ASSESSMENT OF MINERAL STATUS OF CATTLE IN KERALA

By

KURUVILLA VARGHESE

THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Veterinary Science

Façulty of Veterinary and Animal Sciences
Kerala Agricultural University

Department of Animal Nutrition
COLLEGE OF VETERINARY AND ANIMAL SCIENCES
MANNUTHY, THRISSUR - 680651
KERALA

1998

DECLARATION

I hereby declare that the thesis entitled "**ASSESSMENT OF MINERAL STATUS OF CATTLE IN KERALA**" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Mannuthy
22.9.98

KURUVILLA VARGHESE

CERTIFICATE

Certified that the thesis entitled "**ASSESSMENT OF MINERAL STATUS OF CATTLE IN KERALA**" is a record of research work done independently by **Sri. Kuruvilla Varghese**, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

Dr. N. Kunjikutty
(Chairperson, Advisory Committee)
Professor
Department of Animal Nutrition
College of Veterinary &
Animal Sciences, Mannuthy

Mannuthy
22. 9. '98

CERTIFICATE

We, the undersigned members of the Advisory Committee of **Sri. Kuruvilla Varghese**, a candidate for the degree of Master of Veterinary Science in Animal Nutrition, agree that the thesis entitled **"ASSESSMENT OF MINERAL STATUS OF CATTLE IN KERALA"** may be submitted by Sri. Kuruvilla Varghese, in partial fulfilment of the requirement for the degree.

Dr. N. Kunjikutty
(Chairperson, Advisory Committee)
Professor
Department of Animal Nutrition

Dr. C.T. Thomas
Professor & Head (Retd.)
Department of Animal Nutrition
(Member)

Sri. M. Nandakumaran
Associate Professor
Department of Animal Nutrition
(Member)

Dr. U.T Francis
Professor (Retd.)
Department of Dairy Science
(Member)

External Examiner
DR. M. M. KAILAS

ACKNOWLEDGEMENTS

I wish to express my sincere thanks to Dr. N.Kunjikutty, Professor, Department of Animal Nutrition for her expert advice, valuable suggestions and meticulous guidance as the Chairperson of the Advisory Committee.

My sincere thanks are due to Dr. C.T. Thomas, Professor and Head (Retd.), Department of Animal Nutrition, for his inspiring advice, encouragement and constructive criticism as member of the Advisory Committee.

I am very much grateful to Sri. M. Nandakumaran, Associate Professor, Department of Animal Nutrition and Dr. U.T. Francis, Professor (Retd.), Department of Dairy Science for the advice, encouragement and help rendered from time to time.

I express my deep sense of gratitude to Dr. Maggie D. Menachery, Professor and Head, Department of Animal Nutrition for her encouragement and stable support throughout this work.

I gratefully acknowledge the sincere and immense help rendered to me by Dr. P. Gangadevi, Assistant Professor, Department of Animal Nutrition throughout the period of my research work and Dr. A.D. Mercy, Associate Professor, Department of Animal Nutrition for the support and encouragement during the preparation of my thesis.

I extend my sincere thanks to Smt. T.K. Indirabai, Professor i/c, Smt. K.P. Santhabai, Programmer and other staff members of the Department of Statistics, for the help extended in the statistical analysis of the data.

I wish to record my sincere thanks to the Dean, College of Veterinary and Animal Sciences, for all the facilities provided during the course of my research work.

I place on record my gratitude to all the staff of the Department of Animal Nutrition and Sri. K. Kumaran for the co-operation and help rendered to me.

I am indeed grateful to my friends Dr. P. Vidhyadharan, Dr. C.N. Dinesh, Dr. G. Sunil, Dr. K.C. Jayan for the moral support and encouragement.

I also acknowledge the sincere efforts on the part of Veterinary Surgeons, Heads of various organised farms and Livestock Inspectors in the different areas surveyed, who helped me in arranging and conducting the field study.

I am thankful to the Indian Council of Agricultural Research, New Delhi for providing me financial assistance in the form of Junior Research Fellowship during the period of my study.

I express my profound gratitude to my beloved parents, and father-in-law and mother-in-law for their love, affection, moral support and encouragement throughout the period of my study.

I am indeed grateful to my wife Dr. Sunu and our lovely son Vivek who always stood as a source of inspiration and encouragement to me

I am thankful to Mr. O.K. Ravindran, Peagles, Mannuthy for neat typing of the manuscript.

KURUVILLA VARGHESE

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Introduction

1. INTRODUCTION

Mineral imbalances in livestock, resulting from deficiency, excess or abnormal dietary proportions of various mineral elements occur over wide areas in many countries causing loss of productivity, infertility and sometimes high mortality. In the developing countries, animal productivity is limited or inhibited by other factors, notably low genetic potential of the individual animals, shortages of available energy and protein, inadequate total feed; high incidence of infectious and parasitic diseases. In these circumstances dietary mineral abnormalities can be marked or obscured, except when they are severe. When the deficiencies are mild or marginal, they are expressed as unthriftiness or subnormal growth, lowered fertility or production (Underwood, 1966).

An acute deficiency or toxicity problem can be devastating to the dairy producer, but borderline problems are actually more dangerous. A marginal deficiency or toxicity of an essential mineral will reduce bovine resistance to diseases, growth rate, reproductive efficacy and milk production. Increased lactation occurs only when supplementation of these marginally deficient minerals occurs.

The concentration of mineral elements in forages are dependent upon many factors including soil composition, plant species, stage of growth, extent of irrigation, temperature and climate (Reid and Harvath, 1980). Most of the mineral deficiencies in livestock are associated with specific regions and are directly related to the soil characteristics.

Both qualitative and quantitative deficiencies in the feed and fodder would therefore lead to deficiency of major and trace elements. The large scale practice of manuring soil with chemical fertilizers, heavy rainfall and resultant leaching of soil and the changing water management practices in the state upset the ratio of interrelated micro and macro minerals in the soil. This could interfere with the assimilation of trace elements by the fodder plants eventhough there is no deficiency in the soil. There is an added possibility of leaching of the soil especially in the hilly tract during heavy monsoons. All these factors can lead to a reduced trace element availability from the green fodder resulting in a possible trace element deficiency in cattle.

Intensity of cultivation and yield of the forage can also influence the plant mineral composition. Increasing crop intensity and yield remove minerals from the soil at a faster rate and so deficiencies are frequently found in such areas (Chhabra *et al.*, 1991). Climate can affect the mineral content of plants and generally the tropical forages contain less minerals, particularly during the dry season (Mc Donald *et al.*, 1984).

Apart from specific mineral deficiencies, mineral disorders are likely to arise from interaction and interrelationship between minerals and other nutrients. Moreover, the indiscriminate addition of mineral supplements most of them being of substandard quality in feed without ascertaining the mineral content of the feeds and fodders and the mineral status of the animals has complicated the mineral nutrition of animals.

Several methods/techniques to establish the mineral deficiencies or excesses in livestock are available. They include clinical, pathological and biochemical examination of the animals (Bowie and Thornton, 1984). Analysis of soil has always been preferred to that of forage analysis to establish the trace mineral deficiency (Mc Dowell *et al.*, 1983). Determination of the mineral contents of the forages and feeds, available for livestock feeding, as well as the mineral contents of the soil can provide evidence of a specific mineral deficiency or toxicity in animals (Mc Dowell, 1992). Occasionally, mineral imbalance studies are complicated by the concurrent presence of other nutritional disabilities or by the existence of metabolic disturbances, parasitic infestation or bacterial, viral or protozoal infection. Differential diagnosis in such circumstances is difficult. However when the evidences obtained from the clinical, pathological and biochemical examination of the animal and from chemical analysis of the feed stuffs and soil are combined and assessed, it is usually possible to detect and define any mineral deficiency or excess, even when it is mild.

The state of Kerala, with a total area of only 38.86 lakh hectares experiences entirely different agroclimatic conditions in different parts of the state and hence is likely to have variations in the mineral content of soil, plant and hence in the animal body from place to place. Very little systematic work seems to have been carried out in regard to the mineral status of soil, plants and animals in the state inspite of the fact that nutritional problems due to mineral deficiencies are being ameliorated/corrected by supplementation of the respective minerals in the diet. As such the present investigation was taken up with a view to assess the status of important macro and micro minerals in soils, feeds and fodders and in the animal body, and to find out area deficiencies/excesses if any, in the different agroclimatic regions of the state, thereby to suggest suitable mineral combinations based on area problems.

Review of Literature

2. REVIEW OF LITERATURE

The literature available on the different aspects of the study are arranged under separate heads.

2.1 Soil

Rajagopal *et al.* (1977) on analysis of soil samples from different districts of Kerala reported that the values of available iron ranged from 1.6-200 ppm in Kozhikode district and 9.2-5066 ppm in Palghat district. They further reported a deficiency of manganese in soil samples in different districts to the extent of 30 per cent in Thrissur district, 17 per cent in Kozhikode district, 7.1 per cent in Ernakulam district, 2.9 per cent in Palghat district and 1.2 per cent in Thiruvananthapuram district while no deficiency was observed in the manganese status of the soils analysed from Alleppey, Kottayam, Kollam and Kasargod districts. The lowest value for manganese of 0.20 ppm was recorded for soil samples from Kozhikode and Thrissur. However the highest value of 220 ppm was also reported from Kozhikode.

Rajagopal *et al.* (1977) also reported a widespread zinc deficiency in Kerala soils, the deficiency being prominent in Palakkad, Thiruvananthapuram, Kottayam, Thrissur, Alleppey and Kozhikode districts. The lowest content of zinc was seen recorded in soil samples from Kozhikode district (traces) and the highest content in Palakkad district.

Kanwar (1979) reported that calcium became a limiting nutrient only in severe acid and alkaline soil.

McDowell *et al.* (1983) observed that the availability and uptake of certain microminerals are usually decreased with the alkaline pH of soil. He also suggested that soil analysis is always preferred to that of forage analysis to establish the trace micromineral deficiency particularly that of cobalt.

Jose *et al.* (1985) reported that soils of Kerala are deficient in available copper and zinc, sufficient in available manganese, but high in available iron which reached toxic limits sometimes.

Singh *et al.* (1987) on analysis of soil samples from naturally occurring grasslands of the Himalayan region, to investigate the trace element distribution in soil profiles and their concentrations in surface soils, as well as to examine the frequency and geographical distribution of low and high levels of trace elements, observed the following: The concentrations of extractable zinc, manganese, copper and boron in the surface horizons were higher than that in the subsurface horizons. Generally soils from the subhumid tropical climate derived from sedimentary rocks were poorer in most of the elements than those from the temperate climate derived from igneous or metamorphic rocks. Rainfall and temperature showed negative correlations for almost all the trace elements. Proportions of the samples that were considered deficient were about 28 per cent for zinc, 50 per cent for manganese, 20-30 per cent for copper, 4 per cent for iron, 77 per cent for molybdenum and 5-10 per cent for cobalt. The soils of Kuttanadu were found highly deficient in available copper by Aiyer *et al.* (1975).

Daftardar *et al.* (1993) concluded that lateritic soils have low potassium fixing capacity because of their predominantly Kaolinite mineral content.

Muralidharan (1992) and Sakeer (1997) studied the macro and micronutrient status of the lateritic soils of northern Kerala and reported that the available phosphorus, copper, zinc and manganese levels were within the normal range.

2.2 Soil plant factors

Lonergan (1975) concluded that more widespread trace element deficiencies can be expected as increased crop and pasture production result from continued use of legumes and phosphate fertilizers.

Reith (1965) and Fleming (1973) have listed several factors as influential in determining the mineral uptake by crops and pastures such as soil acidity, soil moisture and drainage conditions, soil temperature and season, plant genus species and variety and application of fertilizers.

2.2.1 Soil acidity

Beeson (1978) has summarised data illustrating the effect of pH on mineral absorption by plants, and the synergistic and antagonistic effects of ion interactions at the root surface. Maximum rate of cation absorption was found to be at pH 5-7, and the rate being usually maintained upto pH 10 or 11 while low pH had a lesser effect on anion absorption and above pH 6, the rate of absorption was reduced by increasing OH ion concentration.

2.2.2 Soil moisture and drainage condition

Reith (1965) stated that trace element deficiencies are rare in crops and pastures on soils with impeded drainage and noted that in northern Scotland herbage could contain molybdenum levels in excess of 5 ppm, a concentration which has been associated with toxicity in animals. Similarly it has been suggested that waterlogging of soils could be one factor associated with occurrence of high levels of selenium in plants in seleniferous areas of Ireland. However, the same has also been contributory to the seasonal occurrence of cobalt deficiency in cattle and sheep. However, Elkins *et al.* (1978) found that tall fescue grown in field trials on poorly drained soil had lower concentrations of magnesium than fescue grown on well drained soil. They concluded that pastures on wet soils would need special management to prevent hypomagnesaemic tetany in grazing animals.

2.2.3 Soil temperature and season

Patel *et al.* (1966) studied the serum levels of phosphorus, calcium and magnesium in calves and adult animals and the effect of season on the level of these elements. The serum levels of phosphorus, calcium and magnesium were recorded as 8.9, 10.2 and 2.8 mg/100 ml respectively in calves aged 2-15 months as against 6.6, 9.6 and 3.41 mg/100 ml respectively in adult cows. The calcium and phosphorus levels were found to be the highest in summer and lowest in monsoon in all the age groups.

Pfander (1971) observed that in tropical regions under conditions of high temperature and heavy rainfall there is marked leaching and weathering of soils, making the vegetation deficient in plant materials.

Ford (1972) reported that the extremely variable climate of Great Britain caused marked variation in the quantity and quality of herbage. He further observed that on highly fertile soils these variations were rarely detrimental, but on soils which had slight mineral deficiencies and imbalance, such variations may be critical and that fluctuations in the level of calcium and phosphorus lead to phosphorus deficiency and also influence the availability of certain trace elements thus affecting production performance of grazing animals.

Lamand and Perigand (1973) in a field survey in France, established correlation of trace element deficiency in ruminants with that of the mineral content in the soil of that particular area.

Increased K/(Ca+Mg) ratios have been seen associated with an increased incidence of grass tetany in periods of warm weather following a cool spell in studies carried out by Grunes (1973).

Nye and Tinker (1977) reported that the most clearly demonstrated interaction between temperature and mineral uptake appears to be for phosphorus, which is absorbed more slowly at low temperatures, possibly by mechanisms of depressed root extension and membrane permeability.

Metson and Saunders (1978) determined seasonal changes in the mineral concentration of grass and legume components of pastures where the herbage was grazed down periodically.

Calcium and magnesium concentrations were highest in summer and lowest in mid winter with less variation in magnesium levels, while potassium showed large monthly fluctuations, with lowest levels in early summer and peak levels in early spring.

McDowell *et al.* (1983) observed that in tropical regions under conditions of heavy rainfall and high temperature, there is a marked leaching and weathering of soil, making the vegetation deficient in plant materials particularly the phosphorus of macrominerals.

