1.04 ±0.16	9.23 ±0.83	1.17 ±0.82	11.29 ±7.88
Average ±S.E		4.69 ±0.10	6.06 ±0.09	10.75 ±0.14	8.55 ±0.47	1.21 ±0.10	9.75 ±0.55	0.99 ±0.52	9.32 ±4.84
Trace minerals									
Minerals		Intake of Minerals (mg/day)			Outgo of Minerals (mg/day)			Mineral balance	
		Conc.	Grass	Total	Dung	Urine	Total	Retention (mg/day)	Retention (% of intake)
Cu	Ist Group	19.35 ±0.00	8.85 ±0.24	28.20 ±0.24	14.62 ±2.02	0.82 ±0.06	15.44 ±2.05	12.76 ±1.91	45.40 ±6.98
	IInd Group	18.38 ±0.00	8.79 ±0.14	27.17 ±0.14	9.39 ±1.61	2.21 ±1.13	11.60 ±2.47	15.57 ±2.52	57.22 ±9.17
Average ±S.E		18.87 ±0.15	8.82 ±0.13	27.68 ±0.20	12.01 ±1.46	1.52 ±0.58	13.52 ±1.64	14.17 ±1.57	51.31 ±5.78
Zn	Ist Group	46.98 ±0.00	36.83 ±0.99	83.81 ±0.99	48.81 ±8.53	2.23 ±0.51	51.03 ±8.3	32.78 ±7.43	39.59 ±9.26
	IInd Group	46.31 ±0.00	36.59 ±0.58	82.90 ±0.58	37.67 ±1.90	1.73 ±0.57	39.40 ±1.63	43.49 ±1.36	52.50 ±1.79
Average ±S.E		46.65 ±0.10	36.71 ±0.55	83.36 ±0.57	43.24 ±4.50	1.98 ±0.37	45.22 ±4.40	38.14 ±3.95	46.05 ±4.91
Fe	Ist Group	632.42 ±0.00	1257.94 ±33.84	1890.36 ±33.84	843.16 ±152.37	122.57 ±37.33	965.73 ±159.23	924.62 ±126.27	49.56 ±7.40
	IInd Group	540.05 ±0.00	1249.45 ±19.90	1789.50 ±19.90	719.05 ±94.62	102.80 ±17.77	821.85 ±103.66	967.65 ±109.10	53.99 ±5.84
Average ±S.E		586.24 ±13.94	1253.70 ±18.78	1839.93 ±24.14	781.11 ±87.65	112.69 ±19.96	893.79 ±93.27	946.14 ±79.93	51.78 ±4.55

On comparing the mineral utilization of the calves belonging to group I maintained on concentrate mixture I containing Meat cum bone meal and group II maintained on Concentrate Mixture II in which Meat cum bone meal was fully replaced by dried unsalted fish, from the consolidated data presented below it can be seen that a comparatively higher percentage retention of Ca, P, Mg, Cu, Zn and Fe was recorded by group II calves when compared to group I calves indicating that minerals in fish meal is better utilized by calves than that of Meat cum bone meal. However on statistical analysis of the data on percentage retention of each mineral no significant difference could be observed between the two groups. Statistical analysis of the average daily gain in body weight of the calves of the two groups also did not revealed any significant differences . All the experimental calves were gaining in body weights during the course of study and all the minerals were well utilized.

Feeding Trial - II

After the first set of experiment mineral bioavailability studies were carried out in cross bred females calves of 5 to 6 months of age group maintained on different basal concentrate mixtures containing 2% mineral mixture and fresh green grass as roughage.

Twelve female cross bred calves of 5 to 6 months of age group weighing on an average 73kg selected from the University cattle Breeding Farm, Thumburmuzhi were divided into 2 groups viz, Group I and II of six calves in each as uniformly as possible with regard to age and weight. Before the commencement of study all the experimental calves were dewormed and sprayed against ecto parasites. Experimental animals of the two groups were maintained on two different concentrate mixtures, the ingredient, proximate and mineral composition of concentrate mixtures and green grass used are already reported (AR 99-00). Group II calves received concentrate mixture IV containing 10% fishmeal and group I calves received concentrate mixture III in which fish meal in concentrate mixture IV was fully replaced by silkworm pupae meal. All the calves were housed and fed individually and maintained on identical conditions of feeding and management through out the course of study. Fresh whole some water was fed *ad lib.*

Table - 14.1. Percentage ingredient composition of concentrate mixtures used - Feeding Trial II

Ingredients	Conc. Mixture III	Conc. Mixture IV
Yellow Maize	40.00	40.00
Silkworm pupae meal	10.00	Nil
Fish meal	Nil	10.00
Groundnut cake (expeller)	21.00	26.00
Wheat bran	26.00	21.00
Mineral mixture	2.00	2.00
Salt	1.00	1.00

Table -14.2 Percentage chemical composition of concentrate mixtures, grass and silk worm pupae meal on dry matter basis Feeding Trial - II

	Chemical composition			
	Grass	Conc. Mix. III	Conc. Mix. IV	Silk worm Pupae Meal
Total Ash	12.86	9.42	13.03	4.8
Acid Insoluble Ash	1.38	3.26	4.67	1.8
Crude Fibre	27.1	9.14	7.04	2.8
Ether Extract	2.00	3.85	2.72	4.1
Crude Protein	15.71	25.54	23.92	62.3
NFE	42.33	52.05	53.29	26.0

Table - 14.3 Percentage mineral composition of Concentrate mixture and Grass used for the study(on DMB) - Feeding Trial II

Sample	Ca (g %)	P (g %)	Mg (g %)	Cu (ppm)	Zn (ppm)	Fe (ppm)
Conc. Mix. III	0.69	0.93	0.51	16.00	53.13	857.00
Con. Mix. IV	1.02	1.10	0.45	18.01	59.56	681.00
Grass	0.45	0.33	0.30	7.46	75.38	448.00

Table - 14.4 Summarised data on average daily gain of calves

Parameters	Group I	Group II
Initial Weight	73.17	73.00
Final Weight	89.50	89.58
Total Weight gain	16.33	16.58
Period of experiment(days)	67.00	67.00
Average daily gain	0.244	0.247

Table - 14.5 Data on daily Dry matter intake, dung and urine voided during the metabolism trial on bioavailability of minerals in calves - Feeding Trial II

Animal No.	Body Weight (Kg)	DMI concentrate (Kg)	DMI grass (Kg)	Total DMI (Kg/day)	Total dung outgo DMB (Kg/day)	Total urine voided (L/day)
			Group I (Ration III)			
552	101.00	1.34	2.36	3.70	0.90	6.24
553	90.00	1.34	2.18	3.52	0.81	10.50
565	94.00	1.34	2.36	3.70	1.05	6.38
567	79.00	1.34	2.22	3.56	0.66	6.39
568	84.50	1.34	2.25	3.59	0.82	6.58
555	88.50	1.34	2.27	3.61	0.88	7.98
Aver.	89.50	1.34	2.27	3.61	0.85	7.35
±S.E	±3.10	±0.0	±0.03	±0.03	±0.05	±0.68
			Group II (Ration IV)			
541	103.00	1.34	2.28	3.62	0.89	6.55
547	99.00	1.34	2.25	3.59	0.93	7.21
563	95.00	1.34	2.30	3.64	0.81	6.71
566	83.50	1.34	2.30	3.64	0.86	7.29
569	84.00	1.34	1.98	3.32	0.82	8.43
564	73.00	1.34	2.27	3.61	0.77	8.41
Aver.	89.58	1.34	2.23	3.57	0.85	7.43
±S.E	±4.62	±0.0	±0.05	±0.05	±0.02	±0.33

Daily DMI and fortnightly body weight of experimental animals were recorded. The calves were maintained on their respective dietary regime for a period for 67 days.

Towards the end of the feeding trial a metabolism trial of 7 days duration was carried out with quantitative collection of dung and urine voided. Representative samples of feed and grass given to the experimental animals and dung and urine collected during the metabolism trial were analysed for the various major and trace minerals. Estimation of Ca, Mg, Cu, Zn and Fe were carried out using Atomic Absorption Spectrophotometer (AAS-3110) and P by calorimetry (AOAC-1990). From the data on the total intake of minerals from the ration and total outgo through dung and urine, the balance with respect to each mineral was calculated. Summarised data on average daily gain and dry matter intake of the calves, and also data on average daily dry matter intake, dung and urine voided by the experimental animals, during the metabolism trial are already reported (AR-99-00). The individual data on balance of different minerals estimated viz Ca, P, Mg, Cu, Zn and Fe and the consolidated data on average mineral balances of experimental animals maintained on concentrate mixture-III containing Silk worm pupae meal (Group I) and concentrate mixture-IV containing dried unsalted fish (Group II) are already reported (AR 99-00). Summarised data regarding the mineral balances of experimental animals belonging to group I and II are presented below.

Results of the study on bioavailability of minerals in calves-(Feeding trial II)

Calcium

Results on Ca balance revealed a +ve balance in all the experimental animals , the average Ca retention (g/day) being 10.72±0.35 and 12.95±0.44 respectively with a total average of 11.84±0.43g/day, corresponding percentage retention being 54.84. On statistical analysis significant differences was found in Ca intake and Ca balance between the two groups ($P<0.01$)

Eventhough the per day Ca retention is higher in group II animals compared to group I; animals maintained on concentrate mixture III containing 0.69% Ca (group I) and concentrate mixture IV having 1.02% Ca (group II) registered almost similar percentage retention of 55.08 and 54.59 indicating that increasing the dietary Ca from 0.69 to 1.02

is not increasing the percentage retention. On comparing the Ca balance data of the first feeding trial also, it can be observed that group I calves received concentrate mixture I containing 1.78 % Ca showed a lower % retention of 37.05 with a g/day retention of 8.61 while group II calves received concentrate mixtureII having 1.14% Ca registered a higher Ca retention of 44.64 as percentage of intake.

On scrutiny of the overall data on Ca balance of both trials it can be revealed that an inverse relation exists between the Ca % of the diet and % retention of Ca, as the calves maintained on concentrate mixture III, IV, II and I having a Ca content of 0.69, 1.02, 1.14 and 1.78 % respectively recorded an average percentage retention of 55.08, 54.09, 44.64 and 37.05 respectively.

Phosphorus

Regarding the Phosphorus utilization by calves fed on both diet, the data revealed an average retention of 9.59±0.61g/day and a percentage retention of 48.06 ±3.10 for group I , the corresponding values for group II are 12.11±0.43g/day and 54.77 respectively with a total average of 10.85g/day and 51.41% against a total intake of 21.03g per day for the two groups. Statistical analysis reveals significant difference ($P<0.01$) in the Phosphorus balance as g/day between the two groups. However no significant difference ($P>0.05$) could be observed when retention is measured as % of intake.

Magnesium

Data on Mg balance indicate that calves of group I and II recorded an average Mg retention (g/day) of 6.06±0.38 and 6.34±0.20 with a total average of 6.2±0.21 and the corresponding percentage retention of 44.48, 49.88 and 47.18 respectively with out any significant difference between the two groups though the Magnesium intake is significantly higher in group II ($p<0.01$)

Copper

Regarding the utilization of trace elements, positive copper balance were recorded by all the calves in both groups. Group I calves registered an average daily retention of 9.32±1.97mg which comes to 24.33±5.18 percentage of the daily average intake of 38.40±0.23 mg while the corresponding values for group II are 13.03±1.98mg; 31.85±4.69 % and 40.77±0.38 mg respectively with a total average of 11.17±1.45mg/day and

28.09±3.52 as percentage of intake respectively. On statistical analysis of the data on copper balance of the two groups significant difference ($p<0.01$) could be observed in the Cu intake between the groups while the Cu balance (g/day) or as percentage of intake did not differed significantly ($P>0.05$)

Zinc

Average daily retention of Zn recorded by the calves of group I is 113.05±10.07 mg while the percentage retention being 46.59±4.11 against an average intake of 242.56±2.27mg/day; and the corresponding values for group II calves are 122.27±14.91mg; 49.32±5.9 percentage and 247.91 mg respectively. Consolidated data on Zinc balance reveals that the average retention of the calves of both groups is 117.66±8.70 mg per day and 47.95 percentage against an average daily intake of 245.23±2.27 . On statistical analysis no significant difference could be observed in the Zn intake as well as Zn balance between the two groups ($P>0.05$)

Iron

Regarding the utilization of dietary iron experimental calves belonging to both groups recorded a positive balance, the daily average retention as percentage of intake being 52.63 ± 4.14 for group I and 57.83±2.77 for group II with a total average of 55.23±2.5. Though the Iron intake of the two groups differed significantly ($P<0.01$), daily retention was similar in both groups ($P>0.05$)

On comparing the mineral utilization of the calves belonging to group I maintained on concentrate mixture III containing Silk worm pupae meal and group II maintained on Concentrate Mixture IV containing fish meal, from the data presented in table 39 it can be seen that a comparatively higher percentage retention of Ca, P, Mg, Cu, Zn and Fe was recorded by group II calves compared to group I calves indicating that minerals in the ration IV is better utilized than ration III. However on statistical analysis of the data on per day retention of each mineral no significant difference could be observed between the two groups except for Ca and P($p<0.01$). All the experimental calves were gaining in weight during the course of study and all the minerals were well utilized..

Table – 14.6 Consolidated data on average mineral balance in calves maintained on different rations - Feeding Trial II

Major Minerals										
Minerals		Intake of minerals (g/day)			Outgo of minerals (g/day)			Mineral balance	
		Conc.	Grass	Total	Dung	Urine	Total	Retention (g/day)	Retention (% of intake)
Ca	I st Group	9.25 ±0.00	10.23 ±0.14	19.48 ±0.14	7.77 ±0.42	0.99 ±0.16	8.76 ±0.40	10.72 ±0.35	55.08 ±1.90
	II nd Group	13.67 ±0.00	10.04 ±0.23	23.71 ±0.23	9.77 ±0.31	0.99 ±0.11	10.76 ±0.33	12.95 ±0.44	54.59 ±1.56
Average ±S.E		**11.46 ±0.67**	**10.13 ±0.13**	**21.59 ±0.65**	**8.77 ±0.39**	**0.99 ±0.09**	**9.76 ±0.39**	**11.84 ±0.43**	**54.84 ± 1.17**
P	Ist Group	12.46 ±0.0	7.50 ±0.10	19.96 ±0.10	7.13 ±0.52	3.24 ±0.67	10.37 ±0.62	9.59 ±0.61	48.06 ±. 3.10
	IInd Group	14.74 ±0.00	7.36 ±0.17	22.10 ±0.17	8.88 ±0.45	1.11 ±0.22	9.99 ±0.40	12.11 ±0.43	54.77 ± 1.83
Average ±S.E		**13.6 ±0.34**	**7.43 ±0.10**	**21.03 ±0.34**	**8.01 ±0.42**	**2.18 ±0.47**	**10.18 ±0.36**	**10.85 ±0.52**	**51.41 ± 2.00**
Mg	Ist Group	6.83 ±0.00	6.82 ±0.09	13.65 ±0.09	6.67 ±0.43	0.92 ±0.13	7.59 ±0.43	6.06 ± 0. 38	44.48 ±2.94
	IInd Group	6.03 ±0.00	6.69 ±0.15	12.72 ±0.15	5.72 ±0.19	0.66 ±0.10	6.38 ±0.24	6.34 ±0.20	49.88 ±1.65
Average ±S.E		**6.43 ±0.12**	**6.76 ±0.09**	**13.19 ±0.16**	**6.19 ±0.27**	**0.79 ±0.09**	**6.98 ±0.30**	**6.2 ±0.21**	**47.18 ± 1.81**
Trace minerals									
Minerals		Intake of Minerals (mg/day)			Outgo of Minerals (mg/day)			Mineral balance	
		Conc.	Grass	Total	Dung	Urine	Total	Retention (mg/day)	Retention (% of intake)
Cu	Ist Group	21.44 ±0.00	16.96 ±0.23	38.40 ±0.23	26.42 ±1.87	2.67 ±1.17	29.08 ±2.07	9.32 ±1.97	24.33 ±5.18
	IInd Group	24.13 ±0.00	16.64 ±0.38	40.77 ±0.38	26.88 ±1.79	0.85 ±0.14	27.74 ±1.80	13.03 ±1.98	31.85 ±4.69
Average ±S.E		**22.79 ±0.41**	**16.80 ±0.22**	**39.58 ±0.41**	**26.65 ±1.24**	**1.76 ±0.63**	**28.41 ±1.32**	**11.17 ±1.45**	**28.09 ±3.52**
Zn	Ist Group	71.19 ±0.00	171.37 ±2.27	242.56 ±2.27	68.79 ±7.85	60.72 ±4.62	129.51 ±9.91	113.05 ±10.07	46.59 ±4.11
	IInd Group	79.81 ±0.00	168.10 ±3.81	247.91 ±3.81	64.31 ±2.19	61.32 ±15.47	125.64 ±14.90	122.27 ±14.91	49.32 ±5.90
Average ±S.E		**75.50 ±1.30**	**169.73 ±2.17**	**245.23 ±2.27**	**66.55 ±3.95**	**61.02 ±7.71**	**127.57 ±8.56**	**117.66 ±8.70**	**47.95 ±3.46**
Fe	Ist Group	1148.38 ±0.00	1018.45 ±13.47	2166.83 ±13.47	977.57 ±99.46	50.73 ±8.96	1028.30 ±95.19	1138.53 ±85.98	52.63 ±4.14
	IInd Group	912.54 ±0.00	999.04 ±22.66	1911.58 ±22.66	775.11 ±53.19	29.18 ±8.31	804.28 ±47.72	1107.30 ±61.39	57.83 ±2.77
Average ±S.E		**1030.46 ±35.60**	**1008.75 ±12.92**	**2039.21 ±40.53**	**876.34 ±61.91**	**39.95 ±6.68**	**916.29 ±61.05**	**1122.92 ±50.65**	**55.23 ±2.50**

Mineral requirements worked out by Multiple regression analysis

Data obtained on the mineral balance studies in calves using common rations of four different composition from the first and second feeding trials were subjected to multiple regression analysis for developing regression equations and mineral requirements are worked out. For regression analysis the variables selected are Body weight(kg), Daily Intake and Retention of Ca, P, Mg , Cu, Zn and Fe.

Based on the body weight , daily intake and retention of each mineral daily requirement was calculated using multiple regression equation.

$Y=a+b_1x_1+b_2x_2$

where Y is the intake, x_1 is the body weight and x_2 is the mineral retained per day. Assuming element balance zero , the intake by animals can be formed the requirement of the animal . Therefore requirement/kg body weight can be calculated as $\frac{a}{x_1}+b_1$

Calcium

With regard to Ca requirement only the data from 2nd feeding trial has been taken for regression analysis, since R^2 obtained is very low (0.072) when all the 24 observations of both trial are taken .

Except Calcium for all other minerals 24 observations obtained by combining the data of all the four rations have been considered where the R^2 in each case is above 0.6 and $P<0.01$.

$Y_{Ca} = 6.8458+0.0023X_1+1.228X_2$ n=12; $R^2=0.66$; $P<0.01$

Where Y_{Ca} = Ca intake (g/day) ADG - 250g .

X_1 = Body weight (89.54 kg)

X_2 = Ca balance g/day

From the present experiment the requirement of Ca was calculated as 0.079g/Kg Body weight. In other words of a calf weighing 78.77 kg Body weight required 6.22g.

Phosphorus

$Y_p=8.4278+0.0819\ X_1+0.447\ X_2$ $X_1=78.77$kg; n=24; $R^2=0.726$; $P<0.01$

Thus P requirement/kg Body weight = 0.189g

P requirement for a calf weighing by 78.77kg Body weight = 14.89g/day or 0.5% in the diet

Magnesium

Y_{Mg} = 7.823 + 0.0429 X_1+0.2239 X_2 X_1=78.77kg; n=24; R^2=0.714; P<0.01

Thus Mg Requirement / kg Body weight = 0.14g

Mg requirement for a calf weighing by 78.77 kg Body weight =11.20g/day or 0.37 % in the diet.

Copper

Y_{Cu} = 7.997+0.3451 X_1-0.1219 X_2 X_1=78.77kg; n=24; R^2=0.644; P<0.01

Thus requirement/kg Body weight = 0.447mg

Cu requirement for a calf weighing by 78.77Kg Body weight = 35.21mg/day or 11.78ppm in the diet

Zinc

Y_{Zn} = -92.17+2.1823 X_1+1.0855 X_2 X_1=78.77; n=24; R^2=0.826; P<0.01

Thus requirement /kg Body weight = 1.01 mg

Zn requirement for a calf weighing by 78.77 kg Body weight = 79.56mg/day or 26.61ppm in the diet.

Zn requirement of 25 ppm for older calves has been reported by Miller and Miller, 1962(Miller, J.K. and Miller W.J(1962) Experimental Zinc deficiency and recovery of calves *J. Nutr.* 76.467-474

WORK DONE DURING THE PERIOD UNDER REPORT

2000-2001

1. Studies on the bioavailability of minerals in calves

2. Enhancement of mineral bioavailability using ionophores

3. Feasibility of Wood ash and Egg shell powder as Calcium supplement in calf ration

16. Work done during the period under report

Mineral bioavailability studies in calves

Feeding trial III

As per the approved technical programme different bioavailability studies were planned and feeding trials are going on in goats and calves.

In calves four sets of feeding and metabolism trials involving six different calf rations were carried out to assess the bioavailability of different minerals during growth. Results of two sets of experiments were already reported in Annual Report 1999-2000 and summarised in present report(Annual report-2000-2001). Analytical works and tabulation of the results of third and fourth set of experiment have been completed and the results are presenting in this report.

Studies of the mineral bioavailability in calves and enhancement of bioavailability of minerals using ionophores

Certain carboxylic polyether ionophores when used as feed additives are found to improve growth rate and production performance in ruminants. Sodium monensin and Sodium lasalocid are the two carboxylic polyether ionophores commonly used as feed additives in beef-cattle industry, with improved feed-gain ratios. Recent research has demonstrated that a biologically active ionophore present in the gastro-intestinal tract alters the site and rate of absorption of macro and micro elements and thereby indicating that ionophores can alter the mineral requirements of the ruminants.

Hence an experiment was planned as a part of the mineral bioavailability studies in calves to study the effect of the ionophore viz, monensin sodium on mineral utilization in growing calves.

Twelve cross bred female calves of 5 to 6 months of age weighing on an average 67.5 kg selected from the University Cattle Breeding Farm, Thumburmuzhi formed the subjects for the study. The experimental calves were divided in to two groups viz, group I and group II of six calves in each, as uniformly as possible with regard to age and weight.

While group I calves received basal concentrate mixture supplemented with monensin sodium @ 25 ppm and green grass as roughage group II calves received basal concentrate mixture with out monensin and green grass as roughage. The ingredient composition, proximate composition and mineral composition of the concentrate mixture and green grass are presented in table 15, 16 and 17 respectively. All the experimental animals were housed and fed individually. Records of daily dry matter consumption and weekly body weights of the experimental calves were maintained throughout the experimental period. Wholesome water was offered *ad libitum*. The experimental animals were maintained on their respective dietary regime for a period of 84 days. Consolidated data on average growth rate and feed efficiency of the calves belonging to monensin supplemented group (group I) and non supplemented group (group II) are presented in table 18.

Two digestion cum metabolism trials were carried out during the fifth and 12th week of experiments each involving a collection period of 7 days duration with quantitative collection of dung and urine voided. Data on the average daily DMI, dung and urine voided by the calves during the first and second metabolism trials are presented in table 19 and 20 respectively. Representative samples of concentrate, grass, dung and urine collected during the metabolism trial were subjected to proximate analysis and mineral analysis(AOAC 1990) Estimation of Ca, Mg, Cu, Zn and Fe were carried out using Atomic Absorption Spectrophotometer model-AAS-3110 and P by calorimetry (AOAC - 1990).

From the data on metabolism trials and proximate analysis of dung and urine, digestibility coefficients of different nutrients viz, DM, OM, CP, CF, EE and NFE were calculated and compared between the two groups to study the effect of monensin on the nutrient digestibility. Data on the average digestibility coefficients of different nutrients obtained from the Ist and 2nd trials are presented in table 21 and 22 respectively. Data showing the nitrogen balance of the experimental calves belonging to group I and II are presented in table 23.

From the data on the total intake of minerals from the ration and outgo through dung and urine , the balance with respect to each mineral was calculated in terms of per day retention and retention as percentage of intake. The data on balance of different minerals estimated viz Ca, P, Mg, Cu, Zn and Fe are presented in table 24 to 46.