Baine *et al.* (1986) investigated the seasonal influence on serum copper levels of bovines and found that in higher rainfed areas the copper level is less compared to other areas.

2.2.4 Plant genus, species and variety

Different varieties of plants growing on the same soil and under the same environmental conditions show marked differences in mineral uptake. Kubota (1964) suggested that use of grass pastures instead of legumes may be effective in reducing molybdenum toxicity on some soils, and an increased use of legumes may improve the cobalt status of animals where cobalt is deficient in the soil.

Fleming (1965) from his studies on the mineral contents of legumes and grasses concluded that concentrations of calcium, phosphorus, magnesium, potassium, copper, zinc, iron, cobalt and molybdenum, were higher in the legumes than in the grasses at all stages of maturity, while the reverse was true for sodium, a general decline being seen in the concentration of minerals with advancing maturity with the exception of magnesium. However, concentration of selenium appeared to vary with the level of available selenium in the soil.

Cooper (1973) indicated that the imbalance between copper and molybdenum in herbage may result either in copper deficiency or copper toxicosis in grazing animals.

2.2.5 Application of fertilizers

Application of nitrogen fertilizers appeared to increase the concentration of phosphorus and potassium in the plant when these elements were in adequate supply in the soil as against a decreased uptake when soil reserves were low according to Whitehead (1970).

Kemp (1971) demonstrated a depression of calcium, magnesium and sodium concentration in herbage with application of potassium fertilizer.

Smith (1973) associated outbreaks of post parturient haemoglobinuria with depressed oestrus activity in dairy herds of Newzealand with extremely low liver and blood copper levels. He further drew evidence that application of fertilizers containing molybdenum and or lime to soil resulted in copper deficiency in fodder and resultant post parturient haemoglobinuria.

Wilcos and Hoff (1974) suggested that ammonium absorption by the plant results in a greatly reduced uptake of calcium and magnesium with little change in potassium.

2.3 Soil animal factors

Thornton (1974) calculated from observations in England that the quantity of soil ingested by grazing cattle in winter ranged from 140-1400 g/day, soil providing approximately 10 times the amount of copper, lead and arsenic supplied by the herbage.

Soil ingestion may have adverse effects on mineral utilization and animal health. Suttle *et al.* (1975) incorporated three soils differing in physical properties and molybdenum content in the diets of hypocupraemic ewes. They found that all soils were effective in inhibiting the response of blood copper to supplementary copper feeding and concluded that the release of elements such as molybdenum, zinc, iron and cadmium during digestion might interfere with copper metabolism and contribute to the aetiology of hypocuprosis in cattle and swayback in sheep.

2.4 Plant animal factors

Stewart (1953) noted that sheep on a cobalt deficient soil preferred to graze pasture which had been fertilized with cobalt.

Underwood (1966) in comparing the mineral requirements of plants and animals suggested that while the plant requirements of potassium, manganese and zinc exceed that of animal requirements and deficiency of these elements might depress crop growth but not the animal growth, the animal requirements of sodium, chlorine, iodine, cobalt and selenium are more than the plant requirements and these elements are to be supplied either by direct supplementation or by soil fertilization. For those elements the plant and animal requirements are equal, deficiency may limit the response of both and supplementation is required through fertilizers to give maximum forage to meet the needs of livestock.

Arnold (1970) observed that sodium deficient sheep showed a pronounced preference for plant species high in sodium.

Hartman and Bosman (1970) concluded that the copper in young grass was less available than in older herbage, eventhough the copper concentration in the young grass was higher.

Kiatoko *et al.* (1978) reported that plasma phosphorus content in cattle is related to the phosphorus content in the forages.

Mayland and Grunes (1979) pointed out the effect of oxalic acid in the production of hypocalcaemia in animals and the presence of organic acids such as citric and trans-aconitic acids in the plant which has been associated with the complexing of magnesium and induction of grass tetany in ruminants.

Brooks *et al.* (1984) reported that the infertile cattle which showed deficiency in serum inorganic phosphorus were those which were fed with pastures having high calcium: phosphorus ratio, grown in soil having low phosphorus level.

Suttle (1986) reported copper deficiency in grazing ruminants due to low availability of copper in lush green pasture and due to high content of molybdenum or sulphur in that pasture.

Damir *et al*. (1988) during his studies on infertility in cattle due to zinc deficiency observed that the incidence is related to the low level of zinc in the pasture.

2.5 Soil plant animal relationship

Lorek and Okonski (1974) found no correlation between conception rate of dairy cows and phosphorus content of soil and hay while Bodein (1976), detected deficiency of phosphorus, copper, zinc, manganese, cobalt and iodine in food stuffs as well as in blood and serum of cattle reared in lowlands in Hungary. He further recorded that supplementation of deficient elements in diet improved fertility and reduced the incidence of calf mortality and morbidity.

Nicolas *et al*. (1986) observed that the serum copper content of the adult cattle was related with the soil content of copper and molybdenum.

Saba (1987) could not establish any correlation between the low level of inorganic phosphorus in the serum of cattle and that present in the soil in which the fodder fed to them was grown.

Lall *et al*. (1994) conducted a study to correlate the mineral contents in the soil and in the plants grown in rabi and kharif seasons with their blood concentration in the livestock reared in the area. Contents of calcium, zinc, manganese and copper in the soil were sufficiently high, phosphorus adequate, cadmium below toxicity limit and iron levels marginal, the levels of the different minerals observed not seen affecting the optimum plant growth. In forages, calcium, phosphorus and iron contents were satisfactory, copper in excess, cadmium below toxicity limit and zinc and manganese deficient. Study on the blood levels of these elements in lactating buffaloes maintained in the area fed these forages revealed that the concentration of calcium, phosphorus and iron were within the normal range while zinc and copper were low despite the fact that copper was adequate in soil and was abundant in forages, suggesting the need to supplement these minerals.

2.6 Mineral problems in livestock

Underwood (1966) observed that the lower incidence of calcium disorders than of phosphorus disorder is attributable to 3 major factors, which include a higher concentration of calcium than of phosphorus in the leaves and stems of most plant species and higher concentration of phosphorus in the seeds, a wider distribution of phosphorus deficient soils than of calcium deficient soils and a lesser decline in the concentration of calcium than of phosphorus with advancing maturation of the plant.

Miltimore and Mason (1971) on the basis of a survey analysis of feeds in British Columbia, suggested that copper: molybdenum ratios of less than 2:1 were unsatisfacotry for cattle.

Saunders and Metson (1971) on examination of a range of soil and climatic properties influencing the seasonal changes in the phosphorus concentration and growth of pasture concluded that a major factor producing a high phosphorus status in spring was the release of phosphate from soil organic matter and organic residues, overt symptoms of phosphorus deficiency in ruminants such as poor growth, impaired reproductive performance, deprived appetite and bone abnormalities being noted when the phosphorus concentration in the herbage declined to approximately 0.1 to 0.15 per cent in the dry matter.

Baker (1972) observed that the concentration of magnesium in herbage is better correlated with the Mg/K ratio in the soil than with either Mg/Ca, per cent Mg saturation or extractable magnesium and concluded that high rate of potassium under certain climatic conditions can induce grass tetany in cattle.

Metson (1974) concluded that soil group and possibly soil type, could be related to occurrence of grass tetany either due to a low exchangeable magnesium level, resulting in low herbage magnesium concentration, a high soil potassium status, a free drainage favouring a rapid flush of growth with a high sodium and low magnesium content and a locality factor associating to a particular soil with unfavourable climatic condition such as high rainfall, high altitude or low light intensity.

Thornton and Alloway (1974) associated hypocuprosis manifested by conditions ranging from sway back to live weight responses to copper supplementation in animals in Britain within geochemically defined high molybdenum areas. They considered that marginal bovine copper deficiency might occur on pastures containing as little as 2-4 ppm molybdenum. Clinical copper deficiency was observed on pastures containing 5-17 ppm molybdenum and hypocupraemia without clinical symptoms on pastures with concentration of 1-4 ppm molybdenum even with normal copper concentration in herbage.

Campbell *et al*. (1974) have suggested that intake of iron may depress the copper status of the cattle.

Beeson and Matrone (1976) have stated that it is difficult to establish a clear relationship between properties of the soil and the occurrence of bone diseases in grazing animals because of low availability of soil phosphorus which is associated more with soil reaction such as high acidity or alkalinity resulting in the formation of insoluble iron or aluminium phosphates or basic calcium phosphates than the total concentration of phosphorus in the soil. Excessive leaching or erosion of soil with consequent depletion of the amount of available phosphorus resulting in a decrease in the concentration of phosphorus in the plant were also suggested as contributing factors by the above workers.

Parmar *et al*. (1980) estimated levels of iron, manganese, zinc and copper in the blood of normal cyclic and repeat breeding crossbred cows and reported significant difference in the levels of all elements except zinc.

Ruskan *et al*. (1982) could not detect any significant differences in live weight gain, ovarian activity and conception rate in heifers receiving copper supplementation either orally or subcutaneously than that of the unsupplemented animals.

Prasad *et al*. (1982) found that administration of copper sulphate cured the leg paralysis (Swayback) condition of kids reared in the National Dairy Research Institute (Karnal).

Whitaker (1982) could observe no significant difference in the average interval between calving to first observed heat, services per conception or first service conception rate even by injection of 400 mg of copper glycinate to cows within one week of calving.

Surendra Singh and Vadnere (1987) induced oestrus in anoestrus cows having deficiency of one or several of the elements such as iodine, copper, calcium, inorganic phosphorus and iron with supplementation of the respective minerals for a maximum period of 21 days.

Bonomi *et al.* (1988) found that there was more chance of zinc deficiency in cattle taking feed with high calcium: phosphorus ratio, compared to those taking low calcium:phosphorus ratio diet.

When Santa Gertrudis cows of Cuba maintained in areas deficient for sodium, potassium, calcium, phosphorus, magnesium, copper, zinc and iron received a mineral mixture supplement, Gonzalez *et al.* (1988) noted birth rates to increase by 118 per cent and abortion rates and calving conception intervals to decrease respectively by 1.3 per cent and 32.8 days.

Sharma *et al.* (1988) found that there was significantly low serum zinc levels in non cyclic heifers compared to that of cyclic ones.

Prasad *et al.* (1989) opined that higher values of serum copper affect reproduction in cattle.

Prasad *et al.* (1989) reported significant difference in the serum copper levels of normally cycling and anoestrous cattle, the levels being 70 to 115 μg/100 ml for normally cycling and 52 to 78 μg/100 ml for cattle with acyclic ovaries.

Prasad *et al.* (1989) examined 50 crossbred cows with different reproductive disorders and estimated their serum copper, zinc, manganese, cobalt and iron levels. Both high and low level of copper in serum were found to be associated with repeat breeding in cows. In all the reproductive conditions studied no significant deviation from physiological range was observed for manganese and cobalt levels in blood serum. Serum iron levels tended to be higher in cycling animals and in those with longer postpartum intervals. A significant correlation between serum zinc and copper (r-0.51) and between zinc and cobalt (r=0.37) was also noticed in different reproductive disorders.

Saxena (1991) observed that heifers with a plasma zinc level of 100-290 μg/dl attain puberty faster than those having levels lower than this.

Sangwan *et al.* (1993) observed higher levels of manganese and zinc and low levels of copper in the blood of sheep affected with fascioliasis.

Prasad and Rao (1997) reported that in anoestrous cattle, phosphorus, zinc and iron levels in whole blood were the lowest, manganese level very high and copper level subnormal as against repeat breeders in which blood mineral levels were lower than the normal animals except magnesium and iron.

2.7 Assessment of mineral status of cattle

Patel (1966) analysed the common fodders and concentrates from Gujarat, Maharashtra and Rajasthan for their iron, cobalt, copper, manganese, zinc and molybdenum contents, so as to know whether supplementation of any of trace mineral is necessary or not. The investigation revealed that green fodders are richer in copper content as compared to dry fodders. Compared to other feeds and fodders, tree leaves are rich in zinc. Some of the concentrates such as wheat bran and maize bran are rich in zinc content, and groundnut cake and cottonseed cake are fairly rich in all the trace minerals. It was concluded that if the animals are fed with the required quantity of feeds in proper proportion, supplementation of these trace minerals would not be necessary.

Results of studies carried out by Kunjikutty (1969) in order to assess the nutritional status of cattle maintained in the livestock farm attached to Kerala Veterinary College and Research Institute, Mannuthy and fed standard farm rations revealed that the rations fed to various classes of animals were qualitatively and quantitatively adequate in all respects including calcium, phosphorus and copper in as much as the body weights and blood values of the animals studied were found to be within the normal range reported for the species.

Cohen (1973) found bone phosphorus content to be a more sensitive indicator of pasture phosphorus status than either blood or hair concentration of the element.

Murtuza *et al.* (1979) randomly divided 32 Haryana cattle into 4 groups viz. (a) heifers (b) empty dry cows (c) late pregnant cows and (d) early lactating cows and analysed the serum levels of calcium, phosphorus, magnesium, sodium and potassium. Serum calcium significantly differed between early lactating and late pregnant cows, early dry cows and late pregnant cows and heifers. Similarly serum inorganic phosphorus levels differed between groups except between empty dry cows and early lactating cows.

Chabra *et al.* (1980) reported that dietary zinc will augment the conversion of ß-carotene to Vit.A and its mobilisation from the liver.

Patnayak and Mann (1980) while studying the problems and prospects of arid zone livestock in relation to nutrition observed that the quality of the feed available as range forages and crop residues was very poor with respect to energy, protein and mineral content, the animals in the area exhibiting marginally lower serum levels with regard to Vit.A, calcium, phosphorus and protein.

Sharma and Prasad (1982) reported that blood mineral levels vary with age, growth and physiological condition of animals.

Singal and Lohan (1988) suggested mineral deficiency as a probable contributing factor to infertility in cattle in Haryana since the serum phosphorus concentration ranged from 1.02±0.13 to 5.24±0.70 mg/100 ml and zinc concentration less than 0.9 ppm in the animals in the area.

Bedi and Khan (1989) analysed samples of soil, fodder and animal blood collected from different areas of Bareily district for trace elements, viz., copper, iron, manganese and zinc. The study revealed that in general, soil samples were satisfactory in regard to the content of the above elements. However, nearly 50 per cent fodder samples were low in copper and iron, 40 per cent in manganese and 90 per cent in zinc contents. Wide variations were also observed in the mineral contents of fodders, berseem being the richest source followed by cereal fodders, while rice straw and wheat straw were poor sources. The analysis of serum collected from the animals revealed that 50 and 70 per cent animals in the area had low blood copper and zinc respectively.

Simeonov *et al*. (1989) reported that heifers with a serum manganese level of below 0.02 ppm showed anoestrus condition.

Results of survey work carried out on the mineral contents of soil and plants of grazing fields in Hooghly district of West Bengal by Das *et al*. (1990) revealed that copper, cobalt and manganese contents of soil were marginal to low while only cobalt and manganese contents in some of the forage plants, were found marginal to low indicating that cobalt and manganese deficiency in grasses might be the possible factors for causing anaemia, anoestrus and stunted growth in the grazing livestock ruminant.

Nickerk *et al*. (1990) grouped the cattle showing a plasma zinc level below 80 μg/dl as zinc deficient.

Sarkar *et al*. (1990) observed marginal to low level of cobalt in the plants during the survey of trace mineral status in plants of the grazing field of Nadia district of West Bengal.

Malik (1991) reported that Pakistani soils are coarse to medium textured, highly alkaline and phosphorus and manganese deficient. About 62 per cent of the soils in Punjab, 100 per cent soils in Sind and 77 per cent in North West Frontier province are deficient in zinc while iron and copper are with in the normal range. Regarding studies on the mineral contents of the feed stuffs indicate that almost all of the indigenous animal feed stuffs are more or less deficient in all the essential mineral elements, when compared with American feed stuffs.

Das *et al.* (1992) reported deficiency of phosphorus in most of the grazing forage plants and blood of cattle in the Midnapore district of West Bengal eventhough the phosphorus content in soil was above the critical level.

Rajora and Pachauri (1993) determined the concentration of copper, iron, manganese and zinc in the serum of cattle, roughage, concentrate mixtures and soils in the sub Himalayan region of Tarai and observed that between 33 and 50 per cent of forage samples in this agroclimatic zone were deficient in copper and 33 per cent were low in zinc, these differences being not found in concentrates. However, the serum mineral values of cattle were not seen related to the content of minerals in either forages or concentrates.

Lall *et al.* (1996) reported that buffaloes in the villages of Hisar district, were in short supply of certain essential minerals like zinc and manganese (40 to 50%) while the supply of copper was three times than its requirement.

Investigations carried out by Anantharam *et al.* (1997) to assess the nutritional status of bovines in Karnataka revealed that the available feeds and fodder from crop lands is barely sufficient to meet the maintenance requirement of the breedable bovines, which account for 30 per cent of total livestock population in the state indicating the need to explore alternate feed sources for meeting the requirement of rest of the classes of livestock.

Mandal *et al.* (1997) during their assessment of mineral status of buffaloes in Faridabad district of Haryana observed that dry roughage contained lesser amount of zinc and excess iron when compared to their requirement. Serum mineral status revealed that 73 and 22.5 per cent of buffaloes had calcium and zinc below normal level, while only 6 and 7 per cent of buffaloes had subnormal phosphorus and copper respectively. Analysis of hair also revealed deficiency of zinc and copper, indicating the need of supplementary Ca, P, Zn and Cu to the dairy animals of this district.

Singh *et al.* (1997) conducted a survey to study the plane of nutrition and conventional feeding system of buffaloes during rabi season in Hisar district of Haryana. They observed that the energy intake on live weight basis was higher in buffaloes owned by marginal and landless farmers. However, protein was being fed in excess of their requirements, ranging from 12.93 (landless) to 23.05 per cent (large medium) farmers.

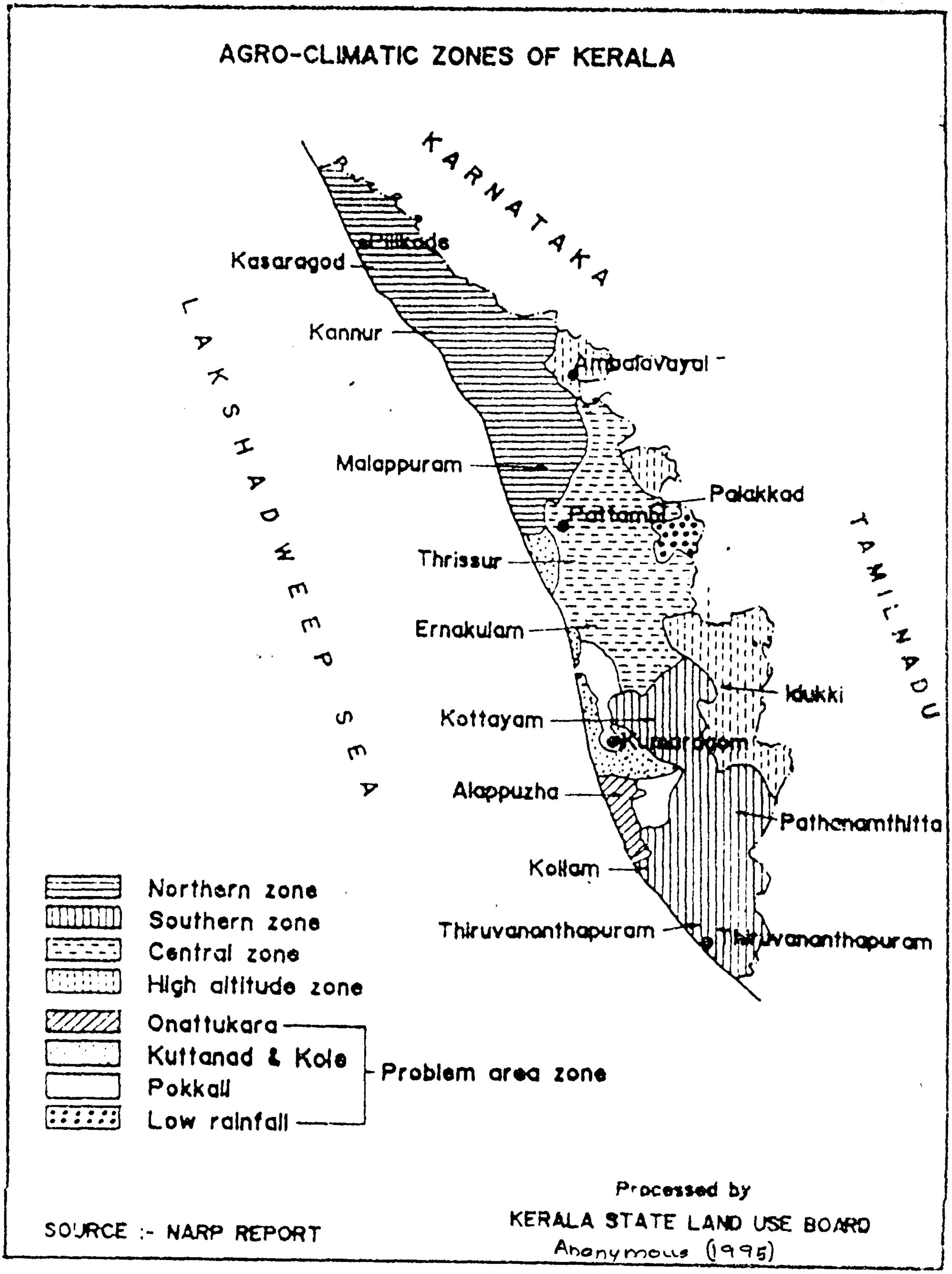
Singh *et al.* (1997) conducted a study in Nainital district in Uttar Pradesh to assess the feeding pattern of concentrate and fodder to dairy animals. The study revealed that marginal and small farmers did not practise feeding of concentrates to the dry cows and buffaloes, while medium categories of the farmers gave very little amount (0.15 kg) of concentrate to the dry cows and buffaloes. The average quantity of fodder fed to the pregnant cows, milking cows and during dry period were 15.75, 19.25 and 12.00 kg respectively by marginal farmers, 19.0, 21.0 and 12.5 kg by small farmers and 23.25, 24.0 and 13.75 kg by medium farmers respectively.

Yadav and Khirwar (1997) collected and analysed samples of soils, feeds and fodders, milk, blood and hair of 150 milch buffaloes from 10 villages of Jind District of Haryana state for copper content. They observed that the copper content of soil was sufficient to meet the requirements of the growth of the plants and therefore the feed stuffs available in the district were containing higher levels of copper. Milk and blood copper content also remained within normal limits, however, copper content of hair was less than those reported earlier for milch buffaloes.

Materials and Methods

3. MATERIALS AND METHODS

With the objective of assessing the present feeding condition as well as the mineral status of cattle in Kerala a survey work was conducted covering all the districts under the different agro-climatic regions in the state. The state of Kerala has been divided into five agro-climatic zones (NARP) based on rainfall distribution, irrigation pattern, soil characteristics, cropping pattern and ecological and social characteristics, the zones being Northern Zone, Central Zone, Southern Zone, High range areas and special problem areas covering all the 14 districts in the state as shown in the map enclosed. From each district under different agro-climatic conditions, 50 per cent of the taluks and from each taluk two villages were selected for the survey work. Details of the taluks selected and villages covered in each taluk for the survey work and collection of sample are presented in Table enclosed. From each village nine samples of blood were collected from cattle maintained by three category of farmers (large, medium and marginal) divided as per socio-economic conditions. Blood samples as well as representative samples of soil and feeds and fodders fed to lactating cattle were collected from farmers households and also from organised and private farms in the different regions surveyed for the estimation of the major and trace elements. Data on nutritional status of animals were collected by using a


AGRO-CLIMATIC ZONES OF KERALA
KARNATAKA
LAKSHADWEEP SEA
TAMILNADU
Pilikode
Kasaragod
Kannur
Ambalavayal
Malappuram
Palakkad
Pattambi
Thrissur
Ernakulam
Idukki
Kottayam
Kumarakom
Alappuzha
Pathanamthitta
Kollam
Thiruvananthapuram
Thiruvananthapuram
Northern zone
Southern zone
Central zone
High altitude zone
Onattukara
Kuttanad & Kole
Pokkali
Low rainfall
Problem area zone
SOURCE :- NARP REPORT
Processed by
KERALA STATE LAND USE BOARD
Anonymous (1995)

Details of taluks selected and villages covered in each taluk for the survey work and collection of samples in Kerala State

District	Taluks covered	Villages covered	
Thiruvananthapuram	1. Thiruvananthapuram	Andoorkonam	Sreekariam
	2. Nedumangad	Pangode	Kallara
Kollam	1. Kottarakkara	Nilamel	Kulakada
	2. Kollam	Thrikkaruva	Thekkevila
Alleppey	1. Kuttanadu	Moncompu	Nedumudy
	2. Ambalapuzha	Punnapra	Arattuvazhy
Pathanamthitta	1. Kozhenchery	Naranganum	Elanthoor
	2. Adoor	Erathu	Ezhamkulam
Kottayam	1. Kottayam	Pampady	Kumarakom
	2. Changanacherry	Kurichy	Thrikodithanam
Idukky	1. Thodupuzha	Karimannoor	Purapuzha
	2. Udumbanchola	Elappara	Ayyappankovil
Ernakulam	1. Aluva	Chengamanade	Manjapra
	2. Kunnathunadu	Vengola	Poonjassery
Thrissur	1. Thrissur	Nadathra	Madakkathra
	2. Mukundapuram	Kodakara	Irinjalakuda
Palakkad	1. Chittoor	Nenmara	Muthalamada
	2. Alathur	Vadakkenchery	Kannambra
Malappuram	1. Thirur	Thanallur	Purathur
	2. Ernadu	Uppada	Pokkotumpadom
Kozhikode	1. Vadakara	Villayappally	Chombala
	2. Kozhikode	Kuttikottoor	Peruvayal
Kannur	1. Kannur	Pallikunnu	Edayavur
Wyanad	1. Kalpetta	Panamaram	Ambalavayal
Kasargod	1. Kasargode	Kodakade	Kuttikol

proforma (enclosed) supplied to each farmer. Incidence of nutritional deficiency conditions, if any, was assessed from information gathered from the clinical cases recorded in various veterinary institutions in the concerned districts. From the information gathered during the survey work on the quantities of feeds and fodders fed and from the results on the mineral analysis of samples of feeds and fodder collected, data on dietary intake of minerals by lactating cattle were calculated to ascertain the mineral status of the animals in the respective areas.

3.1 Collection and analysis of soil samples

From each village surveyed five samples of soil were collected as per the method suggested by Jones *et al.* (1971), the sampling being done as follows. A `V' shaped cut was made in the soil [illegible] by using a spade. Uniformly thick slice of soil, 2 cm in thickness was taken from one side of the cut (from longer side of V). About 15-20 samples were collected from one acre of land. Samples collected were mixed together and reduced to 1 kg by quartering.

Soil samples were mixed, spread uniformly in the form of a square or rectangle on a clean paper and divided into four equal parts. The opposite corners were rejected. The remaining soil was again spread as a square and quartering

PROFORMA FOR SURVEY ON NUTRITIONAL STATUS OF CATTLE SUPPLIED TO FARMERS

1. Name and address of the farmer :

   Name

   House name/number

   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

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

c. Unconventional feeds, if any, used

S.No.	Name	Quantity
1.		
2.		
3.		
4.		

B. Roughage

Type of roughage	Name	Quantity
1. Natural grass		
2. Cultivated grass		
3. Conserved fodder		
4. Grass-legume (mixed) fodder		
5. Straw		
6. Conventional fodder (tree leaves/weeds)		
7. Grazing/stall feed		

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 intercalving period

c. Unthrifty condition

d. Poor growth

6. Biological/feed/soil samples collected

7. Results and remarks

repeated till a convenient sample size of one kg was attained. Samples were spread out on a polythene sheet and dried in shade. After drying, the sample was ground in a mortar and seived through a 2 mm sieve. The properly collected soil samples were prepared for analysis of extractable cations calcium, magnesium, sodium, potassium, copper, zinc, iron and manganese by using 0.1 normal HCl (Mortvedt *et al.*, 1972) and estimated by Atomic Absorption Spectrophotometer Perkin Elmer model 3110. Soil phosphorus was estimated by the colorimeter method of Dickman and Bray (1940).

3.2 Collection and analysis of feeds and fodders

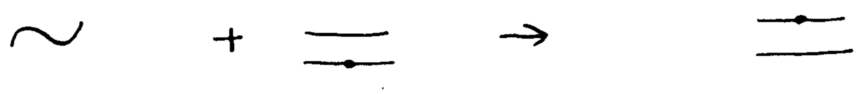
During the survey of the individual households, samples of different compound feeds and individual feed ingredients as well as grass or paddy straw, fed to animals were collected for analysis of mineral contents. A minimum of five samples of each feed and fodder collected from each village were used for analysis. Samples for mineral analysis were prepared by wet digestion using a mixture of perchloric acid and nitric acid (AOAC, 1975) the estimation ofdifferent minerals being carried out by Atomic Absorption Spectrophotometry except phosphorus for which the colorimetric Vanado-Molybdate Method (AOAC, 1980) was used.