Results of the study on the effect of ionophore - Monensin on the mineral bioavailability and growth in calves

Data presented in table 24 on the Ca balance of experimental calves belonging to gp-I receiving concentrate mixture supplemented with 25 ppm monensin ranged from 2.45 to 10.01g with an average retention of 6.3±1.09g/day, the corresponding percentage retention being 39.45±6.81 where as the Ca balance in group II maintained on ration without supplementing monensin averaged a lower value of 5.29±0.72g/day which comes to only 32.81±4.63% of intake (P>0.05)

Average Ca balance (g/day) and as percentage of intake recorded by the monensin supplemented group during the second metabolism trial (table -25) comes to 8.45± 0.31 and 39.83±1.79 respectively while same for non supplemented group being 7.24± 0.4g and 34.23 ±1.71 respectively.

Consolidated data on Ca balance showing the average of both trials for the monensin supplemented and non supplemented group are presented in table 26. On comparing the data on Ca retention between two groups during both trials it can be seen that monensin supplemented group (group I) registered a higher average retention of 39.64± 3.36 percent against a total intake of 18.65±0.87g/day while the group II animals belonging to nonsupplemented group recorded only an average retention of 33.52±2.36% against an average intake of 18.67± 0.76(P>0.05), the percentage increase being 17.54 and 18.26 respectively in group I over group II for daily retention as g/day and percentage of intake.

Phosphorus

Data regarding the utilisation of P by calves belonging to monensin supplemented and non supplemented group are presented in table 27, 28 and 29. During the first metabolism trial group I calves fed on concentrate mixture with 25ppm monensin recorded an average retention of 13.03 ±0.55 g/day which corresponds to 57.72±2.43% against an average daily intake of 22.58±0.12g; the corresponding values for group II calves being only 11.80±0.58g/day 51.92±2.67% and 22.75±1.4g respectively . During the 2nd metabolism trial also group I calves showed a better P retention of 15.52±0.49/day the

percentage of intake being 58.52±2.17 when compared to nonsupplemented group (P<0.05) (table-46). Consolidated data taking the average of the two trials for each group (table-29) reveals that while group II recorded a retention of 51.40±1.81% monensin supplemented group (group II) recorded a higher percentage retention of 58.12±1.56 against an intake of 24.87 ±0.66 and 24.66±0.70g respectively.

Magnesium

Regarding the utilization of Mg by calves of monensin supplemented and non supplemented group, data presented in table 30, 31, 32, 42 and 43 indicates that group I and II recorded an average Mg retention (g/day) of 1.95±1.4 and 1.88±0.26 with a percentage retention of 25.96±1.84 and 24.82±3.67 during the first trial and 2.12±0.23 and 1.93±0.21g/day respectively during the 2nd trial with a corresponding percentage retention of 20.16±2.09 and 18.34±1.84 respectively. Consolidated data taking average of two trials(table 32) indicates that group I calves registers a percentage retention of 23.06±1.59 while group II registers almost similar value of 21.58±2.19(P>0.05)

Copper

Regarding utilization of Copper, positive balance were recorded by all the calves in both trials. (Table 33, 34, 35 and 44). Group I calves registered an average daily retention of 21.72±1.08mg in the first trial and 22.65 ±1.03mg in the second trial with an average of 22.18 ±0.73mg; the corresponding percentage retention being 48.35±2.47; 36.31±2.15 averaging 42.33±2.4 against an intake of 44.93±0.22; 62.72±1.80 and 53.82±2.82mg/day respectively.

Group II calves registered an average daily retention of 16.01±0.45mg and 15.50±1.33mg/day in the first and second metabolism trial respectively with an average of 15.76±0.67mg per day and the corresponding percentage retention being 35.41±1.15; 24.59±1.89 and 30±1.95 respectively against an intake of 45.26±0.27; 62.86±0.71 and 54.06±2.68 respectively.

On comparing the two groups (table 45 and 46) it can be seen that group I calves maintained on concentrate mixture supplemented with monensin(25ppm) recorded significantly higher copper balance (P<0.01) in both metabolism trials when compared to

nonsupplemented groups, the percentage increase in copper retention on monensin supplementation being 36.54 and 47.66 for the first and second metabolism trials respectively.

Zinc

Data on dietary Zn intake, retention as mg/day and as percentage of intake of the experimental calves of group I and group II are depicted in table 36 and 37 respectively for the first and second collection and the consolidated data in table 38. The average retention of Zn (mg/day) for the group I and group II are 122.50±7.25 and 88.05±11.42 respectively during the first metabolism trial and 110.06±7.41 and 79.87±14.13 respectively in the second trial. On comparing the data on Zn balance between the two groups (table 45 and 46) can be seen that monensin supplemented group (group I) recorded significantly higher ($P<0.05$) percentage retention of 51.04±3.07 against 36.50±4.79% for non supplemented group (group II) during first metabolism trial the same for the 2nd metabolism trial being 31.34±2.42 % against 22.45±3.76% ($P<0.01$). The results indicate that monensin supplementation at 25ppm in the concentrate mixture of calves enhanced the Zinc retention, the percentage of increase over the non supplemented group being 39.84 in the first and 39.60% in the second metabolism trial.

Iron

Regarding the utilization of dietary iron (table 39, 40 and 41) experimental calves belonging to both groups recorded almost similar positive balance ($P>0.05$) the average daily retention as percentage of intake being 38.94±1.68 for group I and 37.68±3.52 during Ist trial and 40.72±1.18 and 38.18±1.23 respectively in the 2nd trial with a total average of 39.83±1.01 and 37.93±1.78 for group I and II respectively.

Effect of Monensin on mineral retention

On comparing the mineral utilization of the calves belonging to group I maintained on concentrate mixture supplemented with monensin at 25ppm level and group II maintained on concentrate mixture without monensin from the data presented in tables 45 and 46 revealed that a higher percentage retention of Ca, P, Mg, Cu, Zn and Fe was recorded by group I calves indicating that monensin supplementation resulted in better utilization of minerals. However on statistical analysis of the data on daily retention as percentage of intake no significant difference could be observed for Ca, P, Mg and Fe while Cu and Zn increased significantly ($P<0.01$). All the experimental calves were gaining in weight during the course of study and all the minerals were well utilized. Summarised data on the growth rate and feed efficiency (table 18) and digestibility coefficient of nutrients (table 21 and 22) and Nitrogen balance (table 23) are also found to be comparatively higher in monensin supplemented group, though not differed statistically.

STUDIES ON THE ENHANCEMENT OF BIOAVAILABILITY OF MINERALS IN CALVES USING IONOPHORE-MONENSIN

Table - 15. Percentage ingredient composition of concentrate mixtures used

Ingredients	Conc. Mixture I (Feed - A)	Conc. Mixture II (Feed - C)
Soyabean	33.00	33.00
Black gram husk	16.00	16.00
Maize	16.00	16.00
Rice bran	16.00	16.00
Wheat bran	16.00	16.00
Mineral mixture	2.00	2.00
Salt	1.00	1.00
Monensin*	25 ppm	Nil

* Monensin Sodium (Coban) was added at the rate of 25g per 100kg feed.

Table - 16. Percentage chemical composition of concentrate mixtures and grass on dry matter basis

	Chemical composition	
	Conc. Mixture	Grass
Total Ash	11.79	10.34
Acid Insoluble Ash	5.56	4.93
Crude Fibre	14.35	26.68
Ether Extract	1.38	2.41
Crude Protein	24.91	10.15
NFE	47.57	50.42

Table - 17. Percentage mineral composition of Concentrate mixture and Grass used for the study(on DMB)

Sample	Ca (g %)	P (g %)	Mg (g %)	Cu (ppm)	Zn (ppm)	Fe (ppm)
Conc. Mixture	0.60	1.03	0.29	20.67	112.03	1693.70
Grass(Ist Trial)	0.45	0.36	0.20	6.9	34.48	857.06
Grass(IInd Trial)	0.49	0.28	0.25	10.87	66.49	1086.96

Table - 18. Summarised data on Growth rate & Feed Efficiency of calves maintained under two dietary treatments

Parameters	Ration A	Ration C
Average initial weight (kg)	66.67 ±4.43	68.33 ±3.79
Final weight (kg)	92.00 ±6.19	91.67 ±6.68
Average Daily Gain(kg)	0.302 ±0.03	0.278 ±0.05
Daily Dry Matter Intake(kg)	3.53	3.55
Feed Efficiency(kg)	11.85	12.62

Table - 19. Data on daily Dry matter intake, dung and urine voided during the first metabolism trial

Animal No.	Body Weight (Kg)	DMI concentrate (Kg)	DMI grass (Kg)	Total DMI (Kg/day)	Total dung outgo DMB (Kg/day)	Total urine voided (L/day)
			Group I (Feed A -Monensin supplimented group)			
599	97.50	1.78	1.17	2.95	1.14	5.00
604	76.00	1.78	1.21	2.99	0.94	4.00
609	69.50	1.78	1.19	2.97	1.04	3.30
612	83.00	1.78	1.25	3.03	1.24	3.70
615	70.00	1.78	1.03	2.81	0.91	2.00
618	61.00	1.78	1.23	3.01	0..78	2.00
Aver.	**76.17**	**1.78**	**1.18**	**2.96**	**1.01**	**3.33**
±S.E	±5.21	±0.0	±0.03	±0.03	±0.07	±0.48
			Group II (Feed - C)			
601	101.00	1.78	1.33	3.11	1.24	5.90
606	75.00	1.78	1.11	2.89	0.88	5.30
608	71.00	1.78	1.13	2.91	0.82	5.80
611	68.00	1.78	1.23	3.01	0.93	4.70
613	74.00	1.78	1.33	3.11	1.03	5.90
564	71.00	1.78	1.23	3.01	0.99	5.30
Aver.	**76.67**	**1.78**	**1.23**	**3.01**	**0.98**	**5.48**
±S.E	±4.97	±0.00	±0.04	±0.04	±0.06	±0.19

Table 20. Data on daily Dry matter intake, dung and urine voided during the second metabolism trial

Animal No.	Body Weight (Kg)	DMI concentrate (Kg)	DMI grass (Kg)	Total DMI (Kg/day)	Total dung outgo DMB (Kg/day)	Total urine voided (L/day)
			Group I (Feed - A)			
599	118.00	2.23	1.98	4.21	1.19	5.80
604	92.00	2.23	1.79	4.02	1.28	6.30
609	83.50	2.09	1.88	3.93	1.05	5.00
612	99.00	1.87	1.89	3.76	1.07	3.95
615	85.50	2.14	1.87	4.01	1.03	4.90
618	69.50	2.05	1.23	3.28	0..83	4.80
Aver. ±S.E	91.25 ±6.69	2.10 ±0.06	1.77 ±0.11	3.87 ±0.13	1.08 ±0.06	5.13 ±0.34
			Group II (Feed - C)			
601	125.00	2.09	1.56	3.65	1.29	4.60
606	84.50	2.09	1.71	3.80	1.26	9.00
608	81.00	2.23	1.51	3.74	1.27	7.90
611	83.00	2.23	1.68	3.91	1.24	4.60
613	87.00	2.14	1.77	3.91	1.20	4.00
564	81.00	2.23	1.73	3.96	0.94	9.50
Aver. ±S.E	90.25 ±7.01	2.17 ±0.03	1.66 ±0.04	3.83 ±0.05	1.20 ±0.05	6.60 ±1.01

Table - 21 . Digestibility Coefficients of Nutrients in calves during the First metabolism trial

Animal No.	Dry Matter	Organic Matter	Crude Protein	Crude Fibre	Ether Extract	Nitrogen Free Extract
Group I						
599	61.35	65.48	77.31	59.81	53.79	63.51
604	68.56	71.43	78.96	68.30	43.12	70.79
609	64.98	68.33	78.42	68.11	30.58	65.86
612	59.07	64.08	78.46	58.96	32.91	61.73
615	67.61	71.74	79.03	80.22	37.65	66.76
618	74.09	76.93	81.46	78.01	48.71	75.79
Average	**65.94**	**69.67**	**78.94**	**68.90**	**41.13**	**67.41**
±S.E.	**±2.20**	**± 1.92**	**±0.56**	**±3.62**	**±3.71**	**±2.09**
Group II						
601	60.13	63.22	76.50	57.05	30.69	61.89
606	69.55	71.32	80.27	72.00	49.61	68.32
608	71.82	74.19	81.76	69.58	54.25	73.75
611	69.10	71.69	79.65	67.29	50.37	71.15
613	66.88	69.51	79.82	70.89	48.32	65.83
616	67.11	69.97	80.29	68.87	48.15	67.22
Average	**67.43**	**69.98**	**79.72**	**67.61**	**46.90**	**68.03**
±S.E.	**±1.63**	**±1.51**	**±0.71**	**±2.21**	**±3.36**	**±1.69**

Table - 22. Digestibility Coefficients of Nutrients in calves during the second metabolism trial

Animal No.	Dry Matter	Organic Matter	Crude Protein	Crude Fibre	Ether Extract	Nitrogen Free Extract
Group I						
599	71.85	73.86	81.83	77.39	49.10	70.42
604	68.15	70.31	74.81	76.32	30.48	67.64
609	73.47	76.19	78.55	83.11	59.37	73.14
612	71.46	73.49	78.63	80.12	55.68	69.57
615	74.33	76.72	80.35	84.74	57.44	72.82
618	74.60	76.14	81.79	77.40	49.82	74.38
Average	**72.31**	**74.45**	**79.33**	**79.85**	**50.32**	**71.33**
±S.E.	±0.98	±0.99	±1.07	±1.40	±4.30	±1.04
Group II						
601	64.71	67.13	74.96	72.35	47.66	62.79
606	66.73	68.45	75.06	77.41	43.71	63.24
608	65.93	68.67	72.32	68.45	42.68	68.28
611	68.20	69.70	75.35	80.55	53.72	63.75
613	69.59	72.78	76.45	76.66	45.64	70.83
616	75.95	77.09	83.38	82.90	62.27	72.95
Average	**68.52**	**70.64**	**76.25**	**76.38**	**49.28**	**66.97**
±S.E.	±1.64	±1.50	±1.53	±2.16	±3.05	±1.77

Table - 23. Data on average Nitrogen balance of experimental animals during I[st] metabolism trial

Group	Nitrogen Intake from Conc. (g/day)	Nitrogen Intake grass (g/day)	Nitrogen Intake Total (g/day)	Nitrogen outgo through Dung (g/day)	Nitrogen outgo through Urine (g/day)	Total outgo (g/day)	Nitrogen Retention (g/d)	Nitrogen Retention (% of intake)
I	70.92 ±0.0	19.16 ±0.52	90.08 ±0.52	18.97 ±0.50	33.58 ±3.87	52.55 ±4.33	37.53 ±4.25	41.68 ±4.75
II	70.92 ±0.0	19.97 ±0.66	90.89 ±0.66	17.85 ±0.54	38.36 ±7.39	56.20 ±7.36	34.69 ±7.25	38.20 ±7.99

Table - 24. Enhancement of mineral bioavailability using ionophores -(monensin)

Calcium Balance (Ist Trial)

Anim. No.	Intake of Calcium (gram per day) Conc.	Grass	Total	Outgo of Calcium (gram per day) Dung	Urine	Total	Calcium balance Retention (g/day)	Retention (% of intake)
Group - I (Feed A) (Monensin supplemented group)								
599	10.68	5.27	15.95	10.60	0.08	10.68	5.27	33.04
604	10.68	5.45	16.13	6.02	0.104	6.12	10.01	62.06
609	10.68	5.36	16.04	11.02	0.109	11.13	4.91	30.61
612	10.68	5.63	16.31	13.76	0.104	13.86	2.45	15.02
615	10.68	4.64	15.32	8.37	0.06	8.43	6.89	44.97
618	10.68	5.54	16.22	7.88	0.07	7.95	8.27	50.99
Average + SE	10.68 ±0.00	**5.32** ±0.14	**16.00** ±0.14	**9.61** ±1.12	**0.09** ±0.008	**9.70** ±1.12	**6.3** ±1.09	**39.45** ±6.81
Group - II (Feed C) (Non supplemented group)								
601	10.68	5.99	16.67	14.01	0.271	14.28	2.39	14.34
606	10.68	5.00	15.68	10.21	0.159	10.37	5.31	33.86
608	10.68	5.09	15.77	8.28	0.174	8.45	7.32	46.42
611	10.68	5.54	16.22	9.21	0.226	9.44	6.78	41.80
613	10.68	5.99	16.67	10.92	0.177	11.10	5.57	33.41
616	10.68	5.54	16.22	11.68	0.159	11.84	4.38	27.00
Average ± S.E	**10.68** ±0.00	**5.53** ±0.17	**16.21** ±0.17	**10.72** ±0.82	**0.194** ±0.018	**10.91** ±0.83	**5.29** ±0.72	**32.81** ±4.63

Table - 25. Enhancement of mineral bioavailability using ionophore (Monensin)
Calcium Balance (IInd Trial)

Anim. No.	Intake of Calcium (gram per day) Conc.	Grass	Total	Outgo of Calcium (gram per day) Dung	Urine	Total	Calcium balance Retention (g/day)	Retention (% of intake)
Group - I. (Feed A) (Monensin supplemented group)								
599	13.38	9.70	23.08	14.76	0.255	15.02	8.06	34.92
604	13.38	8.77	22.15	13.18	0.176	13.36	8.79	39.68
609	12.54	9.21	21.75	12.81	0.380	13.19	8.56	39.36
612	11.22	9.26	20.48	10.49	0.277	10.77	9.71	47.41
615	12.84	9.16	22.00	13.70	0.314	14.01	7.99	36.32
618	12.30	6.03	18.33	10.62	0.144	10.76	7.57	41.30
Average ± SE	**12.61 ±0.33**	**8.69 ±0.55**	**21.30 ±0.68**	**12.59 ±0.70**	**0.258 ±0.036**	**12.85 ±0.71**	**8.45 ±0.31**	**39.83 ±1.79**
Group - II.(Feed C) (Non supplemented group)								
601	12.54	7.64	20.18	13.03	0.046	13.08	7.10	35.18
606	12.54	8.38	20.92	13.61	0.108	13.72	7.20	34.42
608	13.38	7.40	20.78	14.35	0.079	14.43	6.35	30.56
611	13.38	8.23	21.61	14.51	0.285	14.80	6.81	31.51
613	12.84	8.67	21.51	14.64	0.040	14.68	6.83	31.75
616	13.38	8.48	21.86	12.50	0.190	12.69	9.17	41.95
Average ± SE	**13.01 ±0.17**	**8.13 ±0.20**	**21.14 ±0.26**	**13.77 ±0.36**	**0.125 ±0.039**	**13.90 ±0.36**	**7.24 ±0.40**	**34.23 ±1.71**

Table - 26. Enhancement of mineral bioavailability using ionophores-monensin Consolidated data on Calcium balance

Particulars		Intake of Calcium (g/day)			Outgo of Calcium (g/day)			Calcium balance	
		Conc.	Grass	Total	Dung	Urine	Total	Retention (g/day)	Retention (% of intake)
Group I (Monensin supplemented)									
Ist Trial	Average	10.68	5.32	16.00	9.61	0.09	9.70	6.30	39.45
	±S.E	±0.00	±0.14	±0.14	±1.12	±0.008	±1.12	±1.09	±6.81
II nd Trial	Average	12.61	8.69	21.30	12.59	0.258	12.85	8.45	39.83
	±S.E	±0.33	±0.55	±0.68	±0.70	±0.036	±0.71	±0.31	±1.79
Average		11.65	7.00	18.65	11.10	0.173	11.27	7.37	39.64
±S.E		±0.33	±0.58	±0.87	±0.77	±0.03	±0.79	±0.63	±3.36
Group II (Without Monensin)									
Ist Trial	Average	10.68	5.53	16.21	10.72	0.194	10.91	5.29	32.81
	±S.E	±0.00	±0.17	±0.17	±0.82	±0.018	±0.83	±0.72	±4.63
IInd Trial	Average	13.01	8.13	21.14	13.77	0.125	13.90	7.24	34.23
	±S.E	±0.17	±0.20	±0.26	±0.36	±0.039	±0.36	±0.40	±1.71
Average		11.85	6.83	18.67	12.25	0.160	12.41	6.27	33.52
±S.E		±0.36	±0.41	±0.76	±0.63	±0.02	±0.62	±0.49	±2.36

Table - 27. Enhancement of mineral bioavailability using ionophores (monensin)
Phosphorus Balance (Ist Trial)

Anim. No.	Intake of Phosphorus (g/day)			Outgo of Phosphorus (g/day)			Phosphorus balance	
	Conc.	Grass	Total	Dung	Urine	Total	Retention (g/day)	Retention (% of intake)
Group - I (Feed A) (Monensin supplemented group)								
599	18.33	4.21	22.54	6.61	3.20	9.81	12.73	56.48
604	18.33	4.36	22.69	7.05	2.08	9.13	13.56	59.76
609	18.33	4.28	22.61	10.09	1.65	11.74	10.87	48.08
612	18.33	4.50	22.83	8.31	1.92	10.23	12.60	55.19
615	18.33	3.71	22.04	7.01	1.50	8.51	13.53	61.39
618	18.33	4.43	22.76	6.47	1.40	7.87	14.89	65.42
Average + SE	**18.33 ±0.00**	**4.25 ±0.12**	**22.58 ±0.12**	**7.59 ±0.57**	**1.96 ±0.27**	**9.55 ±0.56**	**13.03 ±0.55**	**57.72 ±2.43**
Group - II. (Feed C) (Non supplemented group)								
601	18.33	4.79	23.12	11.04	2.36	13.40	9.72	42.04
606	18.33	4.00	22.33	8.54	1.70	10.24	12.09	54.14
608	18.33	4.07	22.40	6.72	3.48	10.20	12.20	54.46
611	18.33	4.43	22.76	9.77	2.07	11.84	10.92	47.98
613	18.33	4.79	23.12	8.14	3.07	11.21	11.91	51.51
616	18.33	4.43	22.76	7.52	1.27	8.79	13.97	61.38
Average ± SE	**18.33 ±0.00**	**4.42 ±0.14**	**22.75 ±0.14**	**8.62 ± 0.64**	**2.33 ± 0.34**	**10.95 +0.65**	**11.80 +0.58**	**51.92 ±2.67**

Table - 28. Enhancement of mineral bioavailability using ionophores (monensin)
Phosphorus Balance (IInd Trial)

Anim. No.	Intake of Phosphorus (g/day) Conc.	Grass	Total	Outgo of Phosphorus (g/day) Dung	Urine	Total	Phosphorus balance Retention (g/day)	Retention (% of intake)
Group - I. (Feed A) (Monensin supplemented group)								
599	22.97	5.54	28.51	7.14	5.27	12.41	16.10	56.47
604	22.97	5.01	27.98	10.88	2.63	13.51	14.47	51.72
609	21.53	5.26	26.79	10.40	2.05	12.45	14.34	53.53
612	19.26	5.29	24.55	7.70	1.34	9.04	15.51	63.18
615	22.04	5.24	27.28	7.00	3.39	10.39	16.89	61.91
618	21.12	3.44	24.56	5.98	2.79	8.77	15.79	64.29
Average + SE	**21.65** ±0.57	**4.96** ±0.31	**26.61** ±0.69	**8.18** ±0.81	**2.91** ±0.55	**11.10** ±0.81	**15.52** ±0.40	**58.52** [a] ±2.17
Group - II. (Feed C) (Non supplemented group)								
601	21.53	4.37	25.90	9.80	3.33	13.13	12.77	49.31
606	21.53	4.79	26.32	10.58	3.28	13.86	12.46	47.34
608	22.97	4.23	27.20	9.78	5.01	14.79	12.41	45.63
611	22.97	4.70	27.67	10.17	2.67	12.84	14.83	53.60
613	22.04	4.96	27.00	12.96	1.48	14.44	12.56	46.52
616	22.97	4.84	27.81	5.55	4.77	10.32	17.49	62.89
Average ± SE	**22.34** ±0.29	**4.65** ±0.12	**26.98** ±0.31	**9.81** ± 0.98	**3.42** ± 0.54	**13.23** +0.66	**13.75** +0.84	**50.88** [b] ±2.67

Values bearing different superscript in the same column differ significantly (P<0.05)

Table - 29. Enhancement of mineral bioavailability using ionophores (monensin)