3.3 Collection and analysis of blood

From the households surveyed, blood samples were collected from lactating cows. Approximately 25 mL of blood was collected in a test tube from the Jugular vein of each animal and the sample was kept in slanting position for clotting and separation of serum. The clotted blood was kept in a refrigerator for 24 hrs. The clear serum was separated and collected in tubes and stored in a labelled container in a refrigerator. Slightly discoloured serum samples were centrifuged at 1000 rpm for five minutes to remove the red cells from the serum before storing. A minimum of nine samples were collected from each village and properly preserved for the estimation of major and trace mineral levels. Minerals except phosphorus were estimated by Atomic Absorption Spectrophotometry. Phosphorus was estimated by the Modified Metol Method using phosphorus kits supplied by Stangen Immunodiagnostics.

3.4 Principle of Atomic Absorption Spectrophotometry

Every element has a specific number of electrons which are associated with the atomic nucleus in a unique orbital structure. The electrons occupy orbital positions in an orderly and predictable way. The most stable electronic configuration of an atom is the "ground state" in which it has the normal orbital configuration and the lowest energy levels. If light of the right wave length impinges on a free ground state atom, the atom may absorb energy from the light and it enters an excited state in a process known as Atomic Absorption. The capacity of atom to absorb very specific wave length of light is utilised in Atomic Absorption Spectrophotometry. In atomic absorption the amount of light at the resonant wave length which is absorbed, as light passes through a cloud of atoms, is measured. As the number of atoms in the light path increases the amount of light absorbed also increases in a predictable way. By measuring the amount of light absorbed a quantitative determination of the amount of analyte element present can be made. The use of special light source and careful selection of wave length allow the specific quantitative determination of individual elements in the presence of others.



Light energy   Excited state atom

The atomic absorption process

Conditions used for the operation of Atomic Absorption Spectrophotometer

The Atomic Absorption Spectrophotometer was set for operation as per the recommendations of the instrument manufacturers (Perkin-Elmer). The standard conditions set for the atomic absorption of the various elements studied are furnished below.[Beaty, R.D and Kuber, J.D. (1993)]

Element	Wavelength	Slit	Flame gas	* Sensitivity check mg/l	** Linear range mg/l
Calcium	422.7	0.1	Air acetylene	4.0	5.0
Magnesium	285.2	0.7	"	0.3	0.5
Sodium	589.0	0.4	"	0.5	1.0
Potassium	766.5	1.4	"	2.0	2.0
Copper	324.8	0.7	"	4.0	5.0
Zinc	213.9	0.7	"	1.0	1.0
Iron	248.3	0.2	"	5.0	5.0
Manganese	279.5	0.2	"	2.5	2.0

* Concentration of an element in milligram per litre (mg/l) required to produce approximately 0.2 absorbance units.

** Maximum limit where the absorbance: Concentration relationship is linear.

3.5 Statistical analysis

The data collected on various parameters are statistically analysed as per methods of Snedecor and Cochran (1980).

ATOMIC ABSORPTION SPECTROPHOTOMETER - PERKIN ELMER MODEL 3110

(Double Beam Photometer)

Results

4. RESULTS

The results obtained during the course of the present investigation are detailed under the following heads.

4.1 Nutritional survey

Data on survey of nutritional status of cattle of different districts are summarised and presented in Table 1.

4.2 Soil analysis

Details of soil characteristics in the different districts are presented in Table 2.

Data on average mineral concentration of soil collected from all the 14 districts of the state are summarised and presented in Table 3 and their statistical analysis presented in Table 3.1 to 3.7. The graphic representation of the same are given in Figures from 1 to 7.

The abbreviations for the districts in the graph (figures 1 to 43) pertain to TVM - Thiruvananthapuram, KLM - Kollam, ALP - Alleppey, PTM - Pathanamthitta, KTM - Kottayam, IDK - Idukki, EKM - Ernakulam, TCR - Thrissur, PKD - Palakkad, MPM - Malappuram, KZK - Kozhikode, KNR - Kannur, WYD - Wyanad and KSGD - Kasargod.

4.3 Analysis of feeds and fodders

4.3.1 Concentrate mixtures

Data on average mineral concentration in the concentrate mixtures collected from all the 14 districts of the state are summarised and presented in Table 4 and their statistical analysis from Table 4.1 to 4.9. The graphic representation of the same are shown in Figures from 8 to 16.

4.3.2 Feed ingredients

Data on average mineral concentration in commonly used feed ingredients collected from different districts of the state are summarised and presented in Table 5.

4.3.3 Mineral mixtures

Data on the mineral composition of various mineral mixtures collected from different districts are presented in Table 6.

4.3.4 Natural (local) grass

Data on average mineral contents of natural grass fed to animals in the surveyed areas collected from all the 14 districts of the state are summarised and presented in Table 7 and their statistical analysis from Table 7.1 to 7.9.

The graphic representation of the same are given in Figures from 17 to 25.

4.3.5 Paddy straw

Data on average mineral contents of paddy straw fed to animals in the surveyed areas collected from all the 14 districts of the state are summarised and presented in Table 8 and their statistical analysis from Table 8.1 to 8.9. The graphic representation of the same are given in Figures from 26 to 34.

4.4 Analysis of serum

Data on average mineral concentration in the serum of lactating cattle in the 14 districts studied are presented in Table 9 and the corresponding statistical analysis from Table 9.1 to 9.9. The graphic representation of the same are shown in Figures from 35 to 43.

4.5 Report on recorded clinical cases in veterinary institutions

Data on deficiency/metabolic/ reproductive cases in cattle recorded in Veterinary Institutions in the 14 districts surveyed for a period of previous six months are presented in Table 10.

4.6 Dietary intake of minerals

Data on the mean daily dietary intake of minerals along with total dry matter consumption and average milk yield of lactating cows in the surveyed areas of 14 districts of Kerala are summarised and presented in Table 11.

4.7 Normal rainfall

Details on normal rainfall in Kerala - district wise and month wise are presented in Table 12.

Table 1. Consolidated report on survey of nutritional status of cattle of different districts

District	Breed	Average milk yield l/day	In addition to cows, percentage of households rearing		Percentage of households having fodder cultivation	Percentage of households using			Percentage of households using unconventional feeds	Concentrate feeding percentage of householding giving			Percentage of households giving mineral mixture separately	Percentage of households reporting reproductive or deficiency conditions
			Goats	Buffaloe		Straw alone as roughage	Grass alone as roughage	Grass + straw as roughage		Compound feed + ingredients	Ingredients alone	Compound feed alone		
Thiruvananthapuram	Cross bred	6.9	28	8	19	14	47	39	19	67	11	22	44	33
Kollam	Cross bred	7.9	19	14	-	5.6	47	47.4	5.6	69.4	5.6	25	36	67
Alleppey	Cross bred	8	8	-	17	-	28	72	56	48	33	19	36	17
Pathanamthitta	Cross bred	8	14	8	16	-	16.7	83.3	36	-	25	-	58	44
Kottayam	Cross bred	7	17	-	6	5	28	67	-	72	14	14	17	44
Idukki	Cross bred	6.6	14	-	11	-	22	78	-	63	18	19	28	28
Ernakulam	Cross bred	8	-	8	8	-	22	78	-	-	22	36	38.9	42
Thrissur	Cross bred	7	17	14	-	-	-	100	-	44	31	22	25	28
Palakkad	Cross bred	7.5	Low population		14	-	30	70	-	55	45	-	24	16.5
Malappuram	Cross bred	6.5	50	-	13.9	27.8	33.3	38.9	-	63.9	19.4	16.7	27.8	47
Kozhikode	Cross bred	7.6	50	11	2.8	11	50	39	-	44.6	13.9	41.7	33	52.8
Kannur	Cross bred	7.3	11	17.6	11	34	22	44	-	67	-	33	44	33
Wyanad	Cross bred	7	22	11	16.7	-	28	72	-	78	16.6	-	39	44
Kasargod	Cross bred	6	16	-	6	28	28	44	-	61	33	-	33	61

Table 2. Details of soil characteristics in the area surveyed in the different districts of Kerala

Sl. No.	District	Type of soil	Details of location
(1)	(2)	(3)	(4)
1.	Thiruvananthapuram	1. Fairly rich brown loam of laterite	Middle part of the district
		2. Sandy loam	Western coastal region
		3. Rich dark brown loam of granite origin	Eastern hilly parts of the district
2.	Kollam	1. Sandy loam	Karunagappally and part of Kollam taluks
		2. Laterite soil	Kottarakkara, Kunnathur and parts of Kollam and Pathanapuram taluks
3.	Pathanamthitta	1. Clay soil	Western and Eastern hilly regions
		2. Laterite soil	Parts of Ranni and Kozhencheri taluks
4.	Alappuzha	1. Sandy loam	Karthigappally and parts of Mavelikkara taluks
		2. Sandy soil	Cherthala and Ambalapuzha taluks
		3. Clay loam with much acidity	Kuttanad
		4. Laterite soil	Chengannur and part of Mavelikara taluk
5.	Kottayam	1. Laterite soil	Parts of Changanachery and Kottayam taluks and Kanjirappally and Meenachil taluks
		2. Alluvial soil	Vaikom taluk and parts of Changanachery and Kottayam taluks
6.	Idukki	1. Laterite soil	Peermade and Thodupuzha taluks
		2. Alluvial soil	Devicolam and Udumbanchola taluks

(1)	(2)	(3)	(4)
7.	Ernakulam	1. Laterite soil	Muvattupuzha, Kothamangalam and part of Aluva and Kunnathunad taluks
		2. Sandy loam	Parur, Kochi and Kanayannur taluks
		3. Alluvial soil	Parts of Aluva and Kunnathunad taluks
8.	Thrissur	1. Sandy loam	Part of Mukundapuram, Thrissur & Chavakkad taluks
		2. Laterite soil	Eastern part of Thrissur and Western part of Talappally taluks
		3. Clay soil	Back-water area of Chavakkad and Mukundapuram taluks
		4. Alluvial soil	Portions of Chavakkad taluk
9.	Palakkad	1. Laterite soil	Major part of the district
		2. Sandy loam	North-Eastern part of Chittur taluk
10.	Malappuram	1. Laterite soil	Interior region of the district
		2. Sandy loam	Along the coastal belt of the district
11.	Kozhikode	1. Laterite soil	Major part of the district except coastal strip
		2. Sandy loam	Coastal strip
12.	Wyanad	1. Laterite soil	Major part of the district
		2. Sandy loam	Valleys in the middle portion of the district
13.	Kannur	1. Laterite soil	Major part of the district except coastal strip
		2. Sandy loam	Coastal strip
14.	Kasargod	1. Laterite soil	Major portions of the district except coastal strip
		2. Sandy loam	Coastal strip

Table 3. Average mineral concentration of soil collected from different districts

District	Calcium (%)	Phosphorus (ppm)	Magnesium (%)	Copper (ppm)	Zinc (ppm)	Iron (ppm)	Manganese (ppm)
Thiruvananthapuram	0.06± 0.01	116.44± 6.25	0.06± 0.01	6.36± 0.72	4.70± 0.52	196.02± 6.67	35.75± 0.74
Kollam	0.05± 0.01	60.14± 3.60	0.04± 0.01	4.86± 0.54	7.29 ± 0.55	232.64± 10.87	41.35± 1.09
Alleppey	0.08± 0.01	97.34± 2.14	0.01± 0.01	7.89± 0.52	7.77± 0.53	143.27± 3.58	42.30± 1.04
Pathanamthitta	0.04± 0.002	52.49± 0.63	0.03± 0.004	6.30± 0.21	4.67± 0.35	113.89± 4.72	19.35± 0.94
Kottayam	0.06± 0.002	40.29± 0.75	0.02± 0.002	4.00± 0.26	4.26± 0.03	127.91± 5.05	29.55± 1.09
Idukki	0.07± 0.002	62.86± 0.35	0.03± 0.002	2.90± 0.06	4.93± 0.05	808.77± 9.05	13.90± 0.44
Ernakulam	0.07± 0.01	56.30± 1.82	0.04± 0.01	3.38± 0.56	5.12± 0.81	187.04± 6.33	35.10± 0.53
Thrissur	0.08± 0.004	124.65± 1.96	0.02± 0.002	8.10± 0.14	7.71± 0.10	295.69± 4.62	19.45± 1.04
Palakkad	0.08± 0.004	96.96± 1.78	0.02± 0.002	2.60± 0.13	6.44± 0.08	190.43± 4.22	29.20± 0.85
Malappuram	0.04± 0.01	69.33± 2.67	0.02± 0.002	2.36± 0.32	4.80± 0.41	210.77± 6.81	45.25± 1.34
Kozhikode	0.08± 0.01	63.02± 1.38	0.02± 0.004	4.32± 0.59	3.39± 0.37	164.65± 5.11	62.50± 0.94
Kannur	0.04± 0.01	67.81± 1.66	0.06± 0.01	6.89± 0.63	5.43± 0.35	259.88± 10.01	51.30± 0.87
Wyanad	0.03± 0.003	81.18± 1.89	0.02± 0.003	2.01± 0.52	5.28± 0.78	212.11± 4.95	25.70± 1.03
Kasargode	0.10± 0.01	97.14± 2.67	0.02± 0.003	3.67± 0.16	4.61± 0.13	47.78± 5.76	26.20± 1.12

Table 3.1 Analysis of variance - Calcium content of soil

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	0.080	0.006	8.199**	0.0000
Within	236	0.176	0.001		
Total	249	0.256			

** P<0.01

Table 3.2 Analysis of variance - Phosphorus content of soil

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	160126.787	12317.445	95.402**	0.0000
Within	236	30470.249	129.111		
Total	249	190597.036			

** P<0.01

Table 3.3 Analysis of variance - Magnesium content of soil

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	0.050	0.004	6.131**	0.0000
Within	236	0.148	0.001		
Total	249	0.197			

** P<0.01

Table 3.4 Analysis of variance - Copper content of soil

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	982.931	75.610	22.339**	0.0000
Within	236	798.767	3.385		
Total	249	1781.699			

** P<0.01

Table 3.5 Analysis of variance - Zinc content of soil

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	456.439	35.111	10.227**	0.0000
Within	236	810.245	3.433		
Total	249	1266.684			

** P<0.01

Table 3.6 Analysis of variance - Iron content of soil

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	7937765.542	610597.349	767.259**	0.0000
Within	236	187812.724	795.817		
Total	249	8125578.266			