Consolidated data on Phosphorus balance

Particulars		Intake of Phosphorus (g/day)			Outgo of Phosphorus (g/day)			Phosphorus balance	
		Conc.	Grass	Total	Dung	Urine	Total	Retention (g/day)	Retention (% of intake)
Group I (Monensin supplemented)									
Ist Trial	Average ±S.E	18.33 ±0.0	4.25 ±0.12	22.58 ±0.12	7.59 ±0.57	1.96 ±0.27	9.55 ±0.56	13.03 ±0.55	57.72 ±2.43
IInd Trial	Average ±S.E	21.65 ±0.57	4.96 ±0.31	26.61 ±0.69	8.18 ±0.81	2.91 ±0.55	11.10 ±0.81	15.52 ±0.40	58.52 [a] ±2.17
Average ±S.E		19.99 ±0.57	4.61 ±0.19	24.60 ±0.70	7.89 ±0.48	2.44 ±0.33	10.32 ±0.52	14.27 ±0.49	58.12 ±1.56
Group II (Without Monensin)									
Ist Trial	Average ±S.E	18.33 ±0.00	4.42 ±0.14	22.75 ±0.14	8.62 ±0.64	2.33 ±0.34	10.95 ±0.65	11.80 ±0.58	51.92 ±2.67
IInd Trial	Average ±S.E	22.34 ±0.29	4.65 ±0.12	26.98 ±0.31	9.81 ±0.98	3.42 ±0.54	13.23 ±0.66	13.75 ±0.84	50.88 [b] ±2.67
Average ±S.E		20.33 ±0.62	4.53 ±0.09	24.87 ±0.66	9.21 ±0.59	2.87 ±0.35	12.09 ±0.56	12.78 ±0.57	51.40 ±1.81

Values bearing different superscript in the same column differ significantly (P<0.05)

Table - 30. Enhancement of mineral bioavailability using ionophores (monensin)
Magnesium Balance (Ist Trial)

Anim. No.	Intake of Magnesium (g/day)			Outgo of Magnesium (g/day)			Magnesium balance	
	Conc.	Grass	Total	Dung	Urine	Total	Retention (g/day)	Retention (% of intake)
Group - I. (Feed A) (Monensin supplemented group)								
599	5.16	2.34	7.50	5.36	0.370	5.73	1.77	23.60
604	5.16	2.42	7.58	5.08	0.248	5.33	2.25	29.68
609	5.16	2.38	7.54	5.30	0.251	5.55	1.99	26.39
612	5.16	2.50	7.66	5.95	0.289	6.24	1.42	18.54
615	5.16	2.06	7.22	5.10	0.210	5.31	1.91	26.45
618	5.16	2.46	7.62	5.07	0.180	5.25	2.37	31.10
Average + SE	**5.16** ±0.00	**2.36** ±0.06	**7.52** ±0.06	**5.31** ±0.14	**0.258** ±0.027	**5.57** ±0.15	**1.95** ±0.14	**25.96** ±1.84
Group - II. (Feed C) (Non supplemented group)								
601	5.16	2.66	7.82	5.95	0.649	6.60	1.22	15.60
606	5.16	2.22	7.38	4.75	0.180	4.93	2.45	33.20
608	5.16	2.26	7.42	4.43	0.615	5.05	2.37	31.94
611	5.16	2.46	7.62	4.84	0.686	5.53	2.09	27.43
613	5.16	2.66	7.82	6.18	0.732	6.91	0.91	11.64
616	5.16	2.46	7.62	5.05	0.350	5.40	2.22	29.13
Average ± SE	**5.16** ±0.00	**2.45** ±0.08	**7.61** ±0.08	**5.20** ± 0.29	**0.535** ±0.09	**5.74** ±0.34	**1.88** ±0.26	**24.82** ±3.67

Table - 31. Enhancement of mineral bioavailability using ionophores (monensin)

Magnesium Balance (IInd Trial)

Anim. No.	Intake of Magnesium (g/day) Conc.	Grass	Total	Outgo of Magnesium (g/day) Dung	Urine	Total	Magnesium balance Retention (g/day)	Retention (% of intake)
Group - I. (Feed A) (Monensin supplemented group)								
599	6.47	4.95	11.42	8.69	0.058	8.75	2.67	23.38
604	6.47	4.48	10.95	9.22	0.126	9.35	1.60	14.61
609	6.06	4.70	10.76	8.51	0.150	8.66	2.10	19.52
612	5.42	4.73	10.15	8.45	0.316	8.77	1.38	13.60
615	6.21	4.68	10.89	8.03	0.049	8.08	2.81	25.80
618	5.95	3.08	9.03	6.81	0.048	6.86	2.17	24.03
Average ± SE	**6.10 ±0.16**	**4.44 ±0.28**	**10.53 ±0.34**	**8.29 ±0.33**	**0.125 ±0.042**	**8.41 ±0.35**	**2.12 ±0.23**	**20.16 ±2.09**
Group - II. (Feed C) (Non supplemented group)								
601	6.06	3.90	9.96	8.39	0.258	8.65	1.31	13.15
606	6.06	4.28	10.34	8.06	0.738	8.80	1.54	14.89
608	6.47	3.78	10.25	8.13	0.569	8.70	1.55	15.12
611	6.47	4.20	10.67	8.18	0.156	8.34	2.33	21.84
613	6.21	4.43	10.64	8.28	0.128	8.41	2.23	20.96
616	6.47	4.33	10.80	7.33	0.874	8.20	2.60	24.07
Average ± SE	**6.29 ±0.08**	**4.15 ±0.10**	**10.44 ±0.13**	**8.06 ± 0.15**	**0.454 ±0.130**	**8.52 ±0.10**	**1.93 ±0.21**	**18.34 ±1.84**

Table - 32. Enhancement of mineral bioavailability using ionophores (monensin)
Consolidated data on Magnesium

Particulars		Intake of Magnesium (g/day)			Outgo of Magnesium (g/day)			Magnesium balance	
		Conc.	Grass	Total	Dung	Urine	Total	Retention (g/day)	Retention (% of intake)
Group I(Monensin supplemented)									
Ist Trial	Average ±S.E	5.16 ±0.00	2.36 ±0.06	7.52 ±0.06	5.31 ±0.14	0.258 ±0.027	5.57 ±0.15	1.95 ±0.14	25.96 ± 1.84
IInd Trial	Average ±S.E	6.10 ±0.16	4.44 ±0.28	10.53 ±0.34	8.29 ±0.33	0.125 ±0.042	8.41 ±0.35	2.12 ±0.23	20.16 ± 2.09
Average ±S.E		**5.63 ±0.16**	**3.40 ±0.34**	**9.03 ±0.48**	**6.80 ±0.48**	**0.19 ±0.03**	**6.99 ±0.47**	**2.04 ±0.13**	**23.06 ±1.59**
Group II(Without Monensin)									
Ist Trial	Average ±S.E	5.16 ±0.00	2.45 ±0.0.08	7.61 ±0.08	5.20 ±0.29	0.535 ±0.090	5.74 ±0.34	1.88 ±0.26	24.82 ±3.67
IInd Trial	Average ±S.E	6.29 ±0.08	4.15 ±0.10	10.44 ±0.13	8.06 ±0.15	0.454 ±0.130	8.52 ±0.10	1.93 ±0.21	18.34 ±1.84
Average ±S.E		**5.73 ±0.18**	**3.30 ±0.26**	**9.03 ±0.0.43**	**6.63 ±0.0.46**	**0.49 ±0.08**	**7.13 ±0.45**	**1.90 ±0.16**	**21.58 ±2.19**

Table - 33. Enhancement of mineral bioavailability using ionophores (monensin) Copper Balance (Ist Trial)

Anim. No.	Intake of Copper (mg/day) Conc.	Grass	Total	Outgo of Copper (mg/day) Dung	Urine	Total	Copper balance Retention (mg/day)	Retention (% of intake)
Group - I. (Feed A) (Monensin supplemented group)								
599	36.79	8.07	44.86	24.97	0.40	25.37	19.49	43.45
604	36.79	8.35	45.14	21.41	0.32	21.73	23.41	51.86
609	36.79	8.21	45.00	22.77	0.33	23.10	21.90	48.67
612	36.79	8.63	45.42	27.53	0.222	27.75	17.67	38.90
615	36.79	7.11	43.90	20.63	0.180	20.81	23.09	52.60
618	36.79	8.49	45.28	20.34	0.200	20.54	24.74	54.64
Average ± SE	36.79 **±0.00**	**8.14 ±0.22**	**44.93 ±0.22**	**22.94 ± 1.15**	**0.275 ±0.036**	**23.22 ±1.16**	**21.72 ±1.08**	**48.35** [a] **±2.47**
Group - II. (Feed C) (Nonsupplemented group)								
601	36.79	9.18	45.97	31.07	0.413	31.48	14.49	31.52
606	36.79	7.66	44.45	27.00	1.060	28.06	16.39	36.87
608	36.79	7.80	44.59	26.35	1.160	27.51	17.08	38.30
611	36.79	8.49	45.28	29.17	0.423	29.59	15.69	34.65
613	36.79	9.18	45.97	30.30	0.531	30.83	15.14	32.93
616	36.79	8.49	45.28	27.57	0.424	27.99	17.29	38.18
Average ± SE	**36.79** ±0.00	**8.47** ±0.27	**45.26** ±0.27	**28.58** ±0.77	**0.669** ± 0.14	**29.24** ± 0.670	**16.01** ±0.45	**35.41** [b] ±1.15

Values bearing different superscript in the same column differ significantly (P<0.01)

Table - 34. Enhancement of mineral bioavailability using ionophores (monensin)

Copper Balance (IInd Trial)

Anim. No.	Intake of Copper (mg/day)			Outgo of Copper (mg/day)			Copper balance Retention	
	Conc.	Grass	Total	Dung	Urine	Total	(mg/day)	(% of intake)
Group - I. (Feed A) (Monensin supplemented group)								
599	46.09	21.52	67.61	44.80	0.464	45.26	22.35	33.06
604	46.09	19.46	65.55	44.47	0.252	44.72	20.83	31.78
609	43.20	20.44	63.64	41.71	0.600	42.31	21.33	33.52
612	38.65	20.54	59.19	39.06	0.119	39.18	20.01	33.81
615	44.23	20.33	64.56	38.05	0.098	38.15	26.41	40.91
618	42.37	13.37	55.74	30.58	0.192	30.77	24.97	44.80
Average + SE	**43.44** ±1.14	**19.28** ±1.21	**62.72** ±1.80	**39.78** ±2.15	**0.288** ±0.082	**40.07** ±2.19	**22.65** ±1.03	**36.31** [a] ±2.15
Group - II. (Feed C) (Non supplemented group)								
601	43.20	16.96	60.16	48.41	0.184	48.59	11.57	19.23
606	43.20	18.59	61.79	47.75	0.180	47.93	13.86	22.43
608	46.09	16.41	62.50	46.38	0.158	46.54	15.96	25.54
611	46.09	18.26	64.35	50.12	0.414	50.53	13.82	21.48
613	44.23	19.24	63.47	46.30	0.320	46.62	16.85	26.55
616	46.09	18.81	64.90	42.81	1.140	43.95	20.95	32.28
Average ± SE	**44.82** ±0.59	**18.05** ±0.45	**62.86** ±0.71	**46.96** ±1.01	**0.399** ± 0.154	**47.36** ± 0.91	**15.50** ±1.33	**24.59** [b] ±1.89

Values bearing different superscript in the same column differ significantly ($P<0.01$)

Table - 35. Enhancement of mineral bioavailability using ionophores (monensin)
Consolidated data on Copper balance

Particulars		Intake of Copper (mg/day)			Outgo of Copper (mg/day)			Copper balance	
		Conc.	Grass	Total	Dung	Urine	Total	Retention (mg/day)	Retention (% of intake)
Group I (Monensin supplemented)									
Ist Trial	Average ±S.E	36.79 ±0.00	8.14 ±0.22	44.93 ±0.22	22.94 ±1.15	0.275 ±0.036	23.22 ±1.16	21.72 ±1.08	48.35 ±2.47
IInd Trial	Average ±S.E	43.44 ±1.14	19.28 ±1.21	62.72 ±1.80	39.78 ±2.15	0.288 ±0.082	40.07 ±2.19	22.65 ±1.03	36.31 ±2.15
Average ±S.E		**40.11** ±1.14	**13.71** ±1.78	**53.82** ±2.82	**31.36** ±2.80	**0.28** ±0.04	**31.64** ±2.81	**22.18** ±0.73	**42.33** [a] ±2.40
Group II (Without Monensin)									
Ist Trial	Average ±S.E	36.79 ±0.00	8.47 ±0.27	45.26 ±0.27	28.58 ±0.77	0.669 ±0.14	29.24 ±0.67	16.01 ±0.45	35.41 ±1.15
IInd Trial	Average ±S.E	44.82 ±0.59	18.05 ±0.45	62.86 ±0.71	46.96 ±1.01	0.399 ±0.154	47.36 ±0.91	15.50 ±1.33	24.59 ±1.89
Average ±S.E		**40.80** ±1.24	**13.26** ±1.47	**54.06** ±2.68	**37.77** ±2.84	**0.53** ±0.11	**38.30** ±2.79	**15.76** ±0.67	**30.00** [b] ±1.95

Values bearing different superscript in the same column differ significantly (P<0.01)

Table - 36. Enhancement of mineral bioavailability using Ionophores (monensin) Zinc Balance (Ist Trial)

Anim. No.	Intake of Zinc (mg/day)			Outgo of Zinc (mg/day)			Zinc balance	
	Conc.	Grass	Total	Dung	Urine	Total	Retention (mg/day)	Retention (% of intake)
Group - I. (Feed A) (Monensin supplemented group)								
599	199.41	40.34	239.75	127.90	2.00	129.90	109.85	45.82
604	199.41	41.72	241.13	101.74	1.12	102.86	138.27	57.34
609	199.41	41.03	240.44	145.97	1.49	147.46	92.98	38.67
612	199.41	43.10	242.51	116.89	0.74	117.63	124.88	51.49
615	199.41	35.51	234.92	93.94	5.20	99.14	135.78	57.80
618	199.41	42.41	241.82	95.99	12.60	108.59	133.23	55.09
Average ± SE	**199.41** ±0.00	**40.69** ±1.11	**240.10** ±1.11	**113.74** ± 8.37	**3.86** ±1.87	**117.60** ±7.49	**122.50** ±7.25	**51.04** [a] ±3.07
Group - II. (Feed C) (Non supplemented group)								
601	199.41	45.86	245.27	186.20	7.32	193.52	51.75	21.10
606	199.41	38.27	237.68	135.56	11.24	146.80	90.88	38.24
608	199.41	38.96	238.37	129.42	12.99	142.41	95.96	40.26
611	199.41	42.41	241.82	143.90	18.05	161.95	79.87	33.03
613	199.41	45.86	245.27	169.42	1.65	171.07	74.20	30.25
616	199.41	42.41	241.82	95.77	10.39	106.16	135.66	56.10
Average ± SE	**199.41** ±0.00	**42.30** ±1.33	**241.71** ±1.33	**143.38** ±12.95	**10.27** ± 2.25	**153.65** ± 12.10	**88.05** ±11.42	**36.50** [b] ±4.79

Values bearing different superscript in the same column differ significantly (P<0.05)

Table - 37. Enhancement of mineral bioavailability using ionophores (monensin) Zinc Balance (IInd Trial)

Anim. No.	Intake of Zinc (mg/day)			Outgo of Zinc (mg/day)			Zinc balance	
	Conc.	Grass	Total	Dung	Urine	Total	Retention (mg/day)	Retention (% of intake)
Group - I. (Feed A) (Monensin supplemented group)								
599	249.83	131.65	381.48	279.22	1.86	281.08	100.40	26.32
604	249.83	119.02	368.85	240.14	1.26	241.40	127.45	34.55
609	234.14	125.00	359.14	277.87	1.20	279.07	80.07	22.29
612	209.50	125.67	335.17	227.23	0.79	228.02	107.15	31.97
615	239.74	124.34	364.08	236.60	1.18	237.78	126.30	34.69
618	229.66	81.78	311.44	191.49	0.96	192.45	118.99	38.21
Average + SE	**235.45 ±6.16**	**117.91 ±7.41**	**353.36 ±10.43**	**242.09 ± 13.51**	**1.21 ±0.15**	**243.30 ±13.61**	**110.06 ±7.41**	**31.34 [a] ±2.42**
Group - II. (Feed C) (Nonsupplemented group)								
601	234.14	103.72	337.86	284.81	1.84	286.65	51.75	15.16
606	234.14	113.70	347.84	264.29	2.52	266.81	81.03	23.30
608	249.83	100.40	350.23	302.72	2.84	305.56	44.67	12.75
611	249.83	111.70	361.53	276.93	1.47	278.40	83.13	22.99
613	239.74	117.69	357.43	276.30	4.32	280.62	76.81	21.49
616	249.83	115.03	364.86	219.43	3.04	222.47	142.39	39.03
Average ± SE	**242.92 ±3.20**	**110.37 ±2.78**	**353.29 ±4.07**	**270.75 ±11.49**	**2.67 ± 0.41**	**273.42 ± 11.43**	**79.87 +14.13**	**22.45 [b] ±3.76**

Values bearing different superscript in the same column differ significantly (P<0.01)

Table - 38. Enhancement of mineral bioavailability using ionophores (monensin)
Consolidated data on Zinc Balance

Particulars		Intake of Zinc (mg/day)			Outgo of Zinc (mg/day)			Zinc balance	
		Conc.	Grass	Total	Dung	Urine	Total	Retention (mg/day)	Retention (% of intake)
Group I (Monensin supplemented)									
Ist Trial	Average ±S.E	199.41 ±0.00	40.69 ±1.11	240.10 ±1.11	113.74 ±8.37	3.86 ±1.87	117.60 ±7.49	122.50 ±7.25	51.04 ±3.07
IInd Trial	Average ±S.E	235.45 ±6.16	117.91 ±7.41	353.36 ±10.43	242.09 ±13.51	1.21 ±0.15	243.30 ±13.61	110.06 ±7.41	31.34 ±2.42
Average ±S.E		**217.43 ±6.18**	**79.30 ±12.19**	**296.73 ±17.81**	**177.92 ±20.80**	**2.53 ±0.98**	**180.45 ±20.37**	**116.28 ±5.29**	**41.19 [a] ±3.51**
Group II Without monensin									
Ist Trial	Average ±S.E	199.41 ±0.00	42.30 ±1.33	241.71 ±1.33	143.38 ±12.95	10.27 ±2.25	153.65 ±12.10	88.05 ±11.42	36.50 ±4.79
IInd Trial	Average ±S.E	242.92 ±3.20	110.37 ±2.78	353.29 ±4.07	270.75 ±11.49	2.67 ±0.41	273.42 ±11.43	79.87 ±14.13	22.45 ±3.76
Average ±S.E		**221.16 ±6.74**	**76.33 ±10.38**	**297.50 ±16.97**	**207.06 ±20.93**	**6.47 ±1.58**	**213.54 ±19.75**	**83.96 ±8.76**	**29.48 [b] ±3.60**

Values bearing different superscript in the same column differ significantly (P<0.01)

Table - 39. Enhancement of mineral bioavailability using ionophores(monensin)
Iron Balance (Ist Trial)

Anim. No.	Intake of Iron (mg/day) Conc.	Grass	Total	Outgo of Iron (mg/day) Dung	Urine	Total	Iron balance Retention (mg/day)	Retention (% of intake)
Group - I. (Feed A) (Monensin supplemented group)								
599	3014.79	1002.76	4017.55	2623.46	8.80	2632.26	1385.29	34.48
604	3014.79	1037.04	4051.83	2511.45	9.12	2520.57	1531.26	37.79
609	3014.79	1019.90	4034.69	2606.33	12.05	2618.38	1416.31	35.10
612	3014.79	1071.33	4086.12	2480.95	11.99	2492.94	1593.18	38.99
615	3014.79	882.77	3897.56	2243.28	8.90	2252.18	1645.38	42.22
618	3014.79	1054.18	4068.97	2227.75	6.80	2234.55	1834.42	45.08
Average ± SE	**3014.79** ±0.00	**1011.33** ±27.55	**4026.12** ±27.55	**2448.87** ±71.02	**9.61** ±0.83	**2458.48** ±71.52	**1567.64** ±67.15	**38.94** ±1.68
Group - II. (Feed C) (Nonsupplemented group)								
601	3014.79	1139.89	4154.68	3151.44	23.36	3174.80	979.88	23.58
606	3014.79	951.34	3966.13	2055.50	20.56	2076.06	1890.07	47.66
608	3014.79	968.48	3983.27	2307.91	39.90	2347.81	1635.46	41.06
611	3014.79	1054.18	4068.97	2247.97	22.37	2270.34	1798.63	44.20
613	3014.79	1139.89	4154.68	2744.42	22.18	2766.60	1388.08	33.41
616	3014.79	1054.18	4068.97	2552.74	44.73	2597.47	1471.50	36.16
Average ± SE	**3014.79** ±0.00	**1051.33** ±32.94	**4066.12** ±32.94	**2510.00** ±161.65	**28.85** ± 4.32	**2538.85** ±161.47	**1527.27** ±134.02	**37.68** ±3.52

Table - 40. Enhancement of mineral bioavailability using Ionophores (monensin) Iron Balance (IInd Trial)

Anim. No.	Intake of Iron (mg/day)			Outgo of Iron (mg/day)			Iron balance	
	Conc.	Grass	Total	Dung	Urine	Total	Retention (mg/day)	Retention (% of intake)
Group - I. (Feed A) (Monensin supplemented group)								
599	3776.95	2152.18	5929.13	3461.27	14.15	3475.42	2453.71	41.38
604	3776.95	1945.66	5722.61	3603.20	10.08	3613.28	2109.33	36.86
609	3539.83	2043.48	5583.31	3083.57	12.20	3095.77	2487.54	44.55
612	3167.22	2054.35	5221.57	3221.50	5.21	3226.71	1994.86	38.20
615	3624.52	2032.62	5657.14	3371.41	6.66	3378.07	2279.07	40.29
618	3472.09	1336.96	4809.05	2729.54	11.14	2740.68	2068.37	43.01
Average + SE	**3559.59 ±93.20**	**1927.54 ±121.10**	**5487.14 ±165.22**	**3245.08 ±126.91**	**9.91 ±1.38**	**3254.99 ±126.83**	**2232.15 ±84.59**	**40.72 ±1.18**
Group - II. (Feed C) (Nonsupplemented group)								
601	3539.83	1695.66	5235.49	3481.19	15.46	3496.65	1738.84	33.21
606	3539.83	1858.70	5398.53	3249.84	27.72	3277.56	2120.97	39.29
608	3776.95	1641.31	5418.26	3440.23	28.12	3468.35	1949.91	35.99
611	3776.95	1826.09	5603.04	3370.20	13.80	3384.00	2219.04	39.60
613	3624.52	1923.92	5548.44	3353.16	10.08	3363.24	2185.20	39.38
616	3776.95	1880.44	5657.39	3277.15	27.74	3304.89	2352.50	41.58
Average ± SE	**3672.51 ±48.38**	**1804.35 ±45.42**	**5476.86 ±63.62**	**3361.96 ±36.62**	**20.49 ±3.37**	**3382.45 ±35.49**	**2094.41 ±89.13**	**38.18 ±1.23**

Table - 41. Enhancement of mineral bioavailability using ionophores (monensin)
Consolidated data on Iron Balance

Particulars		Intake of Iron (mg/day)			Outgo of Iron (mg/day)			Iron balance	
		Conc.	Grass	Total	Dung	Urine	Total	Retention (mg/day)	Retention (% of intake)
Group I (Monensin supplemented)									
Ist Trial	Average ±S.E	3014.79 ±0.00	1011.33 ±27. 55	4026.12 ±27. 55	2448.87 ±71.02	9.61 ±0.83	2458.48 ±71. 52	1567.64 ±67.15	38.94 ±1.68
II nd Trial	Average ±S.E	3559.59 ±93.20	1927.54 ±121.10	5487.14 ±165.22	3245.08 ±126.91	9.91 ±1.38	3254.99 ±126.83	2232.15 ±84. 59	40.72 ±1.18
Average ±S.E		**3287.19 ±93.50**	**1469.44 ±150.46**	**4756.63 ±234.57**	**2846.98 ±138.79**	**9.76 ±0.77**	**2856.73 ±138.87**	**1899.89 ±112.77**	**39.83 ±1.01**
Group II (Non supplemented)									
Ist Trial	Average ±S.E	3014.79 ±0.00	1051.33 ±32 .94	4066.12 ±32. 94	2510.00 ±161.65	28.85 ±4.32	2538.85 ±161.47	1527.27 ±134.02	37.68 ±3.52
IInd Trial	Average ±S.E	3672.51 ±48.38	1804.35 ±45.42	5476.86 ±63. 62	3361.96 ±36. 62	20.49 ±3.37	3382.45 ±35.49	2094.41 ±89.13	38.18 ±1.23
Average ±S.E		**3343.65 ±101.92**	**1427.84 ±116.77**	**4771.49 ±215.66**	**2935.98 ±150.99**	**24.67 ±2.90**	**2960.65 ±149.81**	**1810.84 ±115.03**	**37.93 ±1.78**