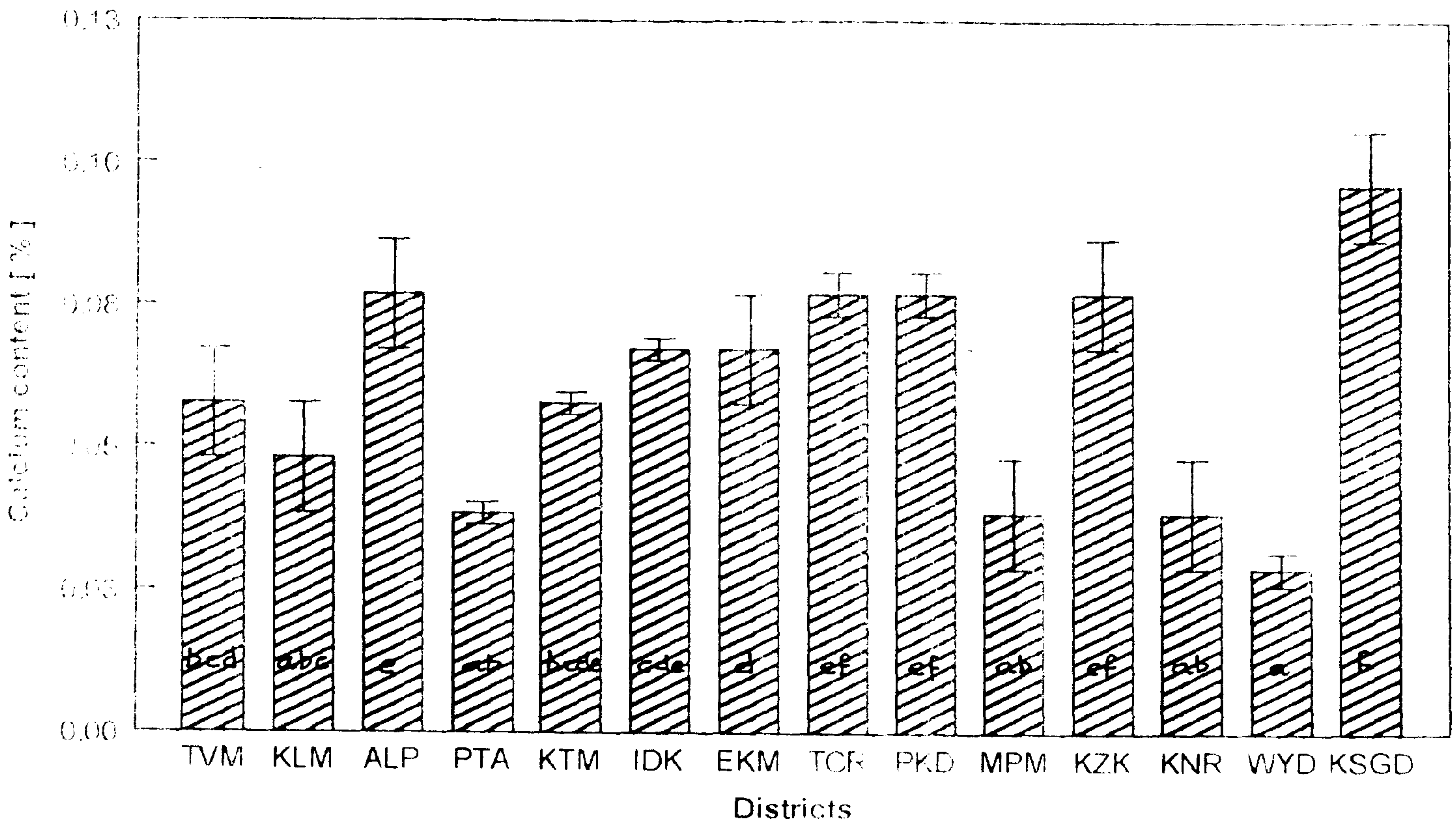
** P<0.01

Table 3.7 Analysis of variance - Manganese content of soil

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	43073.556	3313.350	194.307*	0.0000
Within	236	4024.300	17.052		
Total	249	47097.856			

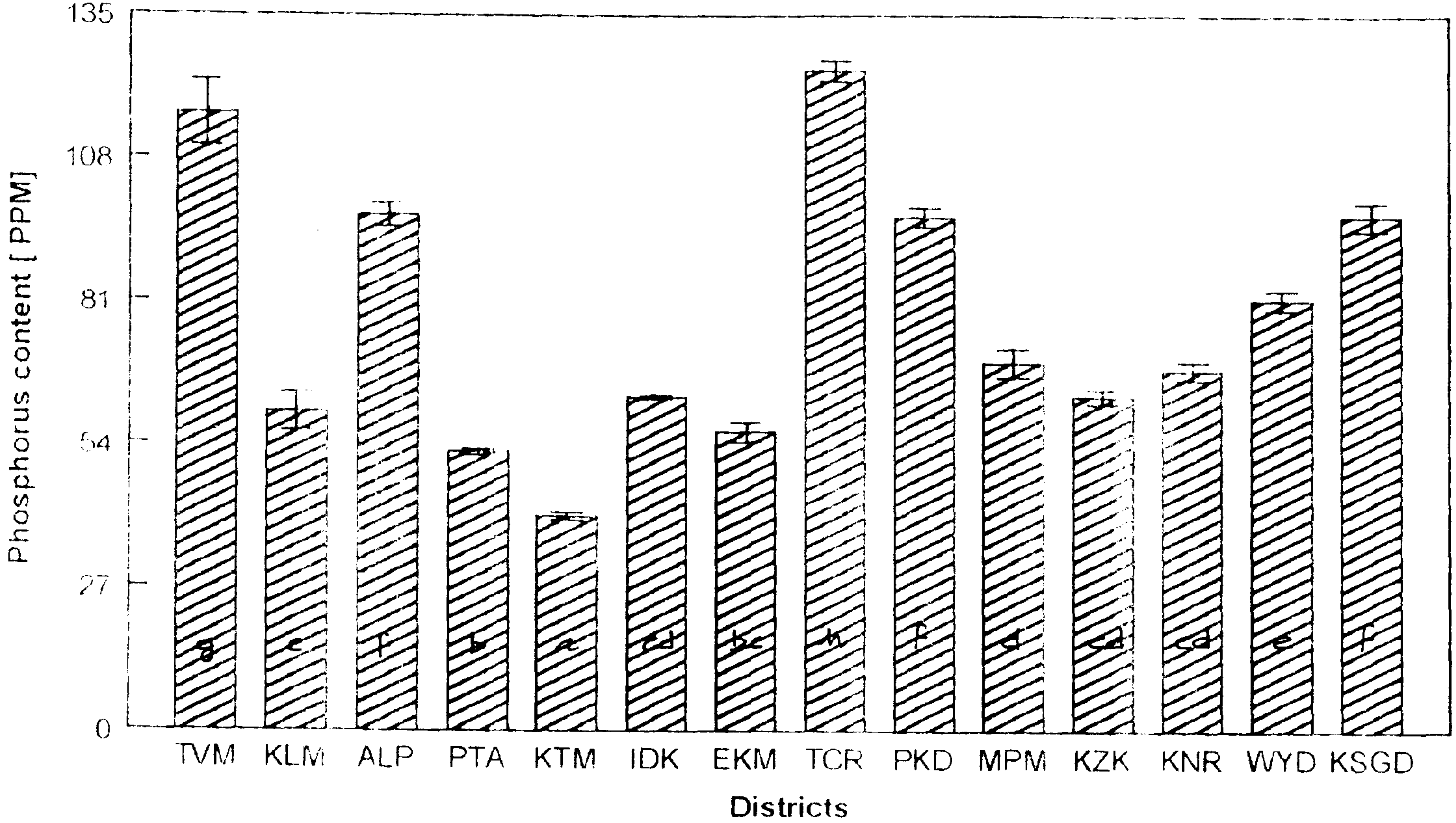
** P<0.01

Fig. 1 Calcium content of soil collected from different districts



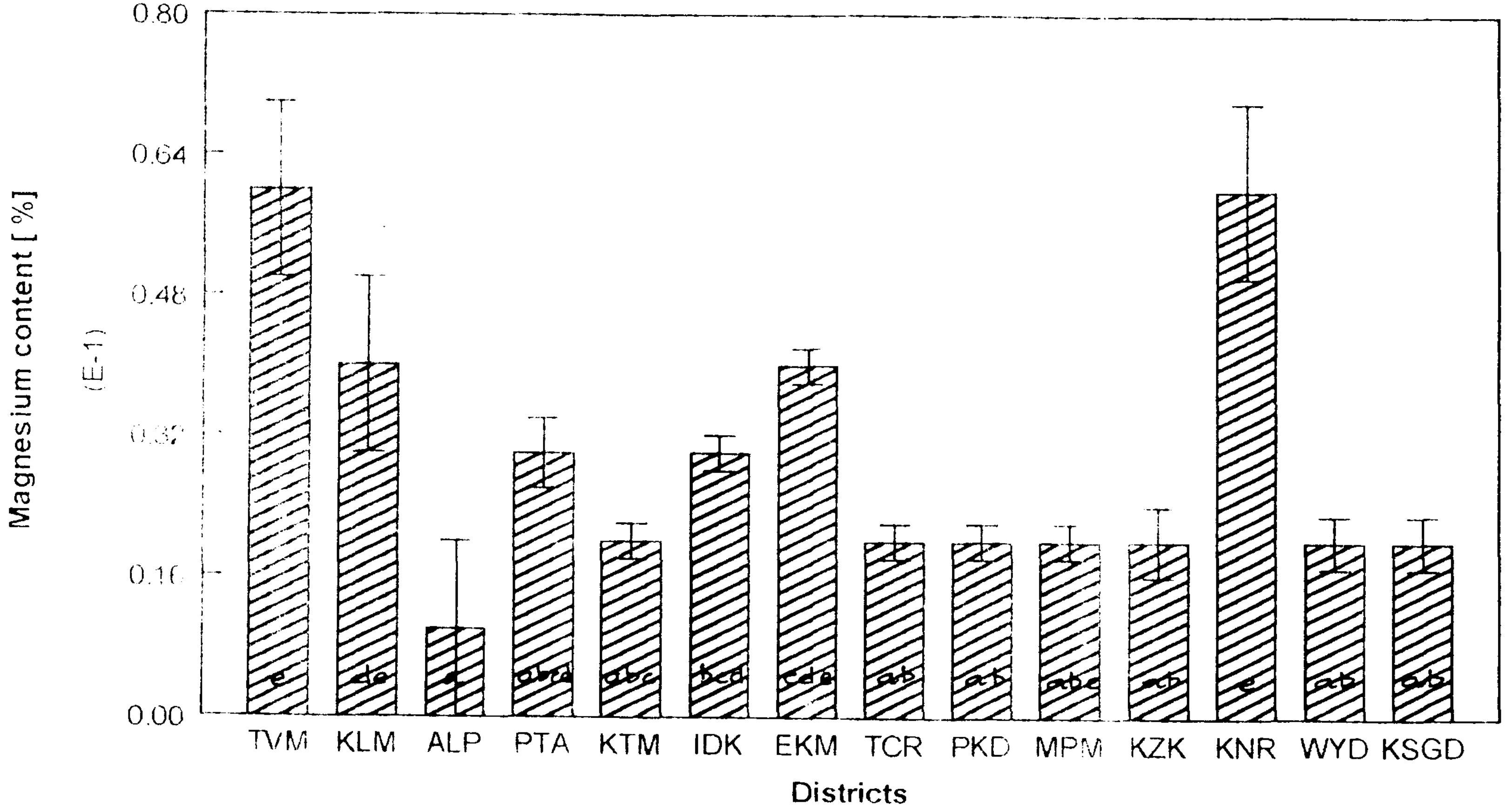
Bars with different letters differ (P< 0.01)

Fig. 2 Phosphorus content of soil collected from different districts



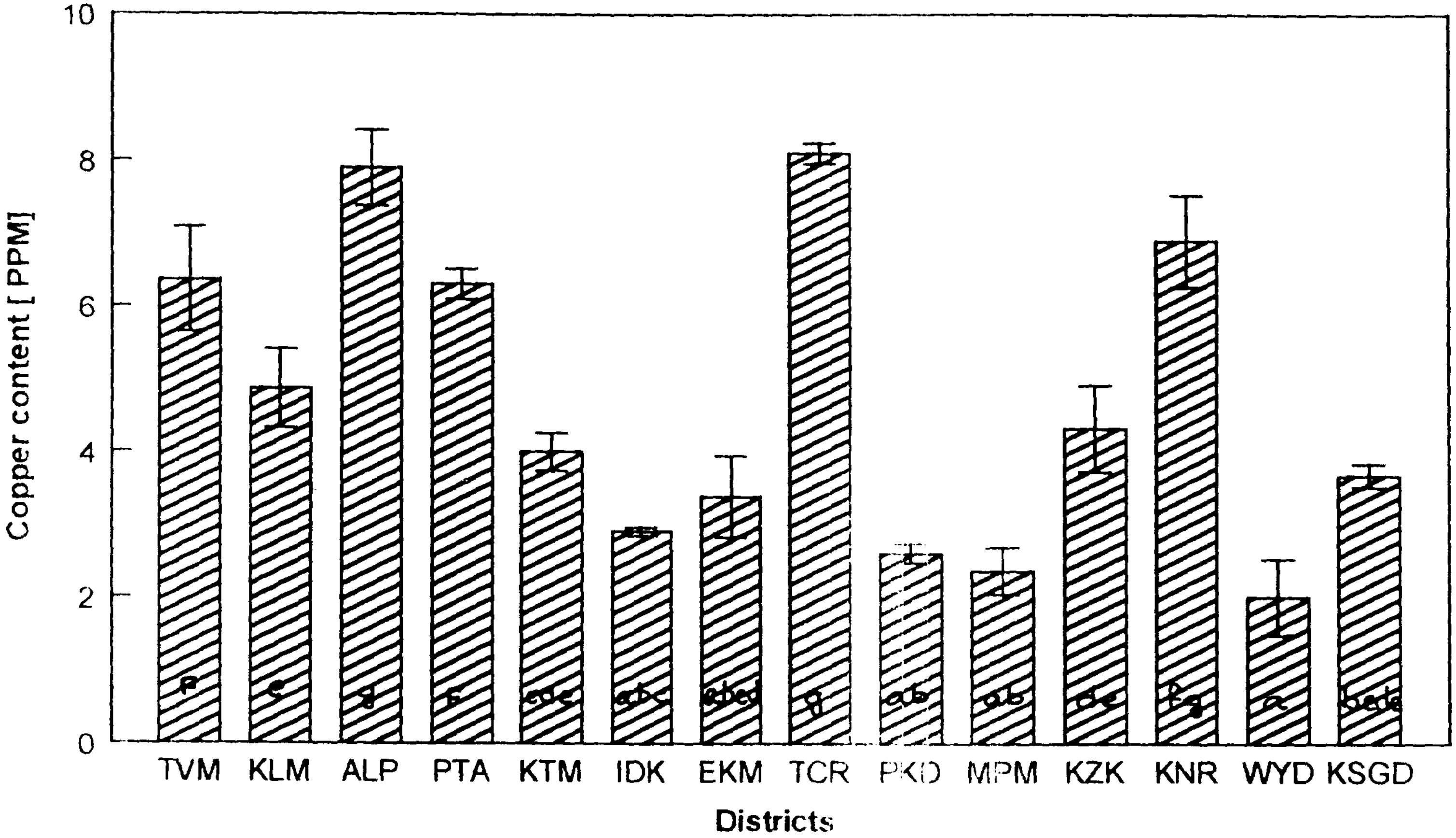
Bars with different letters differ (P<0.01)