Table - 42. CONSOLIDATED DATA ON MINERAL BALANCE IN CALVES MAINTAINED ON MONENSIN SUPPLEMENTED & NON SUPPLEMENTED RATIONS (FIRST METABOLISM TRIAL)

Minerals	Average intake per day			Average Outgo per day			Mineral balance per day	
	Conc.	Grass	Total	Dung	Urine	Total	Retention	Retention
	(grams)			(grams)			(g/day)	(% of intake)
Group - I .(Feed A) (Monensin supplemented group)								
Calcium	10.68 ±0.00	5.32 ±0.14	16.00 ±0.14	9.61 ±1.12	0.09 ±0.008	9.70 ±1.12	6.3 ±1.09	39.45 ± 6.81
Phosphorus	18.33 ±0.00	4.25 ±0.12	22.58 ±0.12	7.59 ±0.57	1.96 ±0.27	9.55 ±0.56	13.03 ±0.55	57.72 ±2.43
Magnesium	5.16 ±0.00	2.36 ±0.06	7.52 ± 0.06	5.31 ±0.14	0.258 ±0.027	5.57 ±0.15	1.95 ±0.14	25.96 ±1.84
	(mg)			(mg)			(mg/day)	(% of intake)
Copper	36.79 ±0.00	8.14 ±0.22	44.93 ±0.22	22.94 ±1.15	0.275 ±0.036	23.22 ±1.16	21.72 ±1.08	48.35 ±2.47
Zinc	199.41 ±0.00	40.69 ±1.11	240.10 ±1.11	113.74 ±8.37	3.86 ±1.87	117.60 ±7.49	122.50 ±7.25	51.04 ±3.07
Iron	3014.79 ±0.00	1011.33 ±27.55	4026.12 ±27.55	2448.87 ±71.02	9.61 ± 0.83	2458.48 ±71.52	1567.64 ±67.15	38.94 ±1.68
Group - II. (Feed C) (Non supplemented group)								
	(grams)			(grams)			(g/day)	(% of intake)
Calcium	10.68 ±0.00	5.53 ±0.17	16.21 ±0.17	10.72 ±0.82	0.194 ±0.018	10.91 ±0.83	5.29 ±0.72	32.81 ±4.63
Phosphorus	18.33 ±0.00	4.42 ±0.14	22.75 ±0.14	8.62 ±0.64	2.33 ±0.34	10.95 ±0.65	11.80 ±0.58	51.92 ±2.67
Magnesium	5.16 ±0.00	2.45 ±0.08	7.61 ±0.08	5.20 ±0.29	0.535 ±0.090	5.74 ±0.34	1.88 ±0.26	24.82 ±3.67
	(mg)			(mg)			(mg/day)	(% of intake)
Copper	36.79 ±0.00	8.47 ±0.27	45.26 ± 0.27	28.58 ±0.77	0.669 ±0.14	29.24 ±0.67	16.01 ±0.45	35.41 ±1.15
Zinc	199.41 ±0.00	42.30 ±1.33	241.71 ±1.33	143.38 ±12.95	10.27 ±2.25	153.65 ±12.10	88.05 ±11.42	36.50 ±4.79
Iron	3014.79 ±0.00	1051.33 ±32.94	4066.12 ±32.94	2510.00 ±161.65	28.85 ±4.32	2538.85 ±161.47	1527.27 ±134.02	37.68 ± 3.52

Table - 43. CONSOLIDATED DATA ON MINERAL BALANCE IN CALVES MAINTAINED ON MONENSIN SUPPLEMENTED & NON SUPPLEMENTED RATIONS (SECOND METABOLISM TRIAL)

Minerals	Average intake per day			Average Outgo per day			Mineral balance per day	
	Conc.	Grass	Total	Dung	Urine	Total	Retention	Retention
	(grams)			(grams)			(g/day)	(% of intake)
Group - I .(Feed A) (Monensin supplemented group)								
Calcium	12.61 ±0.33	8.69 ±0.55	21.30 ±0.68	12.59 ±0.70	0.258 ±0.036	12.85 ±0.71	8.45 ±0.31	39.83 ± 1.79
Phosphorus	21.65 ±0.57	4.96 ±0.31	26.61 ±0.69	8.18 ± 0.81	2.91 ±0.55	11.10 ±0.81	15.52 ±0.40	58.52 ±2.17
Magnesium	6.10 ±0.16	4.44 ±0.28	10.53 ± 0.34	8.29 ±0.33	0.125 ±0.042	8.41 ±0.35	2.12 ±0.23	20.16 ±2.09
	(mg)			(mg)			(mg/day)	(% of intake)
Copper	43.44 ±1.14	19.28 ±1.21	62.72 ±1.80	39.78 ±2.15	0.288 ±0.082	40.07 ±2.19	22.65 ±1.03	36.31 ±2.15
Zinc	235.45 ±6.16	117.91 ±7.41	353.36 ±10.43	242.09 ±13.51	1.21 ±0.15	243.30 ±13.61	110.06 ±7.41	31.34 ±2.42
Iron	3559.59 ±93.20	1927.54 ±121.10	5487.14 ±165.22	3245.08 ± 126.91	9.91 ± 1.38	3254.99 ±126.83	2232.15 ±84.59	40.72 ±1.18
Group - II. (Feed C) (Non supplemented group)								
	(grams)			(grams)			(g/day)	(% of intake)
Calcium	13.01 ±0.17	8.13 ±0.20	21.14 ±0.26	13.77 ±0.36	0.125 ±0.039	13.90 ±0.36	7.24 ±0.40	34.23 ±1.71
Phosphorus	22.34 ±0.29	4.65 ±0.12	26.98 ±0.31	9.81 ±0.98	3.42 ±0.54	13.23 ±0.66	13.75 ±0.84	50.88 ±2.67
Magnesium	6.29 ±0.08	4.15 ±0.10	10.44 ±0.13	8.06 ±0.15	0.454 ±0.130	8.52 ±0.10	1.93 ±0.21	18.34 ±1.84
	(mg)			(mg)			(mg/day)	(% of intake)
Copper	44.82 ±0.59	18.05 ±0.45	62.86 ± 0.71	46.96 ±1.01	0.399 ±0.154	47.36 ±0.91	15.50 ±1.33	24.59 ±1.89
Zinc	242.92 ±3.20	110.37 ±2.78	353.29 ±4.07	270.75 ±11.49	2.67 ±0.41	273.42 ±11.43	79.87 ±14.13	22.45 ±3.76
Iron	3672.51 ±48.38	1804.35 ±45.42	5476.86 ±63.62	3361.96 ±36.62	20.49 ±3.37	3382.45 ±35.49	2094.41 ±89.13	38.18 ± 1.23

Table - 44. CONSOLIDATED DATA ON MINERAL BALANCE IN CALVES MAINTAINED ON MONENSIN SUPPLEMENTED & NONSUPPLEMENTED RATIONS (AVERAGE OF FIRST & SECOND METABOLISM TRIAL)

Minerals		Intake of minerals			Outgo of minerals			Mineral Balance	
		Cone.	Grass	Total	Dung	Urine	Total	Retention	
		(grams)			(grams)			g/day	% of intake
Ca	Grp I	11.65 ±0.33	7.00 ±0.58	18.65 ±0.87	11.10 ±0.77	0.173 ±0.03	11.27 ±0.79	7.37 ±0.63	39.64 ±3.36
	Grp II	11.85 ±0.36	6.83 ±0.41	18.67 ±0.76	12.25 ±0.63	0.160 ±0.02	12.41 ±0.62	6.27 ±0.49	33.52 ±2.36
P	Grp I	19.99 ±0.57	4.61 ±0.19	24.60 ±0.70	7.89 ±0.48	2.44 ±0.33	10.32 ±0.52	14.27 ±0.49	58.12 ±1.56
	Grp II	20.33 ±0.62	4.53 ±0.09	24.87 ±0.66	9.21 ±0.59	2.87 ±0.35	12.09 ±0.56	12.78 0.57	51.40 ±1.81
Mg*	Grp I	5.63 ±0.16	3.40 ±0.34	9.03 ±0.48	6.80 ±0.48	0.19 ±0.03	6.99 ±0.47	2.04 ±0.13	23.06^{a} ±1.59
	Grp II	5.73 ±0.18	3.30 ±0.26	9.03 ±0.43	6.63 ±0.46	0.49 ±0.08	7.13 ±0.45	1.90 ±0.16	21.58^{b} ±2.19
		(mg)			(mg)			(mg/day)	% of intake
Cu**	Grp I	40.11 ±1.14	13.71 ±1.78	53.82 ±2.82	31.36 ±2.80	0.28 ±0.04	31.64 ±2.81	22.18 ±0.73	42.33^{a} ±2.40
	Grp II	40.80 ±1.24	13.26 ±1.47	54.06 ±2.68	37.77 ±2.84	0.53 ±0.11	38.30 ±2.79	15.76 ±0.67	30.00^{b} ±1.95
Zn**	Grp I	217.43 ±6.18	79.30 ±12.19	296.73 ±17.81	177.92 ±20.80	2.53 ±0.98	180.45 ±20.37	116.28 ±5.29	41.19^{a} ±3.51
	Grp II	221.16 ±6.74	76.33 ±10.38	297.50 ±16.97	207.06 ±20.93	6.47 ±1.58	213.54 ±19.75	83.96 ±8.76	29.48^{b} ±3.60
Fe	Grp I	3287.19 ±93.50	1469.44 ±150.46	4756.63 ±234.57	2846.98 ±138.79	9.76 ±0.77	2856.73 ±138.87	1899.89 ±112.77	39.83 ±1.01
	Grp II	3343.65 ±101.92	1427.84 ±116.77	4771.49 ±215.66	2935.98 ±150.99	24.67 ±2.90	2960.65 ±149.81	1810.84 ±115.03	37.93 ±1.78

Values bearing different superscript in the same column for each mineral differ significantly (P<0.01), *P<0.05)**

Table - 45. DATA SHOWING THE COMPARISON OF MINERAL BALANCES IN CALVES (MONENSIN SUPPLEMENTED VS NON SUPPLEMENTED GROUP)

Trial - I

Minerals	Group – I (Monensin supplemeted)					Group - II (Nonsupplemented)				
	Average intake per day			Mineral balance per day		Average intake per day			Balance per day	
	Conc.	Grass	Total	Retention	Retention	Conc.	Grass	Total	Retention	Retention
	(grams)			(g/day)	(% of intake)	(grams)			(g/day)	(% of intake)
Calcium	10.68 ±0.00	5.32 ±0.14	16.00 ±0.14	6.30 ±1.09	39.45 ±6.81	10.68 ±0.00	5.53 ±0.17	16.21 ±0.17	5.29 ±0.72	32.81 ±4.63
Phosphorus	18.33 ±0.00	4.25 ±0.12	22.58 ±0.12	13.03 ±0.55	57.72 ±2.43	18.33 ±0.00	4.42 ±0.14	22.75 ±0.14	11.80 ±0.58	51.92 ±2.67
Magnesium	5.16 ±0.00	2.36 ± 0.06	7.52 ±0.06	1.95 ±0.14	25.96 ±1.84	5.16 ±0.00	2.45 ±0.08	7.61 ±0.08	1.88 ±0.26	24.82 ±3.67
	(mg)			(mg/day)	(% of intake)	(mg)			(mg/day)	(% of intake)
Copper**	36.79 ±0.0	8.14 ±0.22	44.93 ±0.22	21.72 ±1.08	48.35[a] ±2.47	36.79 ±0.00	8.47 ±0.27	45.26 ±0.27	16.01 ±0.45	35.41[b] ±1.15
Zinc*	199.41 ±0.0	40.69 ±1.11	240.10 ±1.11	122.50 ±7.25	51.04[a] ±3.07	199.41 ±0.0	42.30 ±1.33	241.71 ±1.33	88.05 ±11.42	36.50[b] ±4.79
Iron	3014.79 ±0.0	1011.33 ± 27.55	4026.12 ±27.55	1567.64 ±67.15	38.94 ±1.68	3014.79 ±0.00	1051.33 ±32. 94	4066.12 ±32 .94	1527.27 ±134.02	37.68 ±3. 52

Values bearing different superscripts in the same row differ significantly

Table - 46. DATA SHOWING THE COMPARISON OF MINERAL BALANCES IN CALVES (MONENSIN SUPPLEMENTED VS NON SUPPLEMENTED GROUP)

Trial - II

Minerals	Group - I (Monensin supplemeted)					Group - II (Nonsupplemented)				
	Average intake per day			Mineral balance per day		Average intake per day			Balance per day	
	Conc.	Grass	Total	Retention	Retention	Conc.	Grass	Total	Retention	Retention
	(grams)			(g/day)	(% of intake)	(grams)			(g/day)	(% of intake)
Calcium	12.61 ±0.33	8.69 ±0.55	21.30 ±0.68	8.45 ±0.31	39.83 ±1.79	13.01 ±0.17	8.13 ±0.20	21.14 ±0.26	7.24 ±0.40	34.23 ±1.71
Phosphorus*	21.65 ±0.57	4.96 ±0.31	26.61 ±0.69	15.52 ±0.40	58.52[a] ±2.17	22.34 ±0.29	4.65 ±0.12	26.98 ±0.31	13.75 ±0.84	50.88[b] ±2.67
Magnesium	6.10 ±0.16	4.44 ±0.28	10.53 ±0.34	2.12 ±0.23	20.16 ±2.09	6.29 ±0.08	4.15 ±0.10	10.44 ±0.13	1.93 ±0.21	18.34 ±1.84
	(mg)			(mg/day)	(% of intake)	(mg)			(mg/day)	(% of intake)
Copper**	43.44 ±1.14	19.28 ±1.21	62.72 ±1.80	22.65 ±1.03	36.31[a] ±2.15	44.82 ±0.59	18.05 ±0.45	62.86 ±0.71	15.50 ±1.33	24.59[b] ±1.89
Zinc**	235.45 ±6.16	117.91 ±7.41	353.36 ±10.43	110.06 ±7.41	31.34[a] ±2.42	242.92 ±3.20	110.37 ±2.78	353.29 ±4.07	79.87 ±14.13	22.45[b] ±3.76
Iron	3559.59 ±93.20	1927.54 ± 121.10	5487.14 ±165.22	2232.15 ±84.59	40.72 ±1.18	3672.51 ±48. 38	1804.35 ±45.42	5476.86 ±63.62	2094.41 ±89.13	38.18 ±1.23

Values bearing different superscripts in the same row differ significantly

FEEDING TRIAL - IV(CALVES)

FEASIBILITY OF WOOD ASH AND EGG SHELL POWDER AS CALCIUM SUPPLEMENT IN CALF RATION

One of the objectives of 9th plan is to formulate the mineral and trace element supplements and to suggest alternate source of minerals in different categories of animals. Accordingly wood ash and egg shell powder have been identified as two cheap sources of Ca and feeding trials were carried out in calves to study their feasibility as Ca supplements.

Wood ash is estimated to contain about 21% Ca and obtained in large quantities from the nearby tile factory at a low cost of Rs.1.60/kg. Fire wood from rubber, coconut tree etc are regularly burned in the furnace of tile factory as a fuel and the ash left behind is usually discarded as waste. Any measure to utilise this commodity will fetch economic advantage also. Since wood ash is the concentrated source of minerals, the organic matter being burned off, it can be tried as a mineral supplement for livestock. With this objective the present study has been planned.

Apart from Ca, wood ash also contain various trace elements. On analysis of various samples of wood ash from different sources, it is found that wood ash contain on an average 21.88±2.01g% Ca, 0.50±0.06 g% P, 59.8±10.04 ppm Cu, 175.7±35.18ppm Zn, 7390.85±1265.26ppm Fe. Egg shell powder available in large quantity from the Hatchery of University Poultry Farm is another rich source of Ca available at free of cost. Hence a mineral supplement was formulated incorporating 50% wood ash and 50% egg shell powder and it was compared with the commercial mineral mixture.

Twelve female cross bred calves of 5 to 6 months of age selected from the Cattle Breeding Farm, Thumburmuzhi weighing on an average 68 kg formed the experimental subjects for the study. The calves were divided into 2 groups of six each (Group B and Group C) as uniformly as possible with regard to age and weight.

Group C calves formed the control group and were maintained on basal concentrate mixture containing 2% commercial mineral mixture; mineral composition of which is given in Table 49. Group B calves formed the experimental group and received concentrate mixture B containing 1% wood ash and 1% egg shell powder as mineral supplements instead of 2% commercial mineral mixture in the control feed. Since wood ash and egg

shell powder are poor source of Phosphorus from 6th week onwards tri-Sodium Phosphate was added to concentrate mixture-B at the rate of 250g/100kg. Fresh Napier grass was given *ad-libitum* as roughage to calves of both groups.

The ingredient composition, proximate composition and mineral composition of the concentrate mixture and green grass are presented in table 47, 48 and 49 respectively. All the experimental animals were housed and fed individually. Records of daily dry matter consumption and weekly body weights of the experimental calves were maintained throughout the experimental period. Wholesome water was offered *ad libitum*. The experimental animals were maintained on their respective dietary regime for a period of 84 days. Consolidated data on average growth rate and feed efficiency of the calves belonging to experimental group and control group (Group B and C) are presented in table 50.

Two digestion cum metabolism trials were carried out during the fifth and 12th week of experiments each involving a collection period of 7 days duration with quantitative collection of dung and urine voided. Data on the average daily DMI, dung and urine voided by the calves during the first and second metabolism trials are presented in table 51 and 52 respectively. Representative samples of concentrate, grass, dung and urine collected during the metabolism trial were subjected to proximate analysis and mineral analysis(AOAC 1990) Estimation of Ca, Mg, Cu, Zn and Fe were carried out using Atomic Absorption Spectrophotometer model-AAS-3110 and P by calorimetry (AOAC - 1990).

From the data on metabolism trials and proximate analysis of dung and urine, digestibility coefficients of different nutrients viz, DM, OM, CP, CF, EE and NFE were calculated and compared between the two groups. Data on the average digestibility coefficients of different nutrients obtained from the Ist and 2nd trials are presented in table 53 and 54 respectively.

From the data on the total intake of minerals from the ration and outgo through dung and urine , the balance with respect to each mineral was calculated as retention per day and retention as percentage of intake. The data on balance of different minerals estimated viz Ca, P, Mg, Cu, Zn and Fe are presented in table 55 to 74.

RESULTS OF THE STUDY ON THE FEASIBILITY OF WOOD ASH AND EGGSHELL POWDER AS CALCIUM SUPPLEMENTS IN CALF RATION

Data presented in table 55 on the Ca balance of experimental calves belonging to Group-B receiving concentrate mixture containing 1% egg shell powder and 1% wood ash ranged from 7.40 to 12.30g with an average retention of 10.01±0.88g/day, the corresponding percentage retention being 48.74±4.12 where as the Ca balance in group C maintained on ration containing 2% mineral mixture averaged a lower value of 5.29±0.72g/day($P<0.05$) which comes to only 32.81±4.63% of intake.

Average Ca balance (g/day) recorded by the group B and C calves during the second metabolism trial (table -56) comes to 11.13± 0.19 and 7.24±0.40($P<0.01$) respectively while the corresponding percentage retention for group B and C are 39.49±0.65 and 34.23 ±1.71($P<0.05$).

Consolidated data on Ca balance showing the average of both trials for the two groups are presented in table 57, 73 and 74. On comparing the data on Ca retention between two groups during both trials it can be seen that group B calves registered a higher average retention of 44.11± 2.43 percent against a total intake of 24.35±1.17g/day while the group C animals received concentrate mixture with 2% commercial mineral mixture recorded only an average retention of 33.52±2.36% against an average intake of 18.67± 0.76($P>0.05$), the percentage increase being 68.58 and 31.6% in group B over group C for daily retention as g/day and percentage of intake respectively.

Phosphorus

Data regarding the utilisation of P by calves belonging to both groups are presented in table 58, 59 and 60. During the first metabolism trial group B calves fed on concentrate mixture with wood ash and egg shell powder and without any additional Phosphorus supplementation recorded an average retention of 7.52 ±0.54 g/day which corresponds to 41.61±2.68 percentage against an average daily intake of 18.03±0.17g; where as the corresponding values for group C calves offered concentrate mixture with 2% commercial mineral mixture being 11.80±0.58g/day($P<0.01$), 51.92±2.67%($P<0.01$) and 22.75±0.14g

respectively . During the 2nd metabolism trial group B calves showed a lower P retention of 10.31±0.53g/day, (P<0.05) the percentage of intake being 44.83±2.16 (P>0.05) when compared to control group, corresponding values for group C calves being 13.75g/day and 50.88% respectively. Consolidated data taking the average of the two trials for each group (table-60, 73 and 74) reveals that while group B recorded a percentage retention of 43.22±1.71, control group (group C) recorded a higher percentage retention of 51.40±1.81 against an intake of 20.51±0.76g and 24.87 ±0.66 respectively.

Even though group B calves registered a very good positive phosphorus balance in the first and second metabolism trials, group C calves registered significantly higher positive balance in both trials compared to group B which is mainly due to the higher phosphorus intake met from the 2% standard mineral mixture in concentrate mixture C whereas in concentrate mixture B 2% mineral mixture supplement consisted of ash and egg shell powder alone which are very poor source of phosphorus. Even though the tri-sodium phosphate was added in concentrate mixture B during the second half of the experiment since it was of hydrated form it helped to increase the phosphorus content of concentrate mixture B only by about 0.02%. On perusal of the overall data on phosphorus balance in the present study it can be revealed that calves can maintain an average positive phosphorus balance of 7.5 to 10.3g/day without any phosphorus supplementation in the concentrate mixture meeting the phosphorus requirement from the feed ingredients and grass.

Magnesium

Regarding the utilization of Mg by calves of the experimental group (Group B) and control group (Group C), data presented in table 61, 62, 63, 73 and 74 indicates that group B and C recorded an average Mg retention (g/day) of 2.40±0.20 and 1.88±0.26 with a percentage retention of 28.66±2.36 and 24.82±3.67 during the first trial and 2.38±0.14 and 1.93±0.21g/day respectively during the 2nd trial with a corresponding percentage retention of 19.55±1.14 and 18.34±1.84 respectively. Consolidated data taking average of two trials (table 63, 73 and 74) indicate that group B calves registers a percentage retention of 24.10 ± 1.86 while group C registers slightly lower value of 21.58±2.19 indicating that Mg

from concentrate mixture with wood ash is better utilized than that from concentrate mixture C containing commercial mineral mixture($P>0.05$)

Copper

Regarding utilization of Copper, positive balance were recorded by all the calves in both trials. (Table 64, 65, 66, 73 and 74). Group B calves registered an average daily retention of 12.23±1.79mg in the first trial and 14.49±1.33mg in the second trial with an average of 13.36±1.12mg; the corresponding percentage retention being 40.41±5.62; 30.30±2.68 averaging 35.35±3.34 against an intake of 30.12±0.32; 47.74±0.61 and 38.93±2.68mg/day respectively.

Group C calves registered an average daily retention of 16.01±0.45mg and 15.50±1.33mg/day in the first and second metabolism trial respectively with an average of 15.76±0.67mg per day and the corresponding percentage retention being 35.41±1.15; 24.59±1.89 and 30.00±1.95 respectively against an intake of 45.26±0.27; 62.86±0.71 and 54.06±2.68 respectively.

On comparing the two groups (table 66) it can be seen that group B calves maintained on concentrate mixture containing wood ash and egg shell powder recorded apparently higher percentage retention of Cu though not significant statistically in both metabolism trials when compared to control group, the percentage increase being 14.12 and 23.22 for the first and second metabolism trials respectively.

Zinc

Data on dietary Zn intake, retention as mg/day and as percentage of intake of the experimental calves of group B and group C are depicted in table 67 and 68 respectively for the first and second collection and the consolidated data in table 69, 73 and 74. The average retention of Zn (mg/day) for the group B and group C are 62.51±8.51 and 88.05±11.42 respectively during the first metabolism trial and 73.25±6.50 and 79.87±14.13 respectively in the second trial. On comparing the data on percentage retention of Zn between the two groups (table 73 and 74) it can be seen that wood ash and

egg shell powder supplemented group (group B) recorded comparatively higher (P>0.05) percentage retention of 43.20±5.91 against 36.50±4.79 percentage for control group (group C) during first metabolism trial; the same for the 2nd metabolism trial being 28.75±2.30 percentage against 22.45±3.76 percentage (P>0.05). The results reveal that Zn in the concentrate mixture containing wood ash and egg shell powder is better utilized by calves compared to control group . Increase in percentage retention being 18.36 in the first and 28.06% in the second metabolism trial.

Iron

Regarding the utilization of dietary iron (table 70, 71, 72, 73 and 74) experimental calves belonging to both groups recorded a positive balance ($P<0.05$) the average daily retention as percentage of intake being 26.75±3.20 for group B and 37.68±3.52 for group C during Ist trial and 30.71±2.29 and 38.18±1.23 respectively in the 2nd trial with a total average of 28.73±1.97 and 37.93±1.78 for group B and C respectively indicating that Fe in concentrate mixture containing mineral mixture is better utilized than Fe in concentrate mixture with wood ash and egg shell powder.

Conclusion

On scrutiny of the data on Calcium balance from the present study it can be clearly seen that calf fed on egg shell powder and wood ash as Ca supplement showed significantly higher daily Calcium retention as mg/day as well as percentage of intake which reveals that mineral supplement comprising of 50% wood ash and 50% egg shell powder forms efficient Ca supplement when compared to commercial mineral mixture containing conventional Ca supplement.

Regarding the utilisation of phosphorus, Magnesium, Copper, Zinc and Iron also calves maintained on concentrate mixture without mineral mixture could register a very good positive balance indicating that these minerals in feed ingredients as well as grass alone can be utilised very well by the calves to make their requirement. Growth rate and Feed efficiency were also higher in calves maintained on concentrate mixture without standard mineral mixture but containing egg shell powder and ash each at 1% level.

FEASIBILITY OF WOOD ASH & EGG SHELL POWDER AS CALCIUM SUPPLEMENT IN CALF RATION

Feeding trial IV

Table - 47. Percentage ingredient composition of concentrate mixtures used

Ingredients	Conc. Mixture I (Feed - B)	Conc. Mixture II (Feed - C)
Soyabean	33.00	33.00
Black gram bran	16.00	16.00
Maize	16.00	16.00
Rice bran	16.00	16.00
Wheat bran	16.00	16.00
Mineral mixture	-	2.00
Eggshell powder	1.00	-
Ash	1.00	-
Salt	1.00	1.00

Table - 48. Percentage chemical composition of concentrate mixtures and grass on dry matter basis

	Chemical composition		
	Conc. Mix. II (Feed - C)	Conc. Mix. I (Feed - B)	Grass
Total Ash	11.79	12.99	10.34
Acid Insoluble Ash	5.56	5.87	4.93
Crude Fibre	14.35	15.15	26.68
Ether Extract	1.38	1.37	2.41
Crude Protein	24.91	24.90	10.15
NFE	47.57	45.59	50.42

FEASIBILITY OF WOOD ASH & EGG SHELL POWDER AS CALCIUM SUPPLEMENT IN CALF RATION -Feeding trial IV

Table - 49. Percentage mineral composition of Concentrate mixture, Mineral mixture and Grass used for the study(on DMB)

Sample	Ca (g %)	P (g %)	Mg (g %)	Cu (ppm)	Zn (ppm)	Fe (ppm)
Conc.Mix.I(Grp B) (Ist Trial)	0.86	0.78	0.34	12.45	59.03	1468.39
Conc. Mix.I(Grp B) (IInd Trial)	0.86	0.80	0.34	12.45	59.03	1468.39
Con. Mix. II(Grp C)	0.60	1.03	0.29	20.67	112.03	1693.70
Grass(Ist trial)	0.45	0.36	0.20	6.90	34.48	857.06
Grass(IInd trial)	0.49	0.28	0.25	10.87	66.49	1086.96
Min. Mixture (Cacils)	17.41	11.68	0.78	451.71	2726	3110.00

Table -50. Summarised data on Growth rate & Feed Efficiency of calves maintained under two dietary treatments

Parameters	Ration B	Ration C
Average Initial weight (kg)	67.83 ±4.35	68.33 ±3.79
Average Final weight (kg)	96.00 ±6.13	91.67 ±6.68
Average Daily Gain(kg)	0.335 ±0.03	0.278 ±0.05
Average Daily Dry Matter Intake(kg)	3.61 ± 0.05	3.55 ±0.06
Average Feed Efficiency(kg)	10.78 ±0.78	12.62 ±1.59

FEASIBILITY OF WOOD ASH & EGG SHELL POWDER AS CALCIUM SUPPLEMENT IN CALF RATION

Feeding trial IV

Table - 51. Data on daily Dry matter intake, dung and urine voided during the first metabolism trial

Animal No.	Body Weight (Kg)	DMI concentrate (Kg)	DMI grass (Kg)	Total DMI (Kg/day)	Total dung outgo DMB (Kg/day)	Total urine voided (L/day)
			Group - B			
598	77.00	1.78	1.15	2.93	1.03	3.10
602	102.00	1.78	1.17	2.95	1.55	6.30
605	74.00	1.78	0.99	2.77	1.11	4.10
607	80.00	1.78	1.07	2.85	0.77	4.20
614	75.00	1.78	1.23	3.01	0.98	4.55
624	61.00	1.78	1.31	3.09	0.92	3.60
Aver.	**78.17**	**1.78**	**1.15**	**2.93**	**1.06**	**4.31**
±S.E	±5.46	±0.0	±0.05	±0.05	±0.11	±0.45
			Group - C			
601	101.00	1.78	1.33	3.11	1.24	5.90
606	75.00	1.78	1.11	2.89	0.88	5.30
608	71.00	1.78	1.13	2.91	0.82	5.80
611	68.00	1.78	1.23	3.01	0.93	4.70
613	74.00	1.78	1.33	3.11	1.03	5.90
616	71.00	1.78	1.23	3.01	0.99	5.30
Aver.	**76.67**	**1.78**	**1.23**	**3.01**	**0.98**	**5.48**
±S.E	±4.97	±0.00	±0.04	±0.04	±0.06	±0.19

FEASIBILITY OF WOOD ASH & EGG SHELL POWDER AS CALCIUM SUPPLEMENT IN CALF RATION
Feeding trial IV

Table 52. Data on daily Dry matter intake, dung and urine voided during the second metabolism trial

Animal No.	Body Weight (Kg)	DMI concentrate (Kg)	DMI grass (Kg)	Total DMI (Kg/day)	Total dung outgo DMB (Kg/day)	Total urine voided (L/day)
			Group B			
598	91.00	2.23	1.69	3.92	1.36	6.50
602	123.00	2.23	1.98	4.21	1.64	6.60
605	91.00	2.23	1.77	4.00	1.19	7.95
607	96.00	2.23	1.98	4.21	1.30	15.35
614	93.00	2.23	1.92	4.15	1.45	7.20
624	75.00	2.23	1.69	3.92	1.43	6.85
Aver.	**94.83**	**2.23**	**1.84**	**4.07**	**1.40**	**8.41**
±S.E	±5.82	±0.00	±0.06	±0.06	±0.06	±1.40
			Group C			
601	125.00	2.09	1.56	3.65	1.29	4.60
606	84.50	2.09	1.71	3.80	1.26	9.00
608	81.00	2.23	1.51	3.74	1.27	7.90
611	83.00	2.23	1.68	3.91	1.24	4.60
613	87.00	2.14	1.77	3.91	1.20	4.00
616	81.00	2.23	1.73	3.96	0.94	9.50
Aver.	**90.25**	**2.17**	**1.66**	**3.83**	**1.20**	**6.60**
±S.E	±7.01	±0.03	±0.04	±0.05	±0.05	±1.01

FEASIBILITY OF WOOD ASH & EGG SHELL POWDER AS CALCIUM SUPPLEMENT IN CALF RATION-Feeding trial IV

Table - 53. Digestibility coefficients of nutrients in calves during First metabolism trial

Animal No.	Organic Matter	Crude Protein	Crude Fibre	Ether Extract	Nitrogen Free Extract
Group-B					
598	67.55	77.71	63.78	39.54	66.07
602	55.23	69.27	47.10	21.67	54.25
605	64.02	75.06	59.03	38.92	62.39
607	75.49	84.51	73.70	60.96	73.08
614	69.84	80.18	69.66	40.00	66.94
624	73.01	82.61	71.50	59.82	70.39
Average	**67.52**	**78.22**	**64.13**	**43.49**	**65.52**
±S.E.	±2.96	±2.26	±4.05	±6.04	±2.70
Group-C					
601	63.22	76.50	57.05	30.69	61.89
606	71.32	80.27	72.00	49.61	68.32
608	74.19	81.76	69.58	54.25	73.75
611	71.69	79.65	67.29	50.37	71.15
613	69.51	79.82	70.89	48.32	65.83
616	69.97	80.29	68.87	48.15	67.22
Average	**69.98**	**79.72**	**67.61**	**46.90**	**68.03**
±S.E.	±1.51	±0.71	±2.21	±3.36	±1.69

FEASIBILITY OF WOOD ASH & EGG SHELL POWDER AS CALCIUM SUPPLEMENT IN CALF RATION
Feeding trial IV

Table - 54. Digestibility coefficients of nutrients in calves during Second metabolism trial

Animal No.	Dry Matter	Organic Matter	Crude Protein	Crude Fibre	Ether Extract	Nitrogen Free Extract
Group-B						
598	65.17	68.10	72.96	69.43	50.98	66.27
602	61.04	64.41	70.07	67.62	40.02	50.35
605	70.15	73.00	73.03	74.80	60.73	72.72
607	69.21	71.46	75.66	74.80	64.32	68.71
614	65.13	67.52	72.92	67.09	54.62	66.13
624	63.59	67.00	69.57	70.35	46.76	65.36
Average ±S.E.	**65.72** ±1.40	**68.58** ±1.28	**72.37** ±0.91	**70.68** ±1.38	**52.91** ±3.65	**64.92** ±3.11
Group-C						
601	64.71	67.13	74.96	72.35	47.66	62.79
606	66.73	68.45	75.06	77.41	43.71	63.24
608	65.93	68.67	72.32	68.45	42.68	68.28
611	68.20	69.70	75.35	80.55	53.72	63.75
613	69.59	72.78	76.45	76.66	45.64	70.83
616	75.95	77.09	83.38	82.90	62.27	72.95
Average ±S.E.	**68.52** ±1.64	**70.64** ±1.50	**76.25** ±1.53	**76.38** ±2.16	**49.28** ±3.05	**66.97** ±1.77

Table - 55 FEASIBILITY OF WOOD ASH & EGG SHELL POWDER AS CALCIUM SUPPLEMENT IN CALF RATION

Data on Calcium Balance-First Trial

Anim. No.	Intake of Calcium (gram per day)			Outgo of Calcium (gram per day)			Calcium balance	
	Conc.	Grass	Total	Dung	Urine	Total	Retention (g/day)*	Retention (% of intake)
Group B								
598	15.31	5.18	20.49	9.06	0.062	9.12	11.37	55.49
602	15.31	5.27	20.58	13.02	0.164	13.18	7.40	35.96
605	15.31	4.46	19.77	11.99	0.115	12.11	7.66	38.75
607	15.31	4.82	20.13	8.09	0.185	8.28	11.85	58.87
614	15.31	5.54	20.85	11.27	0.118	11.39	9.46	45.37
624	15.31	5.90	21.21	8.83	0.079	8.91	12.30	57.99
Average ± S.E	**15.31** ±0.00	**5.20** ±0.21	**20.51** ±0.21	**10.38** ±0.81	**0.121** ±0.019	**10.50** ±0.81	**10.01**[a] ±0.88	**48.74** ±4.12
Group C								
601	10.68	5.99	16.67	14.01	0.271	14.28	2.39	14.34
606	10.68	5.00	15.68	10.21	0.159	10.37	5.31	33.86
608	10.68	5.09	15.77	8.28	0.174	8.45	7.32	46.42
611	10.68	5.54	16.22	9.21	0.226	9.44	6.78	41.80
613	10.68	5.99	16.67	10.92	0.177	11.10	5.57	33.41
616	10.68	5.54	16.22	11.68	0.159	11.84	4.38	27.00
Average ± S.E	**10.68** ±0.00	**5.53** ±0.17	**16.21** ±0.17	**10.72** ±0.82	**0.194** ±0.018	**10.91** ±0.83	**5.29**[b] ±0.72	**32.81** ±4.63

Table - 56. FEASIBILITY OF WOOD ASH & EGG SHELL POWDER AS CALCIUM SUPPLEMENT IN CALF RATION

Data on Calcium Balance -Second Trial

Anim. No.	Intake of Calcium (gram per day)			Outgo of Calcium (gram per day)			Calcium balance	
	Conc.	Grass	Total	Dung	Urine	Total	Retention (g/day)	Retention (% of intake)
Group B								
598	19.18	8.28	27.46	16.32	0.234	16.55	10.91	39.73
602	19.18	9.70	28.88	18.04	0.066	18.11	10.77	37.29
605	19.18	8.67	27.85	16.18	0.127	16.31	11.54	41.44
607	19.18	9.70	28.88	16.77	0.246	17.02	11.86	41.07
614	19.18	9.41	28.59	17.55	0.072	17.62	10.97	38.37
624	19.18	8.28	27.46	16.59	0.151	16.74	10.72	39.04
Average ± SE	**19.18** ±0.00	**9.01** ±0.28	**28.19** ±0.28	**16.91** ±0.30	**0.149** ±0.032	**17.06** ±0.28	**11.13** ±0.19	**39.49** ±0.65
Group-C								
601	12.54	7.64	20.18	13.03	0.046	13.08	7.10	35.18
606	12.54	8.38	20.92	13.61	0.108	13.72	7.20	34.42
608	13.38	7.40	20.78	14.35	0.079	14.43	6.35	30.56
611	13.38	8.23	21.61	14.51	0.285	14.80	6.81	31.51
613	12.84	8.67	21.51	14.64	0.040	14.68	6.83	31.75
616	13.38	8.48	21.86	12.50	0.190	12.69	9.17	41.95
Average ± SE	**13.01** ±0.17	**8.13** ±0.20	**21.14** ±0.26	**13.77** ±0.36	**0.125** ±0.039	**13.90** ±0.36	**7.24** ±0.40	**34.23** ±1.71

Table - 57. FEASIBILITY OF WOOD ASH & EGG SHELL POWDER AS CALCIUM SUPPLEMENT IN CALF RATION

Consolidated Data on Calcium Balance

Particulars	Intake of Calcium (g/day)			Outgo of Calcium (g/day)			Calcium balance	
	Conc.	Grass	Total	Dung	Urine	Total	Retention (g/day)	Retention (% of intake)
Ist Metabolism Trial								
Group B	15.31 ±0.00	5.20 ±0.21	20.51 ±0.21	10.38 ±0.81	0.121 ±0.019	10.50 ±0.81	10.01^{a*} ±0.88	48.74 ±4.12
Group C	10.68 ±0.00	5.53 ±0.17	16.21 ±0.17	10.72 ±0.82	0.194 ±0.018	10.91 ±0.83	5.29^{b*} ±0.72	32.81 ±4.63
IInd Metabolism Trial								
Group B	19.18 ±0.00	9.01 ±0.28	28.19 ±0.28	16.91 ±0.30	0.149 ±0.032	17.06 ±0.28	11.13^{a**} ±0.19	39.49^{a*} ±0.65
Group C	13.01 ±0.17	8.13 ±0.20	21.14 ±0.26	13.77 ±0.36	0.125 ±0.039	13.90 ±0.36	7.24^{b**} ±0.40	34.23^{b*} ±1.71

Values bearing different superscripts in the same column differ significantly within each trial

DATA ON AVERAGE CALCIUM BALANCE OF CALVES COLLECTED DURING THE FIRST AND SECOND METABOLISM TRIAL

Particulars	Intake of Calcium (g/day)			Outgo of Calcium (g/day)			Calcium balance	
Average of I^{st} and II^{nd} trial	Conc.	Grass	Total	Dung	Urine	Total	Retention (g/day)	Retention (% of intake)
Group B	17.25 ±0.58	7.10 ±0.60	24.35 ±1.17	13.64 ±1.07	0.135 ±0.018	13.78 ±1.07	10.57 ±0.46	44.11 ±2.43
Group C	11.85 ±0.36	6.83 ±0.41	18.67 ±0.76	12.25 ±0.63	0.160 ±0.02	12.41 ±0.62	6.27 ±0.49	33.52 ±2.36

Table - 58 FEASIBILITY OF WOOD ASH & EGG SHELL POWDER AS CALCIUM SUPPLEMENT IN CALF RATION

Data on Phosphorus Balance-First Trial

Anim. No.	Intake of Phosphorus (g/day)			Outgo of Phosphorus (g/day)			Phosphorus balance	
	Conc.	Grass	Total	Dung	Urine	Total	Retention (g/day)**	Retention (% of intake)**
Group -B								
598	13.88	4.14	18.02	9.79	1.86	11.65	6.37	35.35
602	13.88	4.21	18.09	7.44	3.78	11.22	6.87	37.98
605	13.88	3.56	17.44	8.66	2.62	11.28	6.16	35.32
607	13.88	3.85	17.73	9.55	0.50	10.05	7.68	43.32
614	13.88	4.43	18.31	6.96	2.91	9.87	8.44	46.10
624	13.88	4.72	18.60	7.27	1.73	9.00	9.60	51.61
Average + SE	**13.88** ±0.00	**4.15** ±0.17	**18.03** ±0.17	**8.28** ±0.50	**2.23** ±0.46	**10.51** ±0.42	**7.52** ±0.54	**41.61** ±2.68
Group -C								
601	18.33	4.79	23.12	11.04	2.36	13.40	9.72	42.04
606	18.33	4.00	22.33	8.54	1.70	10.24	12.09	54.14
608	18.33	4.07	22.40	6.72	3.48	10.20	12.20	54.46
611	18.33	4.43	22.76	9.77	2.07	11.84	10.92	47.98
613	18.33	4.79	23.12	8.14	3.07	11.21	11.91	51.51
616	18.33	4.43	22.76	7.52	1.27	8.79	13.97	61.38
Average ± SE	**18.33** ±0.00	**4.42** ±0.14	**22.75** ±0.14	**8.62** ± 0.64	**2.33** ± 0.34	**10.95** +0.65	**11.80** +0.58	**51.92** ±2.67

Table - 59. FEASIBILITY OF WOOD ASH & EGG SHELL POWDER AS CALCIUM SUPPLEMENT IN CALF RATION

Data on Phosphorus Balance-Second Trial

Anim. No.	Intake of Phosphorus (g/day) Conc.	Grass	Total	Outgo of Phosphorus (g/day) Dung	Urine	Total	Phosphorus balance Retention (g/day)*	Retention (% of intake)
Group - B								
598	17.84	4.73	22.57	11.83	1.77	13.60	8.97	39.74
602	17.84	5.54	23.38	10.00	3.00	13.00	10.38	44.40
605	17.84	4.96	22.80	10.71	1.01	11.72	11.08	48.60
607	17.84	5.54	23.38	10.27	2.79	13.06	10.32	44.14
614	17.84	5.38	23.22	7.98	2.94	10.92	12.30	52.97
624	17.84	4.73	22.57	12.58	1.16	13.74	8.83	39.12
Average + SE	**17.84** ±0.00	**5.15** ±0.16	**22.99** ±0.16	**10.56** ±0.65	**2.11** ±0.37	**12.67** ±0.46	**10.31** ±0.53	**44.83** ±2.16
Group - C								
601	21.53	4.37	25.90	9.80	3.33	13.13	12.77	49.31
606	21.53	4.79	26.32	10.58	3.28	13.86	12.46	47.34
608	22.97	4.23	27.20	9.78	5.01	14.79	12.41	45.63
611	22.97	4.70	27.67	10.17	2.67	12.84	14.83	53.60
613	22.04	4.96	27.00	12.96	1.48	14.44	12.56	46.52
616	22.97	4.84	27.81	5.55	4.77	10.32	17.49	62.89
Average ± SE	**22.34** ±0.29	**4.65** ±0.12	**26.98** ±0.31	**9.81** ± 0.98	**3.42** ± 0.54	**13.23** +0.66	**13.75** +0.84	**50.88** ±2.67

Table - 60. FEASIBILITY OF WOOD ASH & EGG SHELL POWDER AS CALCIUM SUPPLEMENT IN CALF RATION

Consolidated Data on Phosphorus Balance

Particulars	Intake of Phosphorus (g/day)			Outgo of Phosphorus (g/day)			Phosphorus balance		
	Conc.	Grass	Total	Dung	Urine	Total	Retention (g/day)	Retention (% of intake)	
Ist Metabolism Trial									
Group B	13.88 ±0.00	4.15 ±0.17	18.03 ±0.17	8.28 ±0.50	2.23 ±0.46	10.51 ±0.42	7.52^{a**} ±0.54	41.61^{a**} ±2.68	
Group C	18.33 ±0.00	4.42 ±0.14	22.75 ±0.14	8.62 ±0.64	2.33 ±0.34	10.95 ±0.65	11.80^{b**} ±0.58	51.92^{b**} ±2.67	
IInd Metabolism Trial									
Group B	17.84 ±0.00	5.15 ±0.16	22.99 ±0.16	10.56 ±0.65	2.11 ±0.37	12.67 ±0.46	10.31^{a*} ±0.53	44.83 ±2.16	NS
Group C	22.34 ±0.29	4.65 ±0.12	26.98 ±0.31	9.81 ±0.98	3.42 ±0.54	13.23 ±0.66	13.75^{b*} ±0.84	50.88 ±2.67	NS

Values bearing different superscripts in the same column differ significantly within each trial

DATA ON AVERAGE PHOSPHORUS BALANCE OF CALVES COLLECTED DURING THE FIRST AND SECOND METABOLISM TRIAL

Average of I^{st} and II^{nd} trial	Intake of Phosphorus (g/day)			Outgo of Phosphorus (g/day)			Phosphorus balance	
	Conc.	Grass	Total	Dung	Urine	Total	Retention (g/day)	Retention (% of intake)
Group B	15.86 ±0.60	4.65 ±0.19	20.51 ±0.76	9.42 ±0.52	2.17 ±0.28	11.59 ±0.44	8.92 ±0.56	43.22 ±1.71
Group C	20.33 ±0.62	4.53 ±0.09	24.87 ±0.66	9.21 ±0.59	2.87 ±0.35	12.09 ±0.56	12.78 ±0.57	51.40 ±1.81

Table - 61. Data on mineral availability studies in caves using egg shell powder & wood ash as Ca supplement

Data on Magnesium Balance-First Trial

Anim. No.	Intake of Magnesium (g/day)			Outgo of Magnesium (g/day)			Magnesium balance	
	Conc.	Grass	Total	Dung	Urine	Total	Retention (g/day)	Retention (% of intake)
Group B								
598	6.05	2.30	8.35	4.94	0.670	5.61	2.74	32.81
602	6.05	2.34	8.39	6.20	0.680	6.88	1.51	18.00
605	6.05	1.98	8.03	5.77	0.164	5.93	2.10	26.15
607	6.05	2.14	8.19	4.85	0.672	5.52	2.67	32.60
614	6.05	2.46	8.51	5.49	0.291	5.78	2.73	32.08
624	6.05	2.62	8.67	5.61	0.425	6.04	2.63	30.33
Average ± SE	**6.05** ±0.00	**2.31** ±0.09	**8.36** ±0.09	**5.48** ±0.21	**0.484** ±0.092	**5.96** ±0.20	**2.40** ±0.20	**28.66** ±2.36
Group C								
601	5.16	2.66	7.82	5.95	0.649	6.60	1.22	15.60
606	5.16	2.22	7.38	4.75	0.180	4.93	2.45	33.20
608	5.16	2.26	7.42	4.43	0.615	5.05	2.37	31.94
611	5.16	2.46	7.62	4.84	0.686	5.53	2.09	27.43
613	5.16	2.66	7.82	6.18	0.732	6.91	0.91	11.64
616	5.16	2.46	7.62	5.05	0.350	5.40	2.22	29.13
Average ± SE	**5.16** ±0.00	**2.45** ±0.08	**7.61** ±0.08	**5.20** ± 0.29	**0.535** ±0.09	**5.74** ±0.34	**1.88** ±0.26	**24.82** ±3.67

Table - 62. Data on mineral availability studies in caves using egg shell powder & wood ash as Ca supplement