Fig. 3 Magnesium content of soil collected from different districts



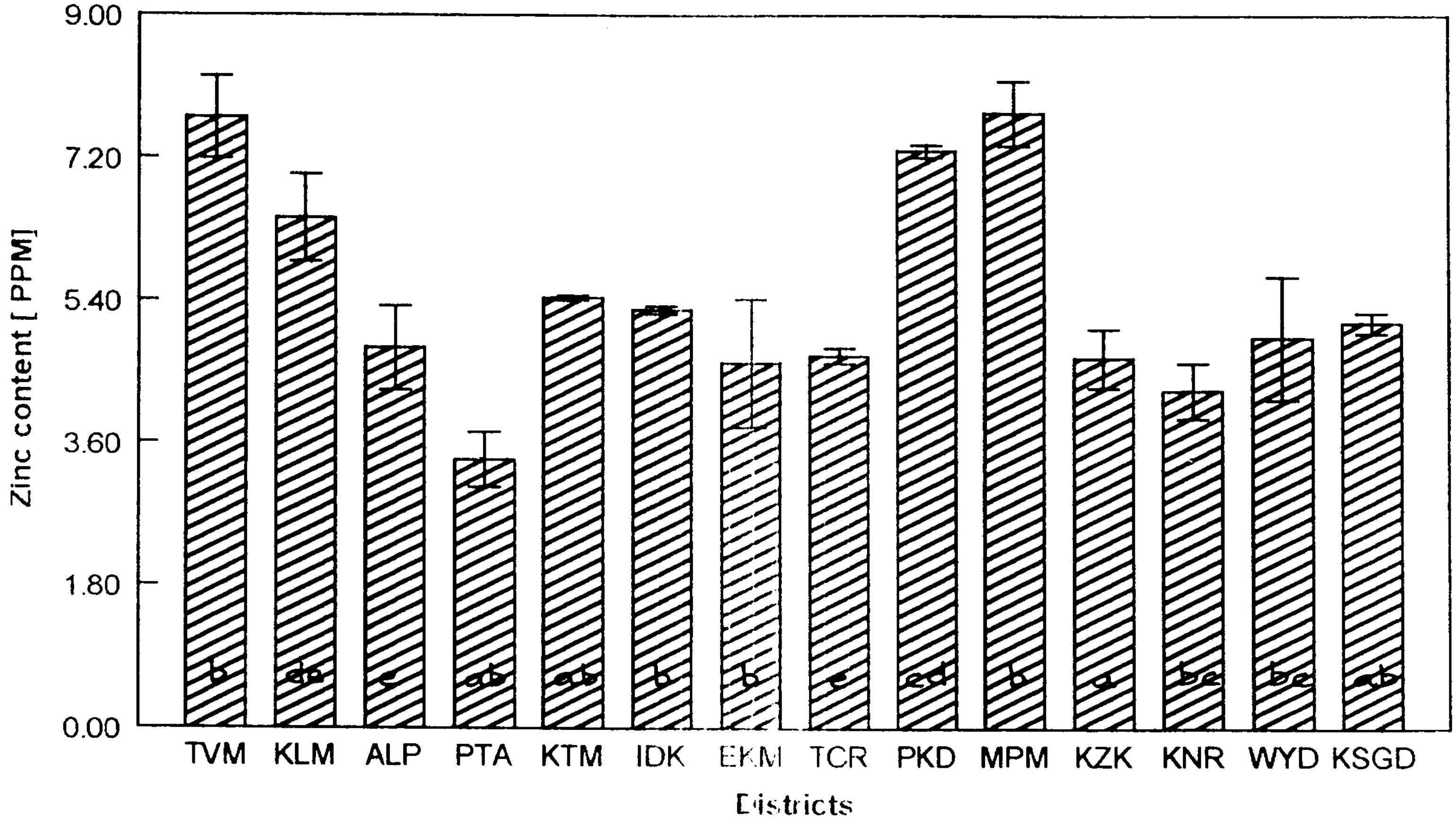
Bars with different letters differ (P<0.01)

Fig. 4 Copper content of soil collected from different districts



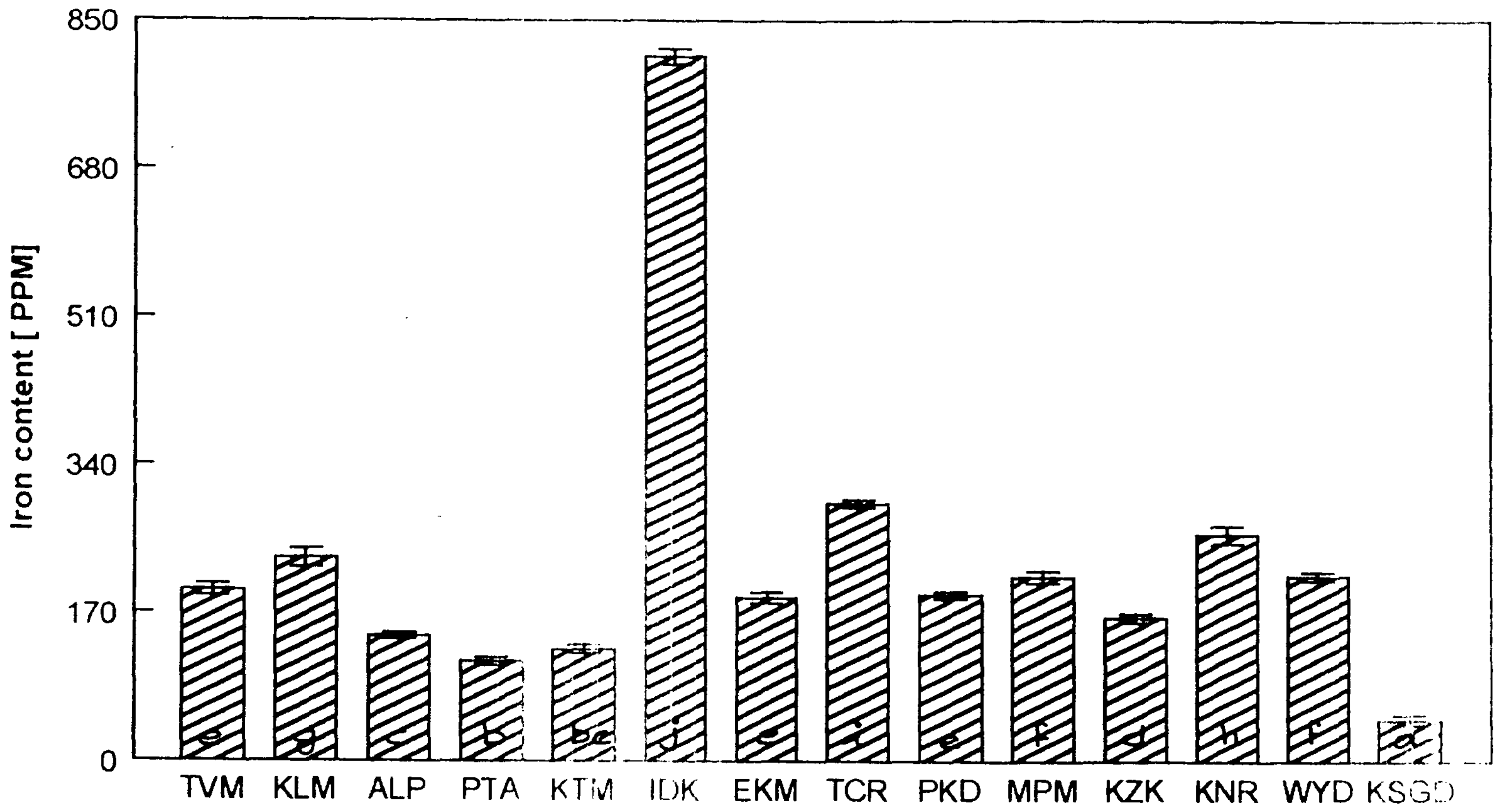
Bars with different letters differ (P<0.01)

Fig. 5 Zinc content of soil collected from different districts



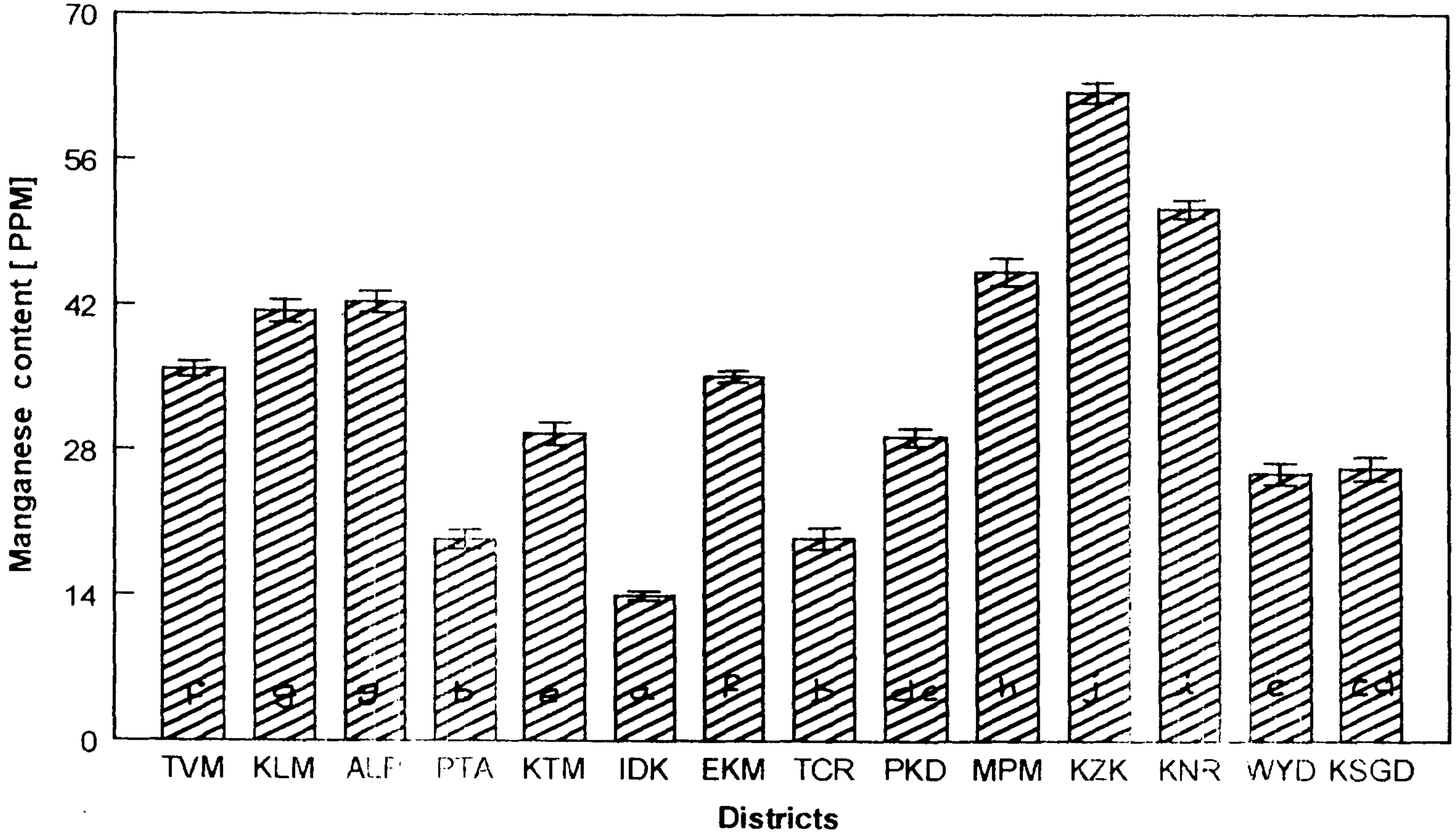
Bars with different letters differ (P< 0.01)

Fig. 6 Iron content of soil collected from different districts



Bars with different letters differ (P<0.01)

Fig. 7 Manganese content of soil collected from different districts



Bars with different letters differ (P<0.01)

Table 4. Average mineral concentration in the concentrate mixtures collected from different districts

District	Calcium (%)	Phosphorus (%)	Magnesium (%)	Sodium (%)	Potassium (%)	Copper (ppm)	Zinc (ppm)	Iron (ppm)	Manganese (ppm)
Thiruvananthapuram	0.82± 0.07	0.72± 0.04	0.51± 0.03	0.04± 0.004	0.41± 0.02	13.43± 0.98	52.61± 2.90	1015.85± 32.13	41.9± 2.30
Kollam	0.74± 0.04	0.66± 0.03	0.49± 0.03	0.08± 0.004	0.47± 0.03	17.62± 1.01	67.82± 3.05	1219.00± 33.9	70.05± 4.10
Alleppey	0.96± 0.03	0.74± 0.04	0.61± 0.03	0.07± 0.004	0.45± 0.02	21.92± 1.64	74.39± 2.02	939.00± 29.79	37.25± 1.95
Pathanamthitta	0.44± 0.01	0.64± 0.01	0.54± 0.01	0.06± 0.004	0.67± 0.01	13.72± 0.48	63.90± 1.56	2499.85± 499.76	63.30± 5.44
Kottayam	0.55± 0.01	0.67± 0.01	0.43± 0.01	0.08± 0.006	0.53± 0.01	17.82± 0.71	59.25± 1.62	1418.45± 66.87	70.10± 1.85
Idukki	0.34± 0.01	0.63± 0.01	0.40± 0.02	0.11± 0.006	0.76± 0.03	11.72± 0.42	53.85± 1.00	1246.55± 45.27	51.95± 3.11
Ernakulam	0.78± 0.03	0.61± 0.05	0.53± 0.04	0.11± 0.004	0.65± 0.02	18.46± 1.53	61.36± 3.39	1236.20± 40.21	44.25± 2.75
Thrissur	0.92± 0.02	0.92± 0.05	0.65± 0.04	0.08± 0.006	0.53± 0.01	17.11± 0.49	48.30± 1.30	1272.75± 407.12	46.95± 3.87
Palakkad	0.96± 0.02	0.86± 0.02	0.64± 0.01	0.06± 0.002	0.43± 0.02	19.43± 0.29	16.16± 2.22	1320.40± 411.44	46.70± 1.50
Malappuram	0.58± 0.03	0.82± 0.04	0.49± 0.04	0.08± 0.002	0.58± 0.01	17.93± 1.10	67.72± 4.20	837.00± 36.40	43.40± 3.07
Kozhikode	0.66± 0.04	0.64± 0.03	0.57± 0.03	0.04± 0.002	0.72± 0.01	14.76± 0.98	49.11± 2.01	948.65± 37.10	38.65± 1.10
Kannur	0.73± 0.02	0.79± 0.06	0.46± 0.03	0.08± 0.001	0.50± 0.06	18.10± 1.34	53.19± 4.16	1079.00± 52.47	46.60± 1.00
Wyanad	0.69± 0.04	0.59± 0.04	0.57± 0.04	0.08± 0.003	0.41± 0.02	17.43± 1.00	66.72± 5.86	1396.00± 57.49	47.30± 1.02
Kasargod	0.33± 0.01	0.68± 0.02	0.58± 0.01	0.05± 0.003	0.50± 0.02	20.53± 0.39	64.57± 1.55	1247.50± 39.13	30.30± 1.73

Table 4.1 Analysis of variance - Calcium content of concentrate mixtures

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	10.020	0.771	39.850**	0.0000
Within	236	4.565	0.019		
Total	249	14.585			

** P<0.01

Table 4.2 Analysis of variance - Phosphorus content of concentrate mixtures

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	2.408	0.185	8.735**	0.0000
Within	236	5.005	0.021		
Total	249	7.414			

** P<0.01

Table 4.3 Analysis of variance - Magnesium content of concentrate mixtures

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	1.352	0.104	6.904**	0.0000
Within	236	3.554	0.015		
Total	249	4.905			

** P<0.01

Table 4.4 Analysis of variance - Sodium content of concentrate mixtures

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	0.112	0.009	21.565**	0.0000
Within	236	0.094	0.000398		
Total	249	0.206			

** P<0.01

Table 4.5 Analysis of variance - Potassium content of concentrate mixtures

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	3.238	0.249	36.372**	0.0000
Within	236	1.616	0.007		
Total	249	4.854			

** P<0.01

Table 4.6 Analysis of variance - Copper content of concentrate mixtures

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	1949.603	149.969	8.366**	0.0000
Within	236	4230.347	17.925		
Total	249	6179.951			

** P<0.01

Table 4.7 Analysis of variance - Zinc content of concentrate mixtures

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	50426.471	3878.959	31.887**	0.0000
Within	236	28708.396	121.646		
Total	249	79134.868			

** P<0.01

Table 4.8 Analysis of variance - Iron content of concentrate mixtures

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	40649213.596	3126862.584	2.314**	0.0066
Within	236	318949859.800	1351482.457		
Total	249	359599073.396			

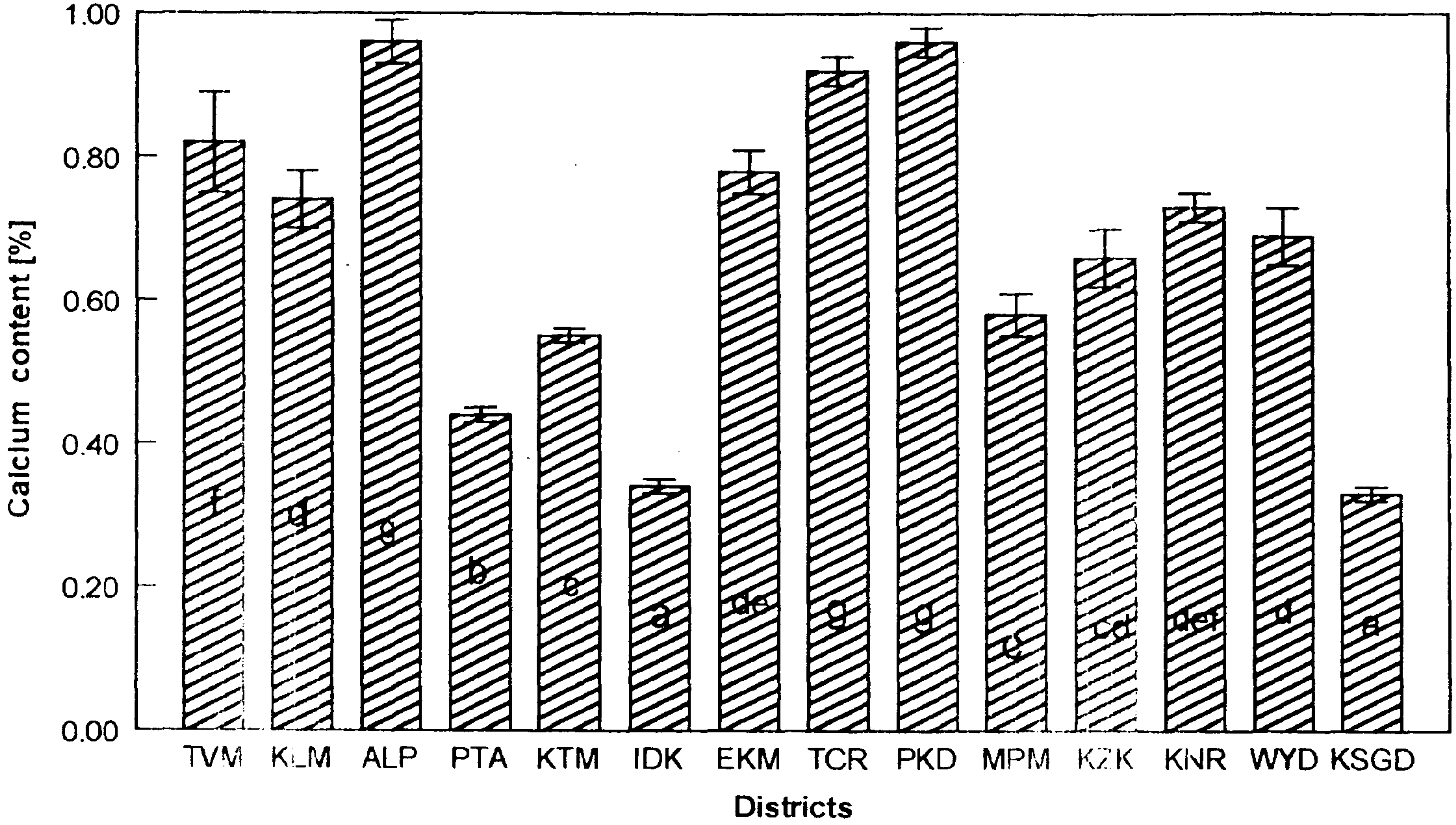
** P<0.01

Table 4.9 Analysis of variance - Manganese content of concentrate mixtures

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	32766.804	2520.523	14.879**	0.0000
Within	236	39978.300	169.400		
Total	249	72745.104			

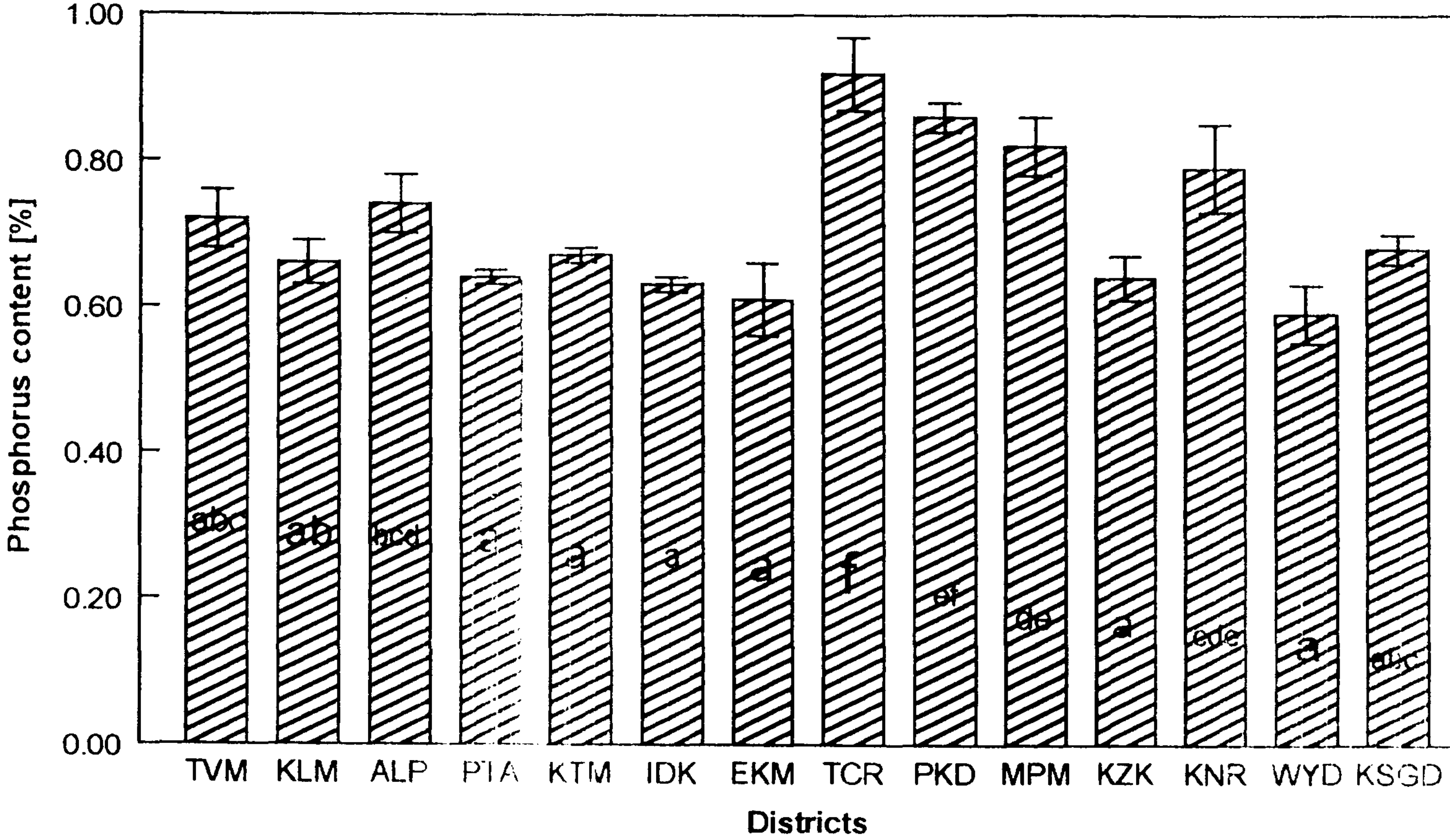
** P<0.01

Fig.8. Calcium content of concentrate
mixtures from different districts



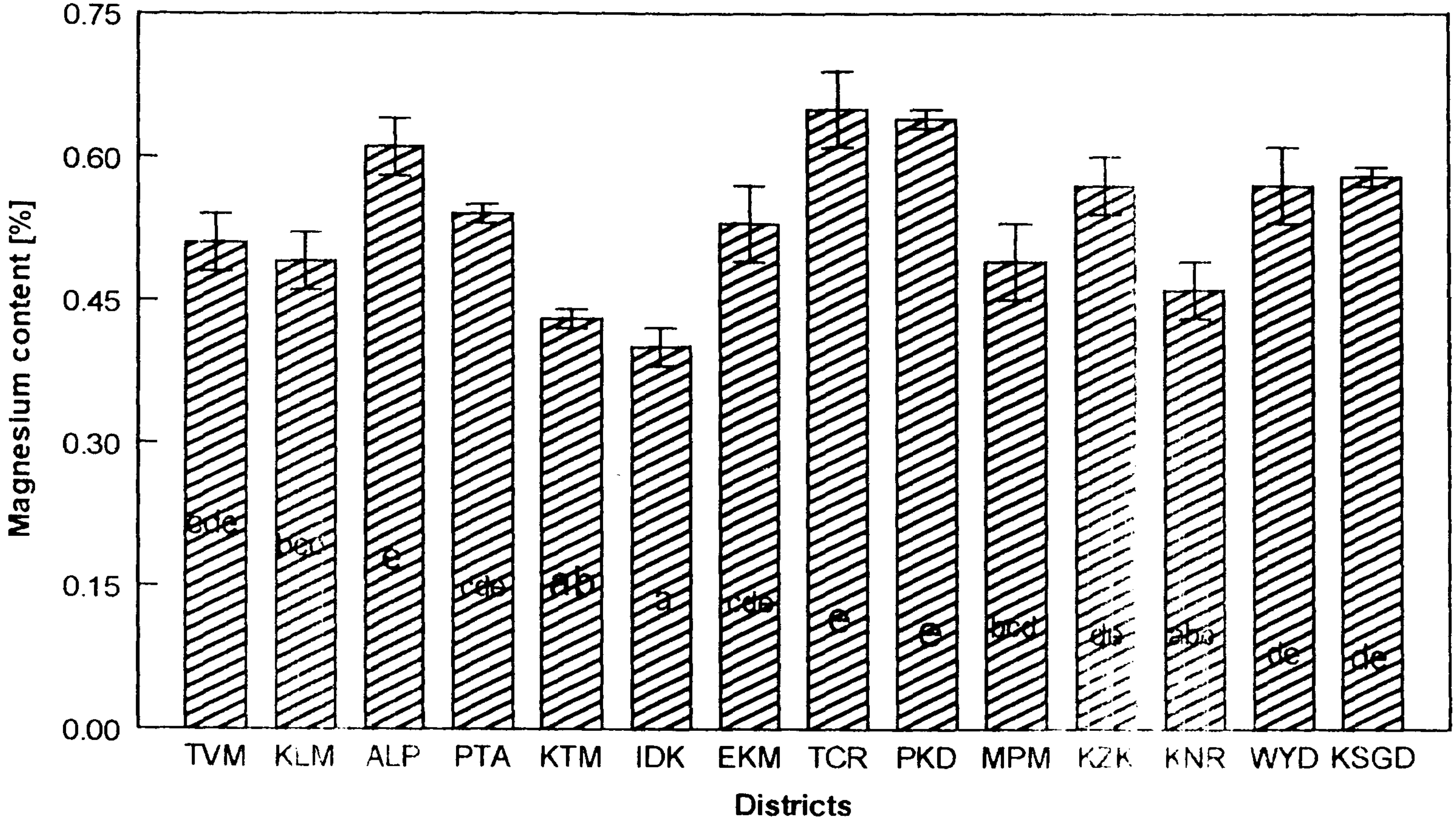
Bars with different letters differ (P< 0.01)