Data on Magnesium Balance-Second Trial

Anim. No.	Intake of Magnesium (g/day)			Outgo of Magnesium (g/day)			Magnesium balance	
	Conc.	Grass	Total	Dung	Urine	Total	Retention (g/day)	Retention (% of intake)
Group B								
598	7.58	4.23	11.81	8.70	0.598	9.30	2.51	21.25
602	7.58	4.95	12.53	9.84	0.528	10.37	2.16	17.24
605	7.58	4.43	12.01	8.69	0.557	9.25	2.76	22.98
607	7.58	4.95	12.53	9.36	0.675	10.04	2.49	19.87
614	7.58	4.80	12.38	9.43	0.403	9.83	2.55	20.60
624	7.58	4.23	11.81	9.44	0.562	10.00	1.81	15.33
Average	**7.58**	**4.60**	**12.18**	**9.24**	**0.554**	**9.80**	**2.38**	**19.55**
± SE	**±0.00**	**±0.14**	**±0.14**	**±0.187**	**±0.037**	**±0.18**	**±0.14**	**±1.14**
Group C								
601	6.06	3.90	9.96	8.39	0.258	8.65	1.31	13.15
606	6.06	4.28	10.34	8.06	0.738	8.80	1.54	14.89
608	6.47	3.78	10.25	8.13	0.569	8.70	1.55	15.12
611	6.47	4.20	10.67	8.18	0.156	8.34	2.33	21.84
613	6.21	4.43	10.64	8.28	0.128	8.41	2.23	20.96
616	6.47	4.33	10.80	7.33	0.874	8.20	2.60	24.07
Average	**6.29**	**4.15**	**10.44**	**8.06**	**0.454**	**8.52**	**1.93**	**18.34**
± SE	**±0.08**	**±0.10**	**±0.13**	**±0.15**	**±0.130**	**±0.10**	**±0.21**	**±1.84**

Table - 63. Data on mineral availability studies in caves using egg shell powder & wood ash as Ca supplement

Consolidated Data on Magnesium Balance

Particulars	Intake of Magnesium (g/day)			Outgo of Magnesium (g/day)			Magnesium balance	
	Conc.	Grass	Total	Dung	Urine	Total	Retention (g/day)	Retention (% of intake)
Ist Metabolism Trial								
Group B	6.05 ±0.00	2.31 ±0.09	8.36 ±0.09	5.48 ±0.21	0.484 ±0.092	5.96 ±0.20	2.40 ±0.20 NS	28.66 ± 2.36 NS
Group C	5.16 ±0.00	2.45 ±0.08	7.61 ±0.08	5.20 ±0.29	0.535 ±0.090	5.74 ±0.34	1.88 ±0.26 NS	24.82 ±3.67 NS
IInd Metabolism Trial								
Group B	7.58 ±0.00	4.60 ±0.14	12.18 ±0.14	9.24 ±0.187	0.554 ±0.037	9.80 ±0.18	2.38 ±0.14 NS	19.55 ± 1.14 NS
Group C	6.29 ±0.08	4.15 ±0.10	10.44 ±0.13	8.06 ±0.15	0.454 ±0.130	8.52 ±0.10	1.93 ±0.21 NS	18.34 ±1.84 NS

AVERAGE MAGNESIUM BALANCE OF CALVES COLLECTED DURING THE FIRST AND SECOND METABOLISM TRIAL

Average of Ist and IInd Trial	Intake of Magnesium (g/day)			Outgo of Magnesium (g/day)			Magnesium balance	
	Conc.	Grass	Total	Dung	Urine	Total	Retention (g/day)	Retention (% of intake)
Group B	6.82 ±0.23	3.45 ±0.36	10.27 ±0.58	7.36 ±0.58	0.519 ±0.048	7.88 ±0.59	2.39 ±0.12	24.10 ±1.86
Group C	5.73 ±0.18	3.30 ±0.26	9.03 ±0.43	6.63 ±0.46	0.49 ±0.08	7.13 ±0.45	1.90 ±0.16	21.58 ±2.19

Table - 64. Data on mineral availability studies in caves using egg shell powder & wood ash as Ca supplement

Data on Copper Balance-First Trial

Anim. No.	Intake of Copper (mg/day)			Outgo of Copper (mg/day)			Copper balance	
	Conc.	Grass	Total	Dung	Urine	Total	Retention (mg/day)	Retention (% of intake)
Group B								
598	22.16	7.94	30.10	19.55	0.372	19.92	10.18	33.82
602	22.16	8.07	30.23	21.87	0.252	22.12	8.11	26.83
605	22.16	6.83	28.99	21.46	0.328	21.79	7.20	24.84
607	22.16	7.38	29.54	15.47	0.336	15.81	13.73	46.48
614	22.16	8.49	30.65	13.66	0.182	13.84	16.81	54.85
624	22.16	9.04	31.20	13.56	0.288	13.85	17.35	55.61
Average ± SE	**22.16** ±0.00	**7.96** ±0.32	**30.12** ±0.32	**17.60** ± 1.56	**0.293** ±0.028	**17.89** ±1.57	**12.23** ±1.79	**40.41** ±5.62
Group C								
601	36.79	9.18	45.97	31.07	0.413	31.48	14.49	31.52
606	36.79	7.66	44.45	27.00	1.060	28.06	16.39	36.87
608	36.79	7.80	44.59	26.35	1.160	27.51	17.08	38.30
611	36.79	8.49	45.28	29.17	0.423	29.59	15.69	34.65
613	36.79	9.18	45.97	30.30	0.531	30.83	15.14	32.93
616	36.79	8.49	45.28	27.57	0.424	27.99	17.29	38.18
Average ± SE	**36.79** ±0.00	**8.47** ±0.27	**45.26** ±0.27	**28.58** ±0.77	**0.669** + 0.14	**29.24** ± 0.670	**16.01** ±0.45	**35.41** ±1.15

Table - 65. Data on mineral availability studies in caves using egg shell powder & wood ash as Ca supplement

Data on Copper Balance-Second Trial

Anim. No.	Intake of Copper (mg/day)			Outgo of Copper (mg/day)			Copper balance	
	Conc.	Grass	Total	Dung	Urine	Total	Retention (mg/day)	Retention (% of intake)
Group B								
598	27.76	18.37	46.13	32.10	0.26	32.36	13.77	29.85
602	27.76	21.52	49.28	31.91	0.462	32.37	16.91	34.31
605	27.76	19.24	47.00	28.48	0.239	28.72	18.28	38.89
607	27.76	21.52	49.28	32.85	0.307	33.16	16.12	32.71
614	27.76	20.87	48.63	35.93	0.288	36.22	12.41	25.52
624	27.76	18.37	46.13	36.54	0.137	36.68	9.45	20.49
Average + SE	**27.76** ±0.00	**19.98** ±0.61	**47.74** ±0.61	**32.97** ±1.20	**0.282** ±0.043	**33.25** ±1.19	**14.49** ±1.33	**30.30** ±2.68
Group C								
601	43.20	16.96	60.16	48.41	0.184	48.59	11.57	19.23
606	43.20	18.59	61.79	47.75	0.180	47.93	13.86	22.43
608	46.09	16.41	62.50	46.38	0.158	46.54	15.96	25.54
611	46.09	18.26	64.35	50.12	0.414	50.53	13.82	21.48
613	44.23	19.24	63.47	46.30	0.320	46.62	16.85	26.55
616	46.09	18.81	64.90	42.81	1.140	43.95	20.95	32.28
Average ± SE	**44.82** ±0.59	**18.05** ±0.45	**62.86** ±0.71	**46.96** ±1.01	**0.399** + 0.154	**47.36** ± 0.91	**15.50** ±1.33	**24.59** ±1.89

Table - 66. Data on mineral availability studies in caves using egg shell powder & wood ash as Ca supplement

Consolidated data on Copper Balance

Particulars	Intake of Copper (mg/day)			Outgo of Copper (mg/day)			Copper balance	
	Conc.	Grass	Total	Dung	Urine	Total	Retention (mg/day)	Retention (% of intake)
Ist Metabolism Trial								
Group B	22.16 ±0.00	7.96 ±0.32	30.12 ±0.32	17.60 ±1.56	0.293 ±0.028	17.89 ±1.57	12.23 ±1.79 NS	40.41 ±5.62 NS
Group C	36.79 ±0.00	8.47 ±0.27	45.26 ±0.27	28.58 ±0.77	0.669 ±0.14	29.24 ±0.67	16.01 ±0.45 NS	35.41 ±1.15 NS
IInd Metabolism Trial								
Group B	27.76 ±0.00	19.98 ±0.61	47.74 ±0.61	32.97 ±1.20	0.282 ±0.043	33.25 ±1.19	14.49 ±1.33 NS	30.30 ±2.68 NS
Group C	44.82 ±0.59	18.05 ±0.45	62.86 ±0.71	46.96 ±1.01	0.399 ±0.154	47.36 ±0.91	15.50 ±1.33 NS	24.59 ±1.89 NS

AVERAGE COPPER BALANCE OF CALVES COLLECTED DURING THE FIRST AND SECOND METABOLISM TRIAL

Average of Ist and IInd Trial	Intake of Copper (mg/day)			Outgo of Copper (mg/day)			Copper balance	
	Conc.	Grass	Total	Dung	Urine	Total	Retention (mg/day)	Retention (% of intake)
Group B	24.96 ±0.85	13.97 ±1.84	38.93 ±2.68	25.28 ±2.50	0.288 ±0.02	25.57 ±2.50	13.36 ±1.12	35.35 ±3.34
Group C	40.80 ±1.24	13.26 ±1.47	54.06 ±2.68	37.77 ±2.84	0.53 ±0.11	38.30 ±2.79	15.76 ±0.67	30.00 ±1.95

Table - 67. Data on mineral availability studies in calves using egg shell powder & wood ash as Ca supplement

Data on Zinc Balance-First Trial

Anim. No.	Intake of Zinc (mg/day)			Outgo of Zinc (mg/day)			Zinc balance	
	Conc.	Grass	Total	Dung	Urine	Total	Retention (mg/day)	Retention (% of intake)
Group - B								
598	105.07	39.65	144.72	109.00	4.19	113.19	31.53	21.79
602	105.07	40.34	145.41	60.90	5.92	66.82	78.59	54.05
605	105.07	34.14	139.21	60.00	3.69	63.69	75.52	54.25
607	105.07	36.89	141.96	86.90	3.99	90.89	51.07	35.97
614	105.07	42.41	147.48	60.00	1.50	61.50	85.98	58.30
624	105.07	45.17	150.24	96.53	1.33	97.86	52.38	34.86
Average ± SE	**105.07 ±0.00**	**39.77 ±1.60**	**144.84 ±1.60**	**78.89 ± 8.79**	**3.44 ±0.71**	**82.33 ±8.73**	**62.51 ±8.51**	**43.20 ±5.91**
Group C								
601	199.41	45.86	245.27	186.20	7.32	193.52	51.75	21.10
606	199.41	38.27	237.68	135.56	11.24	146.80	90.88	38.24
608	199.41	38.96	238.37	129.42	12.99	142.41	95.96	40.26
611	199.41	42.41	241.82	143.90	18.05	161.95	79.87	33.03
613	199.41	45.86	245.27	169.42	1.65	171.07	74.20	30.25
616	199.41	42.41	241.82	95.77	10.39	106.16	135.66	56.10
Average ± SE	**199.41 ±0.00**	**42.30 ±1.33**	**241.71 ±1.33**	**143.38 ±12.95**	**10.27 ± 2.25**	**153.65 ± 12.10**	**88.05 ±11.42**	**36.50 ±4.79**

Table - 68. Data on mineral availability studies in caves using egg shell powder and wood ash as Ca supplement

Data on Zinc Balance-Second Trial

Anim. No.	Intake of Zinc (mg/day) Conc.	Grass	Total	Outgo of Zinc (mg/day) Dung	Urine	Total	Zinc balance Retention (mg/day)	Retention (% of intake)
Group - B								
598	131.64	112.37	244.01	183.67	1.56	185.23	58.78	24.09
602	131.64	131.65	263.29	190.04	1.58	191.62	71.67	27.22
605	131.64	117.69	249.33	163.93	1.59	165.52	83.81	33.61
607	131.64	131.65	263.29	171.64	1.84	173.48	89.81	34.11
614	131.64	127.66	259.30	173.01	1.15	174.16	85.14	32.83
624	131.64	112.37	244.01	191.81	1.92	193.73	50.28	20.61
Average + SE	**131.64 ±0.00**	**122.23 ±3.75**	**253.87 ±3.75**	**179.02 ±4.56**	**1.61 ±0.11**	**180.62 ±4.60**	**73.25 ±6.50**	**28.75 ±2.30**
Group C								
601	234.14	103.72	337.86	284.81	1.84	286.65	51.21	15.16
606	234.14	113.70	347.84	264.29	2.52	266.81	81.03	23.30
608	249.83	100.40	350.23	302.72	2.84	305.56	44.67	12.75
611	249.83	111.70	361.53	276.93	1.47	278.40	83.13	22.99
613	239.74	117.69	357.43	276.30	4.32	280.62	76.81	21.49
616	249.83	115.03	364.86	219.43	3.04	222.47	142.39	39.03
Average ± SE	**242.92 ±3.20**	**110.37 ±2.78**	**353.29 ±4.07**	**270.75 ±11.49**	**2.67 ± 0.41**	**273.42 ± 11.43**	**79.87 ±14.13**	**22.45 ±3.76**

Table - 69 . Data on mineral availability studies in caves using egg shell powder & wood ash as Ca supplement

Consolidated data on Zinc Balance

Particulars	Intake of Zinc (mg/day)			Outgo of Zinc (mg/day)			Zinc balance	
	Conc.	Grass	Total	Dung	Urine	Total	Retention (mg/day)	Retention (% of intake)
Ist Metabolism Trial								
Group B	105.07 ±0.00	39.77 ±1.60	144.84 ±1.60	78.89 ±8.79	3.44 ±0.71	82.33 ±8.73	62.51 ±8.51	43.20 ±5.91
Group C	199.41 ±0.00	42.30 ±1.33	241.71 ±1.33	143.38 ±12.95	10.27 ±2.25	153.65 ±12.10	88.05 ±11.42	36.50 ±4.79
IInd Metabolism Trial								
Group B	131.64 ±0.00	122.23 ±3.75	253.87 ±3.75	179.02 ±4.56	1.61 ±0.11	180.62 ±4.60	73.25 ±6.50	28.75 ±2.30
Group C	242.92 ±3.20	110.37 ±2.78	353.29 ±4.07	270.75 ±11.49	2.67 ±0.41	273.42 ±11.43	79.87 ±14.13	22.45 ±3.76

AVERAGE ZINC BALANCE OF CALVES COLLECTED DURING THE FIRST AND SECOND METABOLISM TRIAL

Average of Ist and IInd Trial	Intake of Zinc (mg/day)			Outgo of Zinc (mg/day)			Zinc balance	
	Conc.	Grass	Total	Dung	Urine	Total	Retention (mg/day)	Retention (% of intake)
Group B	118.36 ±4.01	81.00 ±12.60	199.35 ±16.57	128.95 ±15.84	2.52 ±0.44	131.47 ±15.57	67.88 ±5.36	35.97 ±3.73
Group C	221.16 ±6.74	76.33 ±10.38	297.50 ±16.97	207.06 ±20.93	6.47 ±1.58	213.54 ±19.75	83.96 ±8.76	29.48 ±3.60

Table - 70. Data on mineral availability studies in caves using egg shell powder & wood ash as Ca supplement

Data on Iron Balance-First Trial

Anim. No.	Intake of Iron (mg/day)			Outgo of Iron (mg/day)			Iron balance	
	Conc.	Grass	Total **	Dung	Urine	Total	Retention (mg/day)*	Retention (% of intake)
Group B								
598	2613.73	985.62	3599.35	2650.35	19.96	2670.31	929.04	25.81
602	2613.73	1002.76	3616.49	3112.52	26.46	3138.98	477.51	13.20
605	2613.73	848.49	3462.22	2634.54	25.26	2659.80	802.42	23.18
607	2613.73	917.05	3530.78	2332.87	23.02	2355.89	1174.89	33.28
614	2613.73	1054.18	3667.91	2448.34	13.29	2461.63	1206.28	32.89
624	2613.73	1122.75	3736.48	2522.75	12.67	2535.42	1201.06	32.14
Average + SE	**2613.73 ±0.00**	**988.48 ±39.68**	**3602.21 ±39.68**	**2616.90 ±110.28**	**20.11 ±2.43**	**2637.01 ±111.59**	**965.20 ±118.77**	**26.75 ±3.20**
Group C								
601	3014.79	1139.89	4154.68	3151.44	23.36	3174.80	979.88	23.58
606	3014.79	951.34	3966.13	2055.50	20.56	2076.06	1890.07	47.66
608	3014.79	968.48	3983.27	2307.91	39.90	2347.81	1635.46	41.06
611	3014.79	1054.18	4068.97	2247.97	22.37	2270.34	1798.63	44.20
613	3014.79	1139.89	4154.68	2744.42	22.18	2766.60	1388.08	33.41
616	3014.79	1054.18	4068.97	2552.74	44.73	2597.47	1471.50	36.16
Average ± SE	**3014.79 ±0.00**	**1051.33 ±32.94**	**4066.12 ±32.94**	**2510.00 ±161.65**	**28.85 ± 4.32**	**2538.85 ±161.47**	**1527.27 ±134.02**	**37.68 ±3.52**

Table - 71. Data on mineral availability studies in caves using egg shell powder & wood ash as Ca supplement

Data on Iron Balance-Second Trial

Anim. No.	Intake of Iron (mg/day)			Outgo of Iron (mg/day)			Iron balance	
	Conc.	Grass	Total *	Dung	Urine	Total	Retention (mg/day) *	Retention (% of intake) *
Group - B								
598	3274.51	1836.96	5111.47	3661.70	13.26	3674.96	1436.51	28.10
602	3274.51	2152.18	5426.69	4145.72	15.05	4160.77	1265.92	23.33
605	3274.51	1923.92	5198.43	3205.42	17.17	3222.59	1975.84	38.01
607	3274.51	2152.18	5426.69	3449.59	59.56	3509.15	1917.54	35.34
614	3274.51	2086.96	5361.47	3587.13	16.13	3603.26	1758.21	32.79
624	3274.51	1836.96	5111.47	3727.14	21.65	3748.79	1362.68	26.66
Average ± SE	**3274.51 ±0.00**	**1998.19 ±61.31**	**5272.70 ±61.31**	**3629.45 ±127.91**	**23.80 ± 7.24**	**3653.25 ±125.92**	**1619.45 ±123.74**	**30.71 ±2.29**
Group - C								
601	3539.83	1695.66	5235.49	3481.19	15.46	3496.65	1738.84	33.21
606	3539.83	1858.70	5398.53	3249.84	27.72	3277.56	2120.97	39.29
608	3776.95	1641.31	5418.26	3440.23	28.12	3468.35	1949.91	35.99
611	3776.95	1826.09	5603.04	3370.20	13.80	3384.00	2219.04	39.60
613	3624.52	1923.92	5548.44	3353.16	10.08	3363.24	2185.20	39.38
616	3776.95	1880.44	5657.39	3277.15	27.74	3304.89	2352.50	41.58
Average ± SE	**3672.51 ±48.38**	**1804.35 ±45.42**	**5476.86 ±63.62**	**3361.96 ±36.62**	**20.49 ± 3.37**	**3382.45 ±35.49**	**2094.41 ±89.13**	**38.18 ±1.23**

Table - 72. Data on mineral availability studies in caves using egg shell powder & wood ash as Ca supplement

Consolidated data on Iron Balance

Particulars	Intake of Iron (mg/day)			Outgo of Iron (mg/day)			Iron balance	
	Conc.	Grass	Total *	Dung	Urine	Total	Retention (mg/day)	Retention (% of intake)
Ist Metabolism Trial								
Group B	2613.73 ±0.00	988.48 ±39.68	3602.21 ±39.68	2616.90 ±110.28	20.11 ±2.43	2637.01 ±111.59	965.20^{a*} ±118.77	26.75 ±3.20
Group C	3014.79 ±0.00	1051.33 ±32.94	4066.12 ±32.94	2510.00 ±161.65	28.85 ±4.32	2538.85 ±161.47	1527.27^{b*} ±134.02	37.68 ±3.52
IInd Metabolism Trial								
Group B	3274.51 ±0.00	1998.19 ±61.31	5272.70 ±61.31	3629.45 ±127.91	23.80 ±7.24	3653.25 ±125.92	1619.45^{a*} ±123.74	30.71^{a*} ±2.29
Group C	3672.51 ±48.38	1804.35 ±45.42	5476.86 ±63.62	3361.96 ±36.62	20.49 ±3.37	3382.45 ±35.49	2094.41^{b*} ±89.13	38.18^{b*} ±1.23

AVERAGE IRON BALANCE OF CALVES COLLECTED DURING THE FIRST AND SECOND METABOLISM TRIAL

Average of Ist & IInd Trial	Intake of Iron (mg/day)			Outgo of Iron (mg/day)			Iron balance	
	Conc.	Grass	Total	Dung	Urine	Total	Retention (mg/day)	Retention (% of intake)
Group B	2944.12 ±99.73	1493.33 ±156.34	4437.45 ±254.53	3123.17 ±172.99	21.96 ±3.69	3145.13 ±173.15	1292.33 ±128.28	28.73 ±1.97
Group C	3343.65 ±101.92	1427.84 ±116.77	4771.49 ±215.66	2935.98 ±150.99	24.67 ±2.90	2960.65 ±149.81	1810.84 ±115.03	37.93 ±1.78

Table - 73. FEASIBILITY OF WOOD ASH AND EGG SHELL POWDER AS CALCIUM SUPPLEMENT IN CALF RATION - CONSOLIDATED DATA ON MINERAL BALANCE (Ist METABOLISM TRIAL)

Minerals	Intake of minerals			Outgo of minerals			Mineral balance	
	Conc.	Grass	Total	Dung	Urine	Total	Retention	
Group B (Egg shell powder + Wood ash)								
	(grams)			(grams)			(g/day)	(% of intake)
Calcium	15.31 ±0.00	5.20 ±0.21	20.51 ±0.21	10.38 ±0.81	0.121 ±0.019	10.50 ±0.81	10.01 ±0.88	48.74 ±4.12
Phosphorus	13.88 ±0.00	4.15 ±0.17	18.03 ±0.17	8.28 ±0.50	2.23 ±0.46	10.51 ±0.42	7.52 ±0.54	41.61 ±2.68
Magnesium	6.05 ±0.00	2.31 ±0.09	8.36 ±0.09	5.48 ±0.21	0.484 ±0.092	5.96 ±0.20	2.40 ±0.20	28.66 ±2.36
	(mg)			(mg)			(mg/day)	(% of intake)
Copper	22.16 ±0.00	7.96 ±0.32	30.12 ± 0.32	17.60 ±1.56	0.293 ±0.028	17.89 ±1.57	12.23 ±1.79	40.41 ±5.62
Zinc	105.07 ±0.00	39.77 ±1.60	144.84 ±1.60	78.89 ±8.79	3.44 ±0.71	82.33 ±8.73	62.51 ±8.51	43.20 ±5.91
Iron	2613.73 ±0.00	988.48 ±39.68	3602.21 ±39.68	2616.90 ±110.28	20.11 ±2.43	2637.01 ±111.59	965.20 ±118.77	26.75 ± 3.20
Group C (Control group)								
	(grams)			(grams)			(g/day)	(% of intake)
Calcium	10.68 ±0.00	5.53 ±0.17	16.21 ±0.17	10.72 ±0.82	0.194 ±0.018	10.91 ±0.83	5.29 ±0.72	32.81 ±4.63
Phosphorus	18.33 ±0.00	4.42 ±0.14	22.75 ±0.14	8.62 ±0.64	2.33 ±0.34	10.95 ±0.65	11.80 ±0.58	51.92 ±2.67
Magnesium	5.16 ±0.00	2.45 ±0.08	7.61 ±0.08	5.20 ±0.29	0.535 ±0.090	5.74 ±0.34	1.88 ±0.26	24.82 ±3.67
	(mg)			(mg)			(mg/day)	(% of intake)
Copper	36.79 ±0.00	8.47 ±0.27	45.26 ± 0.27	28.58 ±0.77	0.669 ±0.14	29.24 ±0.67	16.01 ±0.45	35.41 ±1.15
Zinc	199.41 ±0.00	42.30 ±1.33	241.71 ±1.33	143.38 ±12.95	10.27 ±2.25	153.65 ±12.10	88.05 ±11.42	36.50 ±4.79
Iron	3014.79 ±0.00	1051.33 ±32.94	4066.12 ±32.94	2510.00 ±161.65	28.85 ±4.32	2538.85 ±161.47	1527.27 ±134.02	37.68 ± 3.52

Table - 74. FEASIBILITY OF WOOD ASH AND EGG SHELL POWDER AS CALCIUM SUPPLIMENT IN CALF RATION - CONSOLIDATED DATA ON MINERAL BALANCE (IInd METABOLISM TRIAL)

Minerals	Intake of Minerals			Outgo of Minerals			Mineral Balance Retention	
	Conc.	Grass	Total	Conc.	Grass	Total		
Group - B. (Experimental group)								
	(grams)			(grams)			(g/day)	(% of intake)
Calcium	19.18 ±0.00	9.01 ±0.28	28.19 ±0.28	16.91 ±0.30	0.149 ±0.032	17.06 ±0.28	11.13 ±0.19	39.49 ±0.65
Phosphorus	17.84 ±0.00	5.15 ±0.16	22.99 ±0.16	10.56 ±0.65	2.11 ±0.37	12.67 ±0.46	10.31 ±0.53	44.83 ±2.16
Magnesium	7.58 ±0.00	4.60 ±0.14	12.18 ±0.14	9.24 ±0.187	0.554 ±0.037	9.80 ±0.18	2.38 ±0.14	19.55 ±1.14
	(mg)			(mg)			(mg/day)	(% of intake)
Copper	27.76 ±0.00	19.98 ±0.61	47.74 ± 0.61	32.97 ±1.20	0.282 ±0.043	33.25 ±1.19	14.49 ±1.33	30.30 ±2.68
Zinc	131.64 ±0.00	122.23 ±3.75	253.87 ±3.75	179.02 ±4.56	1.61 ±0.11	180.62 ±4.60	73.25 ±6.50	28.75 ±2.30
Iron	3274.51 ±0.00	1998.19 ±61.31	5272.70 ±61.31	3629.45 ±127.91	23.80 ±7.24	3653.25 ±125.92	1619.45 ±123.74	30.71 ± 2.29
Group- C (Control group)								
	(grams)			(grams)			(g/day)	(% of intake)
Calcium	13.01 ±0.17	8.13 ±0.20	21.14 ±0.26	13.77 ±0.36	0.125 ±0.039	13.90 ±0.36	7.24 ±0.40	34.23 ±1.71
Phosphorus	22.34 ±0.29	4.65 ±0.12	26.98 ±0.31	9.81 ±0.98	3.42 ±0.54	13.23 ±0.66	13.75 ±0.84	50.88 ±2.67
Magnesium	6.29 ±0.08	4.15 ±0.10	10.44 ±0.13	8.06 ±0.15	0.454 ±0.130	8.52 ±0.10	1.93 ±0.21	18.34 ±1.84
	(mg)			(mg)			(mg/day)	(% of intake)
Copper	44.82 ±0.59	18.05 ±0.45	62.86 ± 0.71	46.96 ±1.01	0.399 ±0.154	47.36 ±0.91	15.50 ±1.33	24.59 ±1.89
Zinc	242.92 ±3.20	110.37 ±2.78	353.29 ±4.07	270.75 ±11.49	2.67 ±0.41	273.42 ±11.43	79.87 ±14.13	22.45 ±3.76
Iron	3672.51 ±48.38	1804.35 ±45.42	5476.86 ±63.62	3361.96 ±36.62	20.49 ±3.37	3382.45 ±35.49	2094.41 ±89.13	38.18 ± 1.23

17. SUMMARY

As per the approved technical programme survey work and analytical studies to assess the present feeding condition and mineral status of cattle in Kerala covering all the 14 districts under five agroclimatic zones have been completed. For survey work from each district 50% of taluks and from each taluks two villages were selected. Data on feeding status of animals in the respective areas were collected through a proforma supplied to each farmer taking nine households, three from each type (large, medium and marginal farmers) from each village. Representative samples of soil, feeds and fodders were collected from the surveyed areas and analysed for the concentration of Ca, P, Mg, Fe, Cu and Zn. A minimum of nine samples of blood each for different species and classes of animals were collected from the surveyed areas and analysed for the major and trace mineral concentrations. Various unconventional feeds and fodders fed to livestock were screened for antinutritional factors such as tannin and oxalates. Tissue sample collected from slaughter houses in the regions surveyed were also subjected to mineral analysis. Mineral contents in the feeds and fodders and biological materials collected from organised private farms in the region were also analysed. Average dietary intake of various minerals by lactating cows were calculated from the information gathered during survey work on the quantities of feed and fodders fed and from the results of mineral analysis of the samples of feeds and fodders collected. Deficiency conditions in the form of clinical cases or reproductive problems reported by the farmers during survey were recorded. Incidence of deficiency/ reproductive problems were also ascertained from veterinary institutions in the concerned districts.

The results of the nutritional survey indicated that majority of farmers maintained crossbred cows and a small proportion in all the districts practiced fodder cultivation. The animals in all the districts received both straw and grass as roughage. As concentrate feeds, majority of farmers used a mixture of compound feed and feed ingredients. Feeding of separate mineral mixture was practiced in all the districts. On an assessment of the quantities provided to heifers as well as lactating cows, it was found that the farmers were not following any definite pattern or schedule of feeding either with regard to concentrate or roughage. But in most cases quantities provided were found to be more, since compound

feeds were supplemented with feed ingredients also. It was found that out of the total households surveyed in all the 14 districts nearly 35% were providing separate mineral mixtures to the animals.

From the results of analysis of soil, it was seen that while the level of Fe in soil from all the districts was much higher and level of P, Mg and Zn adequate, low Ca levels was seen in majority of the districts, the lowest value recorded being 0.03 % for Wayanad, 0.04% for Kannur and Malappuram, 0.05% for Pathanamthitta and Kollam and 0.06% for Thiruvananthapuram.

The results of analysis of concentrate mixtures and feed ingredients revealed that the levels of different minerals were with in the normal range. The mineral concentration in the different mineral mixtures collected during the present study revealed that none of the mineral mixtures analysed were found to conform fully to the BIS standards, the content of most of the minerals being either higher or lower an observation which warrants strict regulations of quality control of mineral mixtures marketed. Results of mineral analysis of natural grass indicated that the levels of various minerals were within the normal range except for a scattered deficiency of Cu and P in certain districts. Lower values of copper were recorded in the natural grass collected from Kasargod, Kannur, Kozhikod and Ernakulam districts the values being 4.68, 5.42, 4.19 and 5.21 respectively against the normal value of 10ppm. Paddy straw collected from Kannur , Kozhikode, Ernakulam, Thiruvananthapuram, Kollam, Thrissur, Kasargod and Kottayam were also recorded lower copper levels. Results of analysis of blood samples collected from the surveyed areas showed almost normal values for Ca, P, Mg, Cu, Zn and Fe in different species. However, marginally lower values were recorded for blood Mg levels in growing cattle in Kottayam, Pathanamthitta and Kozhikode, buffaloes in Kottayam and Kasargod districts and in goats of Kottayam, Kasargod, Ernakulam and Kozhikode districts and lower copper value of 0.43 ppm were recorded in buffaloes in Kozhikode district. Results of mineral analysis of tissue sample (liver) collected from slaughter houses in the regions surveyed did not reveal any mineral deficiency.

From the information gathered in this survey of individual households in the different regions of the state on the total quantities of the feeds consumed (both concentrates and roughage) by lactating cows and from the analysis of mineral content of feeds and fodders, average daily dietary intake of different minerals were calculated and did not indicate any mineral deficiency. On comparison of the requirements for different minerals for lactating cows of particular body weight, milk yield and dry matter consumption (NRC, 1989) the calculated dietary intake were all found to be adequate except for a slightly lower intake of Ca in Kasargod, Kannur, Kottayam, Malappuram and Idukki districts. However, the serum Ca concentrations of animals in these areas did not indicate any deficiency. Nearly 40% of the households reported deficiency/ reproductive problems in their animals. Regarding the clinical cases recorded at the veterinary institutions most of the cases were either metabolic (milk fever) or reproductive problems (delayed sexual maturity, anoestrum, long intercalving period etc.

From a critical evaluation of the overall results obtained in the present study, it can be inferred that the animals in the surveyed areas maintained a satisfactory mineral status as evidenced by normal serum mineral concentrations except for a marginal deficiency of Mg in certain areas and scattered deficiency of Ca in soil samples and Cu and P levels in a few fodder samples. The lower dietary intake of Ca in certain areas probably is due to the differences in the type of feeds and quality of mineral mixture provided to them. Over all evaluation of the results of survey and analysis of soil, feeds, fodders and biological materials in all the 14 districts of the state did not reveal any specific mineral deficiency. Regarding the reported cases from the Veterinary Institutions and by the farmers at the household, higher incidence of low production and reproductive disorders may be due to either marginal deficiencies of minerals/vitamins which may go undetected, lower utilization of minerals due to interaction or imbalances or mainly deficiencies of major nutrients particularly energy.

As per the approved technical programme studies on the bioavailability of major as well as trace elements during, maintenance, growth, pregnancy and lactation in cattle were completed.

Results on the bioavailability of minerals in adult crossbred cows maintained on rations consisting of a basal concentrate mixture with 2% mineral mixture and paddy straw as roughage indicated that the average mineral balances with respect to P, Mg, Cu, Zn and Fe were all positive. However, marginally lower negative balance was seen with regard to Ca. Low Ca content and high oxalate content in paddy straw may be the reason for the slightly negative balance for Ca. Mg balances were also marginally negative in majority of animals though the average values were on the positive side.

Mineral balance study for growth was conducted in growing crossbred heifers using basal concentrate mixture containing 2% mineral mixture and Napier grass as roughage and the results revealed positive balances for all the minerals.

Results of feeding trials in pregnant cows involving two metabolism trials with a collection period of seven days each to assess the bioavailability of different minerals in cattle during pregnancy revealed positive balances for all the minerals. Results of balance studies in lactating cows using basal concentrate mixture with 2% mineral mixture and green grass as the roughage involving two metabolism trials revealed that all the minerals were well utilised with positive balances with respect to each mineral.

Since the results on the bioavailability studies in cattle for maintenance using straw as roughage indicated negative balance for Ca in all the animals and poor availability of Mg with negative balances in majority of the animals, the experiment was repeated using green grass as roughage instead of paddy straw, thinking that high oxalate content in paddy straw may be the cause of poor Ca availability. As expected all the animals showed significantly higher positive balance of Ca and Mg when grass is fed instead of straw as roughage and the results revealed positive balances for all the minerals.

Two feeding trials were carried out in calves using common rations (4 different types) to study the mineral bioavailability.

The first feeding trial was conducted in 12 cross bred calves of 3 to 4 months of age divided in to two groups (Group I and II) of six each and maintained on basal concentrate mixture I and II respectively and green grass as the roughage for a period of 3 months. In concentrate mixture I complete replacement of dry unsalted fish in the

concentrate mixture II was made by meat cum bone meal each at 10 % level. Daily DMI and weekly body weight of the experimental animals were recorded through out the study. Towards the end of feeding trial a metabolism trial was conducted with a collection period of 7 days with quantitative collection of dung and urine. Samples of feed, dung and urine were subjected to mineral analysis for the content of various major and trace minerals viz; Ca, P, Mg, Zn, Cu and Fe. Knowing the quantities of mineral intake in ration and outgo through dung and urine the balance with respect to each mineral was calculated. Positive balances were obtained for all the minerals studied. Average daily retention as percentage of intake with respect to Ca, P, Mg, Cu, Zn and Fe were found to be 37.05 $\pm$ 8.67, 39.58 $\pm$ 4.69 ; 7.35 $\pm$6.26 ; 45.40 $\pm$6.98, 39.59 $\pm$ 9.26 and 49.56 $\pm$7.40 respectively for group I and 44.64 $\pm$9.33 ; 44.02 $\pm$6.53; 11.29 $\pm$7.88; 57.22 $\pm$ 9.17, 52.50 $\pm$1.79 and 53.99 $\pm$5.84 respectively for group II. On comparing the results, calves of group II fed on concentrate mixture II containing dried fish recorded higher percentage retention than group I calves fed on concentrate mixture II in which dried fish was fully replaced with equal quantity of meat cum bone meal. On statistical analysis of the data on percentage retention of each mineral no significant difference could be observed between the two groups.

In the 2nd trial conducted, 12 female cross bred calves of 5 to 6 months of age divided in to 2 uniform groups of six each (group I & II) and maintained respectively on ration III and ration IV each consisting of basal concentrate mixture and green grass as roughage for a period of 67 days with metabolism trial of 7 days duration to study the balance of Ca, P, Mg, Cu, Zn and Fe during the last week of experiment. In calf ration III an equal quantity of silk worm pupae meal was used instead of 10% fish meal in ration IV. Results on the balance study revealed positive balances of all the minerals studied in both groups. Average daily retention as percentage of intake with respect to Ca, P, Mg, Cu, Zn and Fe were found to be 55.08, 48.06, 44.48, 24.33, 46.59, 52.63 respectively for group I maintained on ration III and 54.59, 54.77, 49.88, 31.85, 49.32 and 57.83 respectively for group II calves maintained on ration IV. On comparing the results, calves of group II fed on concentrate mixture IV recorded higher intake ($p<0.01$) except of Fe and daily retention ($p>0.05$) except for Ca than group I calves maintained on ration III containing 10% silkworm pupae meal.

Data on body weight, mineral intake and daily balance of the two trials were subjected to the multiple regression analysis and the requirements were worked out by linear equations, and the figures arrived at for different minerals are as follows. The requirement thus worked out from the present study is applicable to calves of 6 to 8 months of age group with body weight ranging from 57 to 103 kg.

Calcium

$Y_{Ca} = 6.8458+0.0023X_1+1.228X_2$ n=12; $R^2=0.66$; $P<0.01$

Where Y_{Ca} = Ca intake (g/day)

X_1 = Body weight (89.54 kg)

X_2 = Ca balance g/day

From the present experiment the requirement of Ca was calculated as 0.079g/Kg Body weight. In other words of a calf weighing 78.77 kg Body weight required 6.22g.

Copper

$Y_{Cu} = 7.997+0.3451\ X_1-0.1219\ X_2$ X_1=78.77kg; n=24; $R^2=0.644$; $P<0.01$

Thus requirement/kg Body weight = 0.447mg

Cu requirement for a calf weighing 78.77Kg Body weight = 35.21mg/day or 11.78ppm in the diet

Zinc

$Y_{Zn} = -92.17+2.1823\ X_1+1.0855\ X_2$ X_1=78.77; n=24; $R^2=0.826$; $P<0.01$

Thus requirement /kg Body weight = 1.01 mg

Zn requirement for a calf weighing 78.77 kg Body weight = 79.56mg/day or 26.61ppm in the diet.

The above requirements are based on the present investigation and further studies with varying levels of each mineral are required to predict the exact requirements.

All the experimental animals were gaining in body weight and overall results of the different studies indicated that all the minerals were well utilised.

Effect of ionophore(monensin) on mineral utilization

Mineral bioavailability study was carried out in 12 female cross bred calves of 5 to 6 months of age divided into 2 group of six each and maintained on a basal concentrate mixture with and without monensin at 25ppm level and fresh green grass as roughage for a period of 12 weeks. Two digestion cum metabolism trials were conducted one at 5th week

and second at 12th week of experiment to estimate the balance of different minerals. The results revealed higher percentage retention of major as well as trace minerals in monensin supplemented group; the average values of retention as percentage of intake for the monensin supplemented and nonsupplemented group being 39.64±3.36 and 33.52±2.36 respectively for Ca; 58.12±1.56 and 51.40±1.81 for P; 23.06±1.59 and 21.58±2.19 for Mg($P<0.05$); 42.33±2.40 and 30.00±1.95 for Cu($P<0.01$); 41.19±3.51 and 29.48±3.60 for Zn ($P<0.01$) and 39.83±1.01 and 37.93±1.78 for Fe. Growth rate and feed efficiency were also higher in monensin supplemented group. The study indicates that ionophore-monensin Sodium supplemented at 25ppm in concentrate mixture favours the growth, feed efficiency and utilization of major as well as trace minerals in calves.

Feasibility of Wood ash and Egg shell powder as Ca supplement

With an objective of studying the feasibility of wood ash and egg shell powder as Ca supplement, an experiment was planned in calves. Twelve female cross bred calves of 5 to 6 months of age were divided into two groups of six each as uniformly as possible with regard to age and weight and maintained on a basal concentrate mixture and fresh green grass as roughage for a period of 12 weeks. Mineral supplement incorporating 50% wood ash and 50% egg shell powder was tried at a level of 2% in basal concentrate mixture in goup I calves against a commercial mineral mixture at 2% in the concentrate mixture in group II calves. Two metabolism trials were conducted, one during the fifth week and the other at the twelfth week of experiment to estimate the balance of different minerals. The results of the study revealed higher growth rate, feed efficiency and percentage retention of various major as well as trace minerals in group I calves indicating that minerals in ration containing wood ash and egg shell powder were better utilized by the calves compared to ration containing commercial mineral mixture. Significantly higher Ca balance ($P<0.01$) registered by calves given 1% wood ash and 1% egg shell powder in concentrate mixture in the present study indicates that wood ash and egg shell powder can be used as Ca supplements in calf ration.

Results obtained on various bioavailability studies conducted in cattle during different physiological stages are graphically represented in figures 1 to 9 on page 149 to 157.

18. Publications : Nil

19. Contributions made by the Co-operators :

Facilities available in the Department of Nutrition, College of Veterinary and Animal Sciences are made use of for the scheme.

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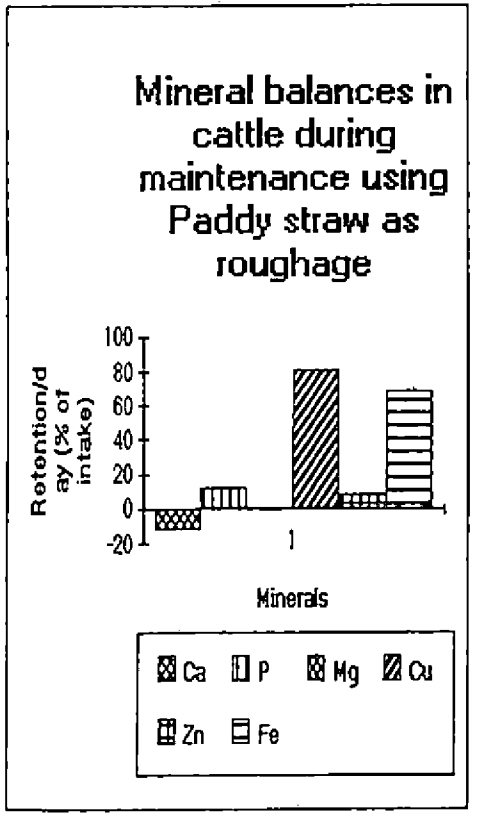
FIGURE 1 : CONSOLIDATED DATA ON MINERAL BALANCES OF CATTLE DURING MAINTENANCE AND GROWTH (RETENTION AS PERCENTAGE OF INTAKE)

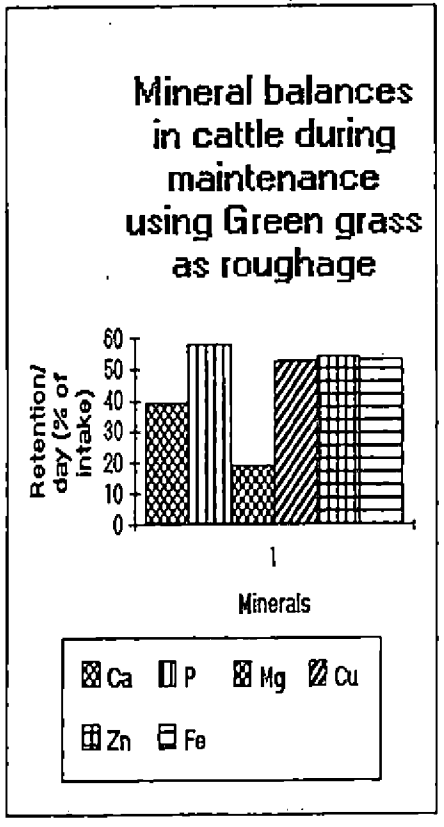
Minerals (% of intake)					
Ca	P	Mg	Cu	Zn	Fe
-12.19	12.17	0.13	80.73	8.66	68.43

Figure - 1(a)



Minerals (% of intake)					
Ca	P	Mg	Cu	Zn	Fe
39.19	57.99	18.8	52.99	54.62	53.54

Figure - 1(b)



Minerals (% of intake)					
Ca	P	Mg	Cu	Zn	Fe
26.4	16.06	9.75	31.76	0.29	21.2

Figure - 1(c)

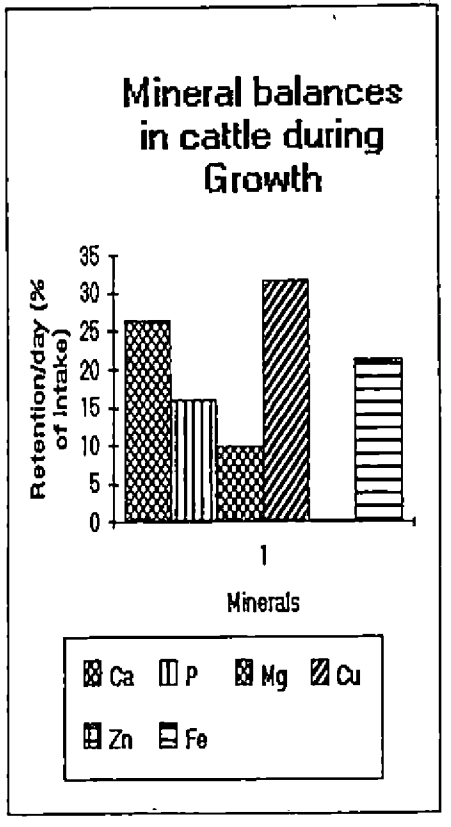


FIGURE 2 : CONSOLIDATED DATA ON MINERAL BALANCES OF CATTLE DURING PREGNANCY (RETENTION AS PERCENTAGE OF INTAKE)

Figure - 2(a)

First Trial					
Ca	P	Mg	Cu	Zn	Fe
35.02	22.19	21.38	62.31	39.76	45.36

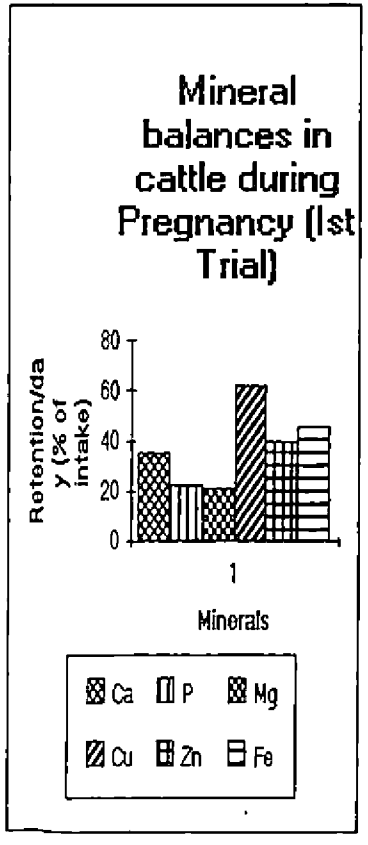


Figure - 2(b)

Second Trial					
Ca	P	Mg	Cu	Zn	Fe
40.69	18.65	56.76	19.23	21.14	55.38

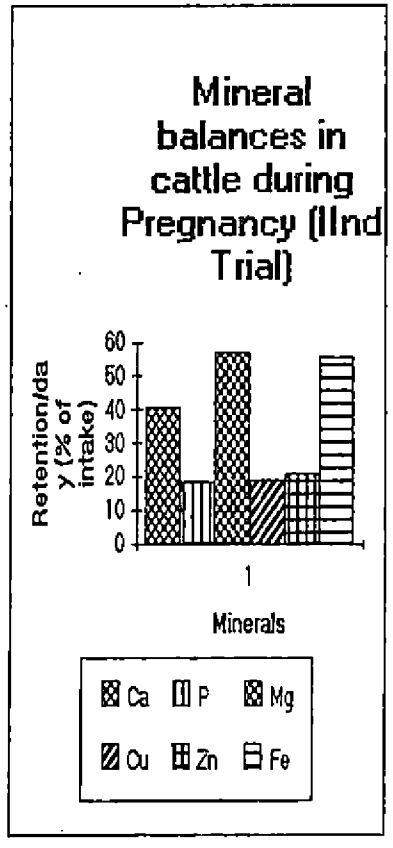


Figure - 2(c)

Minerals (% of intake)					
Ca	P	Mg	Cu	Zn	Fe
37.85	20.42	39.07	40.77	30.45	50.37

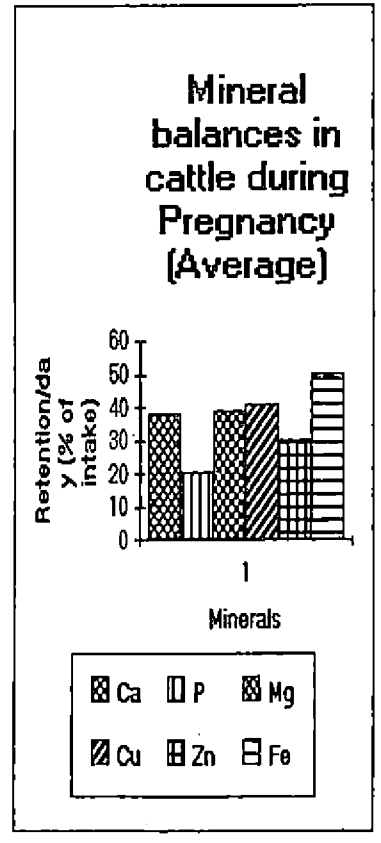
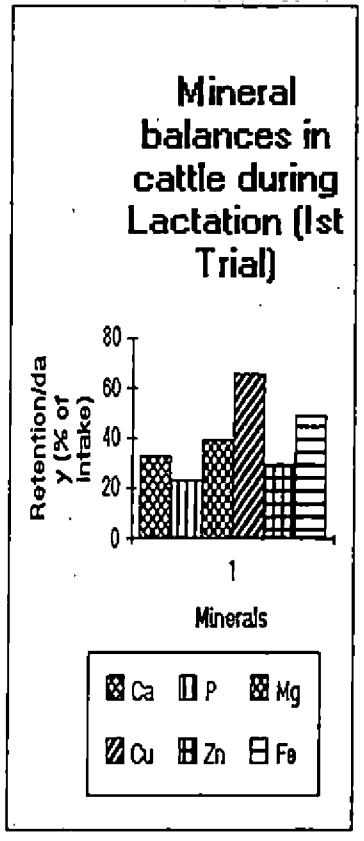


FIGURE 3: CONSOLIDATED DATA ON MINERAL BALANCES OF CATTLE DURING LACTATION (RETENTION AS PERCENTAGE OF INTAKE)

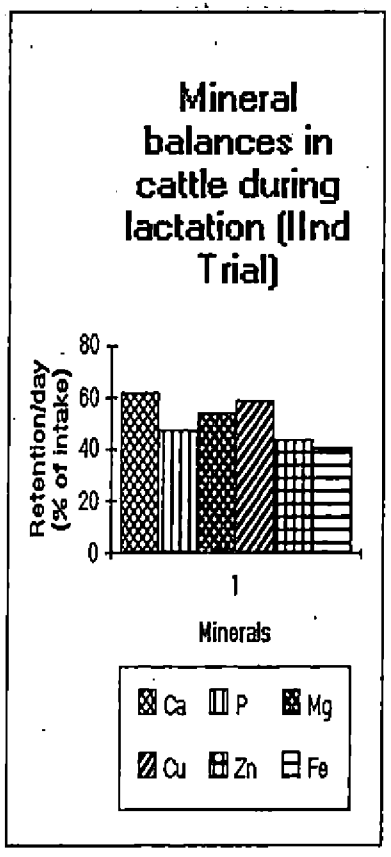
First Trial					
Ca	P	Mg	Cu	Zn	Fe
32.6	28.14	39.25	66.02	29.45	48.69

Figure - 3(a)



Second Trial					
Ca	P	Mg	Cu	Zn	Fe
62.15	47.39	53.78	58.87	43.64	40.71

Figure - 3(b)



Average					
Ca	P	Mg	Cu	Zn	Fe
47.37	35.27	46.52	62.44	36.54	44.7

Figure - 3(c)

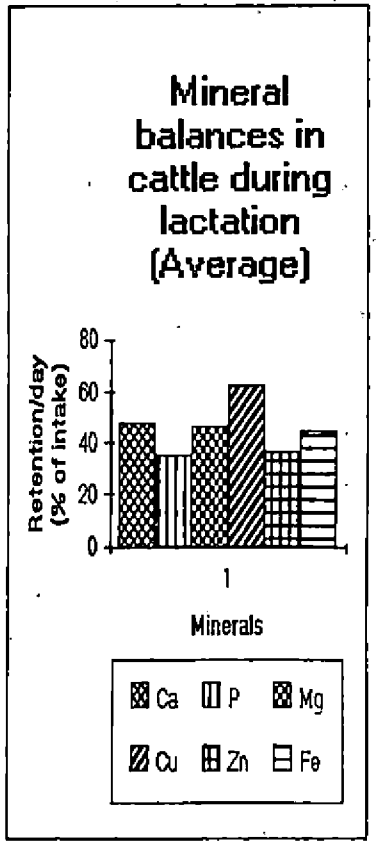
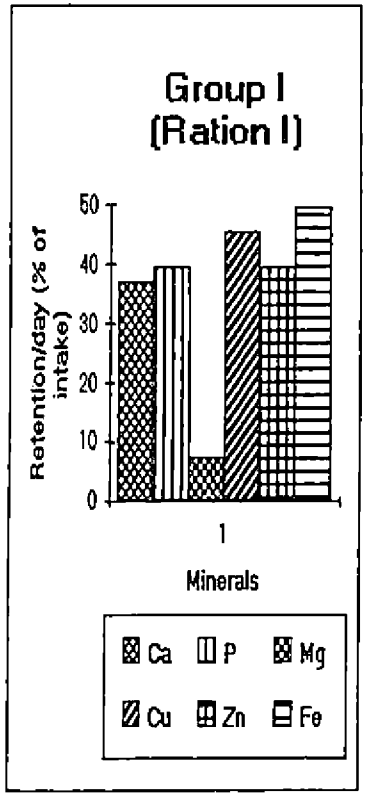


FIGURE 4 : CONSOLIDATED DATA ON MINERAL BALANCES OF CALVES MAINTAINED ON DIFFERENT RATIONS - Feeding Trial I
(DAILY RETENTION AS PERCENTAGE OF INTAKE)

Group I

Ca	P	Mg	Cu	Zn	Fe
37.05	39.58	7.36	45.4	39.59	49.56

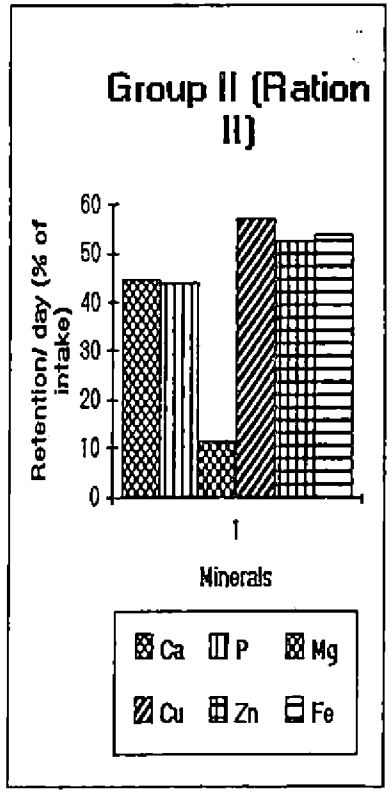
Figure - 4(a)



Group II

Ca	P	Mg	Cu	Zn	Fe
44.64	44.02	11.29	57.22	52.5	53.99

Figure - 4(b)



Average

Ca	P	Mg	Cu	Zn	Fe
40.85	41.8	9.32	51.31	46.05	51.78

Figure - 4(c)

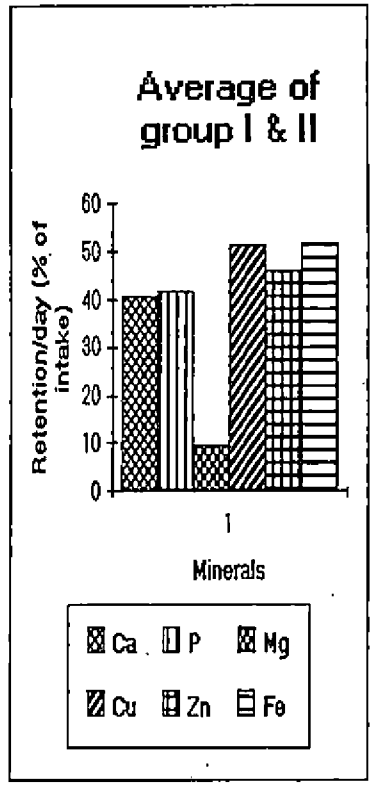
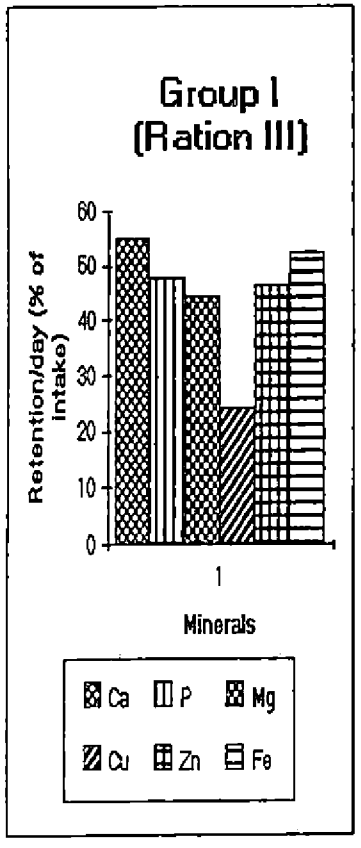


FIGURE 5 : CONSOLIDATED DATA ON MINERAL BALANCES OF CALVES MAINTAINED ON DIFFERENT RATIONS - Feeding Trial II
(DAILY RETENTION AS PERCENTAGE OF INTAKE)

Group I

Ca	P	Mg	Cu	Zn	Fe
55.08	48.06	44.48	24.33	46.59	52.63

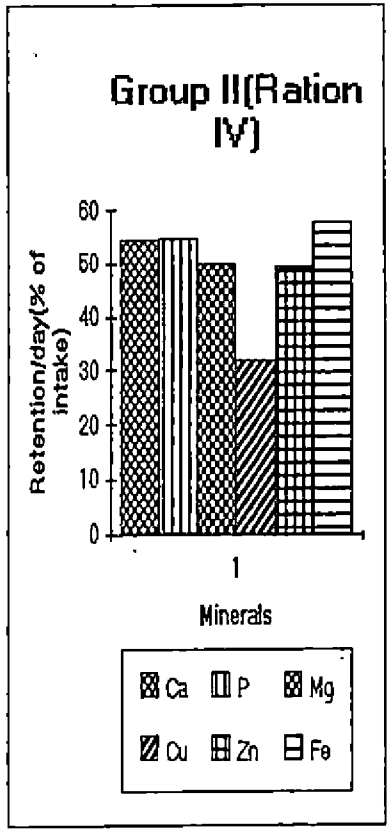
Figure - 5(a)



Group II

Ca	P	Mg	Cu	Zn	Fe
54.59	54.77	49.88	31.85	49.32	57.83

Figure - 5(b)



Average

Ca	P	Mg	Cu	Zn	Fe
54.84	51.41	47.18	28.09	47.95	55.23

Figure - 5(c)

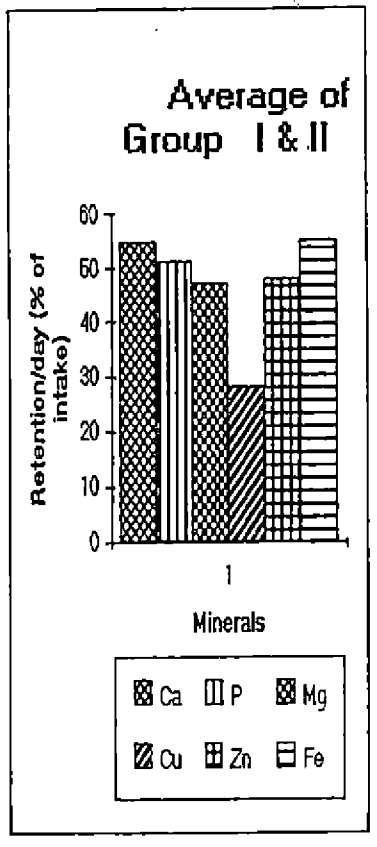
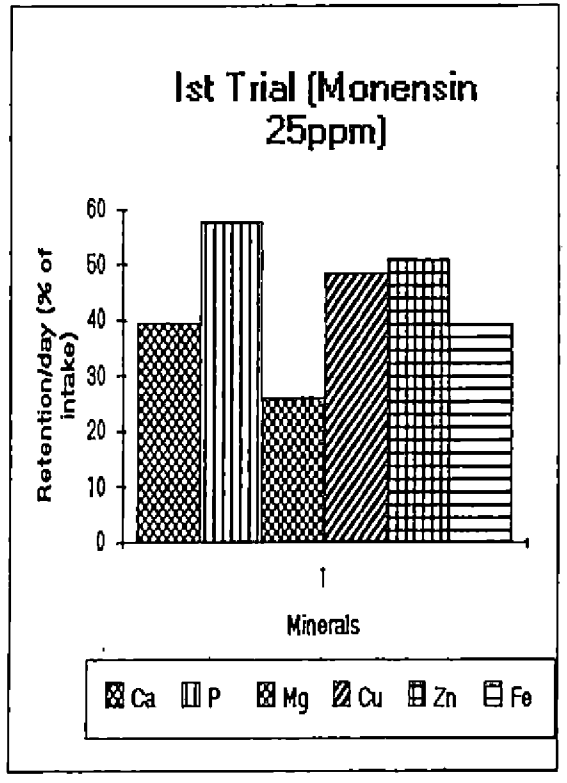


FIGURE 6 : CONSOLIDATED DATA ON MINERAL BALANCES OF CALVES - FEEDING TRIAL - III (RETENTION AS PERCENTAGE OF INTAKE)

Minerals (% of intake)					
Ca	P	Mg	Cu	Zn	Fe
39.46	57.72	25.96	48.35	51.04	38.94

Figure - 6(a)



Minerals (% of intake)					
Ca	P	Mg	Cu	Zn	Fe
32.81	51.92	24.82	35.41	36.6	37.68

Figure - 6(b)

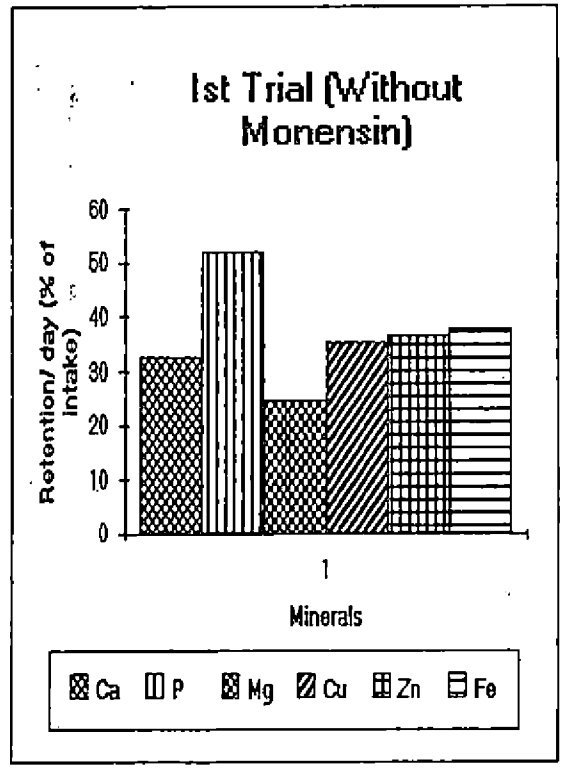


FIGURE 7 : CONSOLIDATED DATA ON MINERAL BALANCE OF CALVES - MONENSIN SUPPLEMENTATION (SECOND METABOLISM TRIAL - RETENTION AS PERCENTAGE OF INTAKE)

Figure - 7(a)

Second Trial(Group I)					
Ca	P	Mg	Cu	Zn	Fe
39.83	58.52	20.16	36.31	31.34	40.72

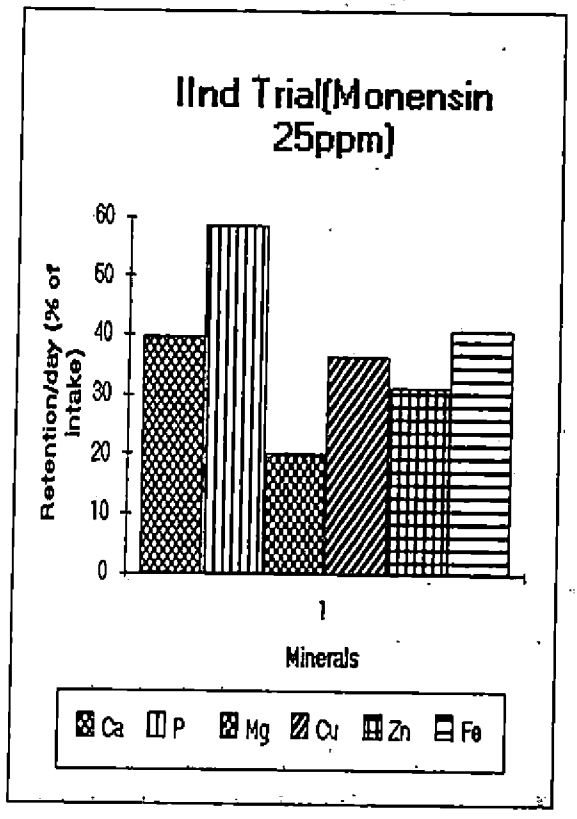


Figure - 7(b)

Second Trial(Group II)					
Ca	P	Mg	Cu	Zn	Fe
34.23	50.88	18.34	24.59	22.45	38.18

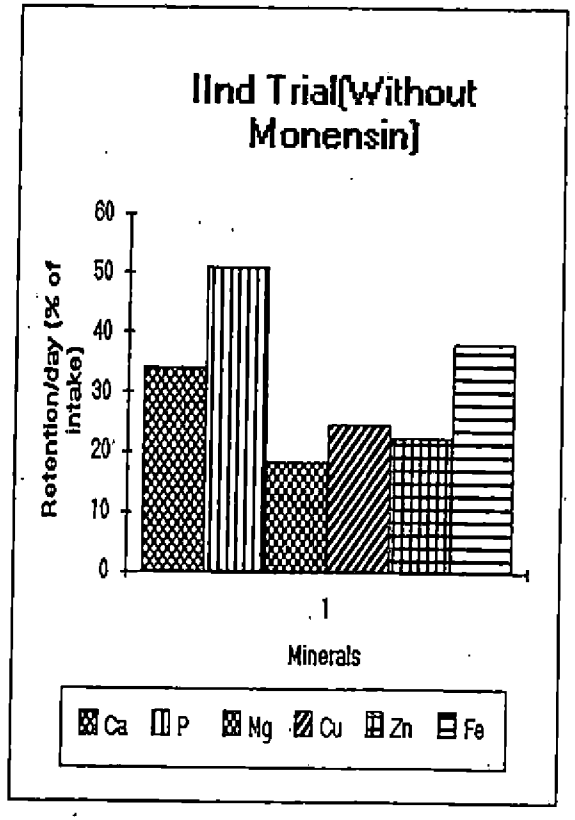
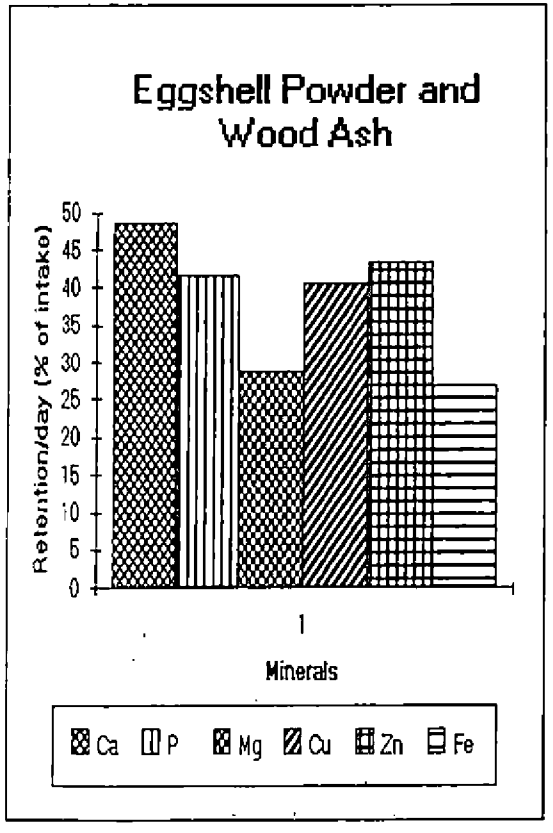


FIGURE 8: FEASIBILITY OF WOOD ASH AND EGG SHELL POWDER AS CALCIUM SUPPLEMENT IN CALVES
CONSOLIDATED DATA ON MINERAL BALANCES IN CALVES

First Trial- Group B

Ca	P	Mg	Cu	Zn	Fe
48.74	41.61	28.66	40.41	43.2	26.75

Figure - 8(a)



First Trial - Group C

Ca	P	Mg	Cu	Zn	Fe
32.81	51.92	24.82	35.41	36.6	37.68

Figure - 8(b)

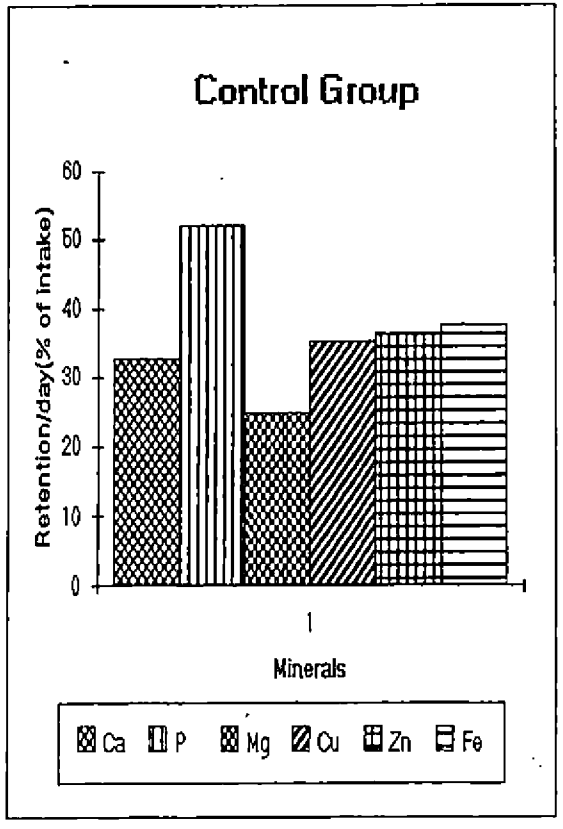
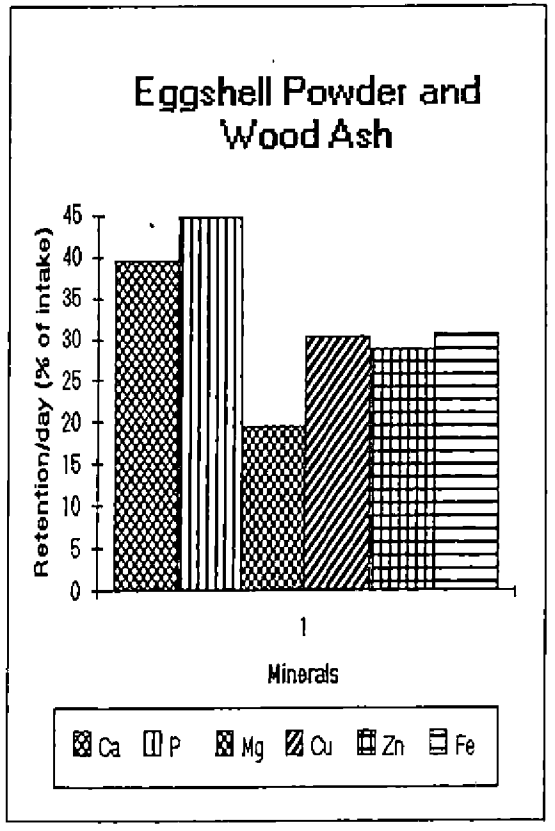


FIGURE 9: FEASIBILITY OF WOOD ASH AND EGG SHELL POWDER AS CALCIUM SUPPLEMENT IN CALVES
CONSOLIDATED DATA ON MINERAL BALANCES IN CALVES

Second Trial - Group B

Ca	P	Mg	Cu	Zn	Fe
39.49	44.83	19.55	30.3	28.75	30.71

Figure-9(a)



Second Trial - Group C

Ca	P	Mg	Cu	Zn	Fe
34.23	50.88	18.34	24.59	22.45	38.18

Figure-9(b)