Fig. 9. Phosphorus content of concentrate mixtures from different districts



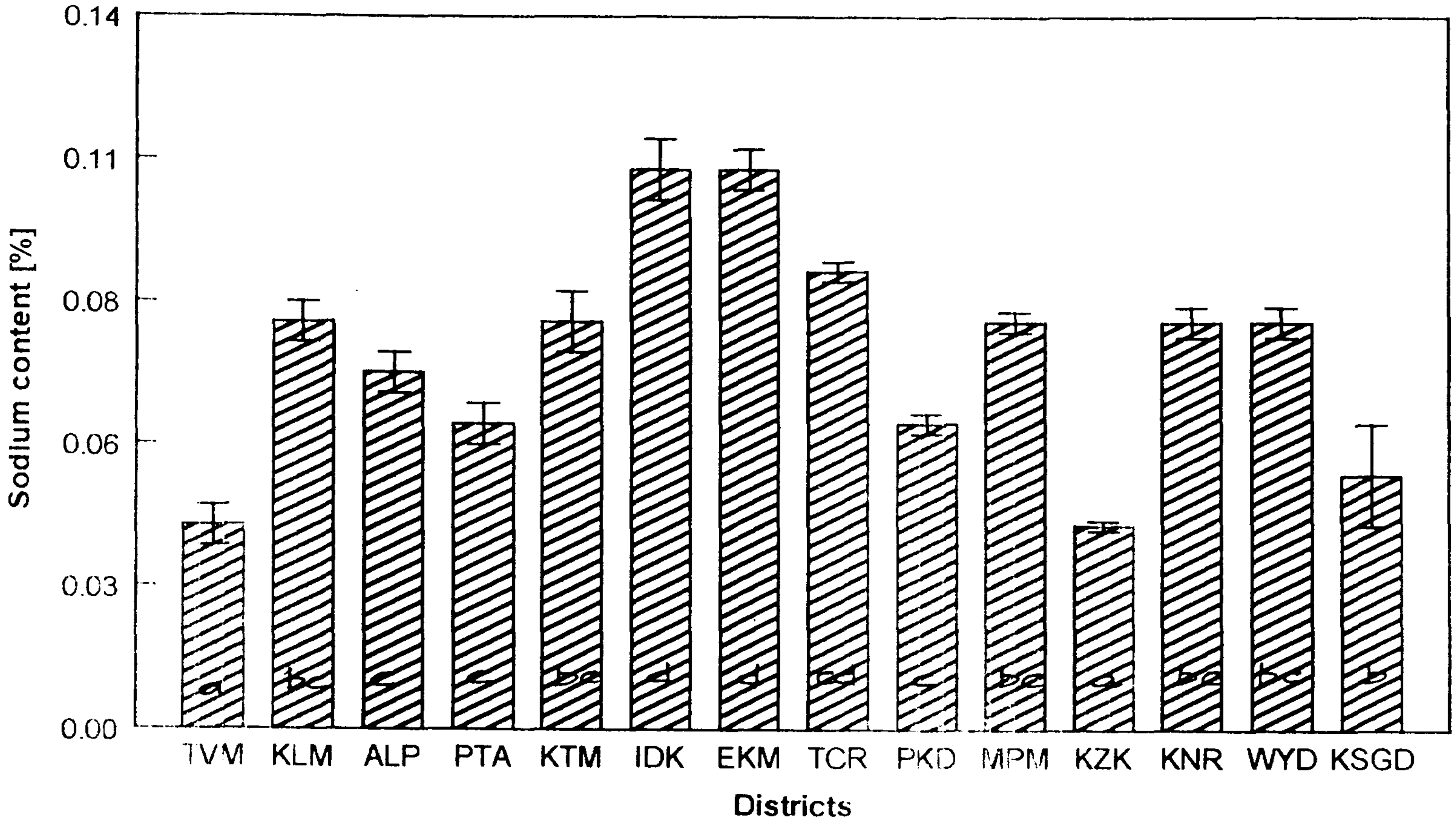
Bars with different letters differ (P< 0.01)

Fig. 10. Magnesium content of concentrate mixtures from different districts



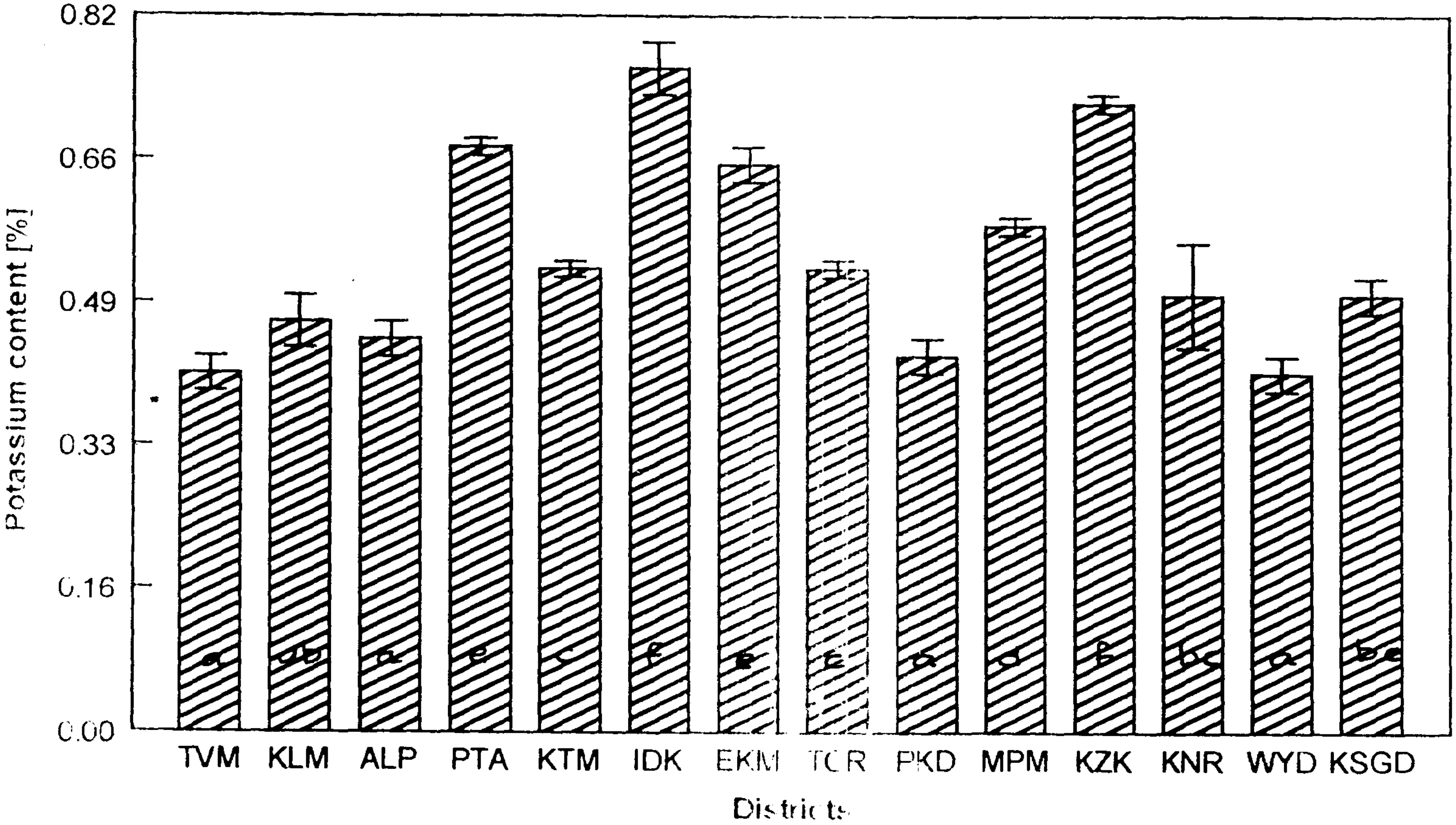
Bars with different letters differ (P< 0.01)

Fig.11. Sodium content of concentrate mixtures from different districts



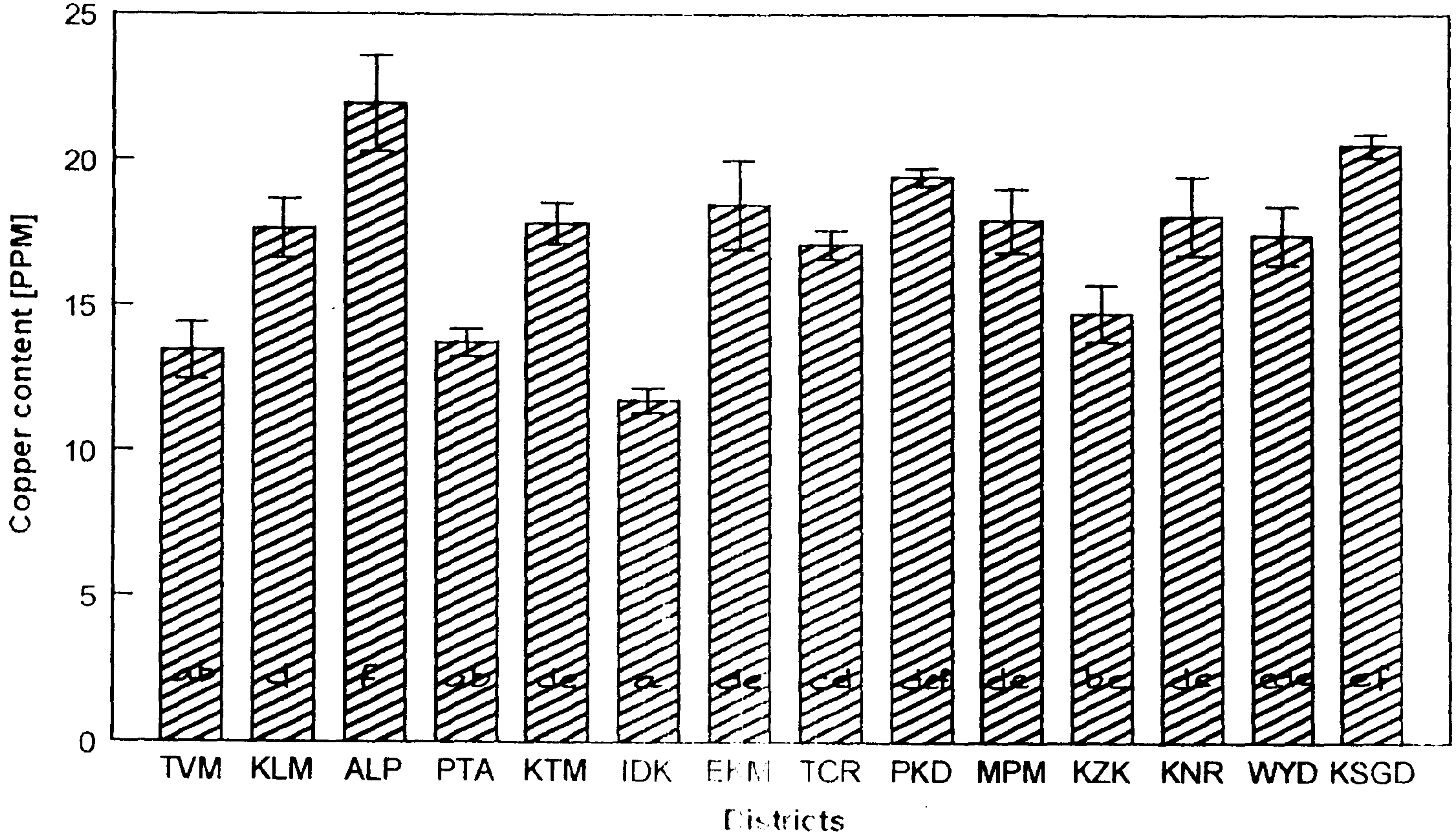
Bars with different letters differ (P<0.01)

Fig.12. Potassium content of concentrate mixtures from different districts



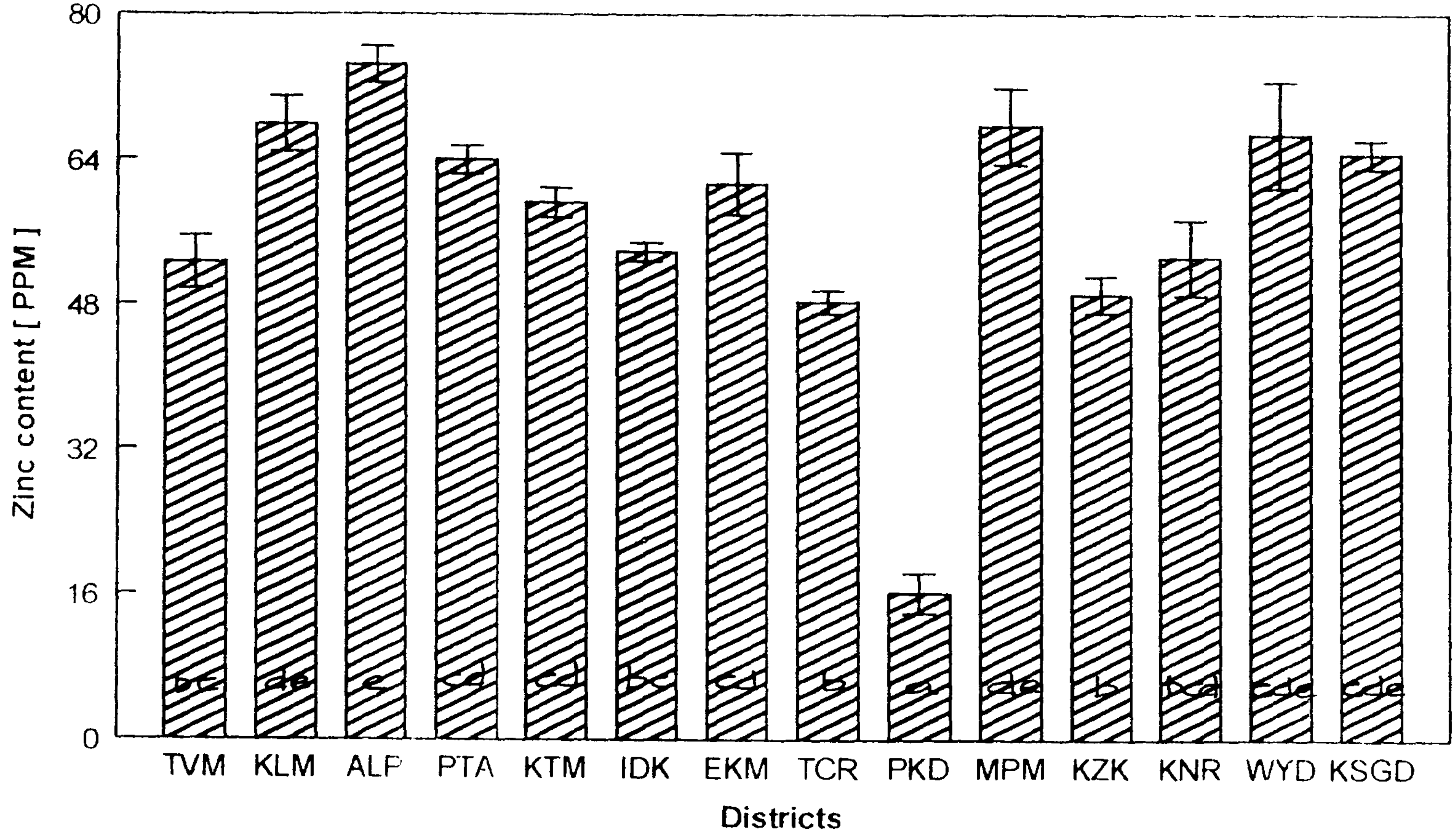
Bars with different letters differ (P< 0.01)

Fig.13. Copper content of concentrate mixtures from different districts



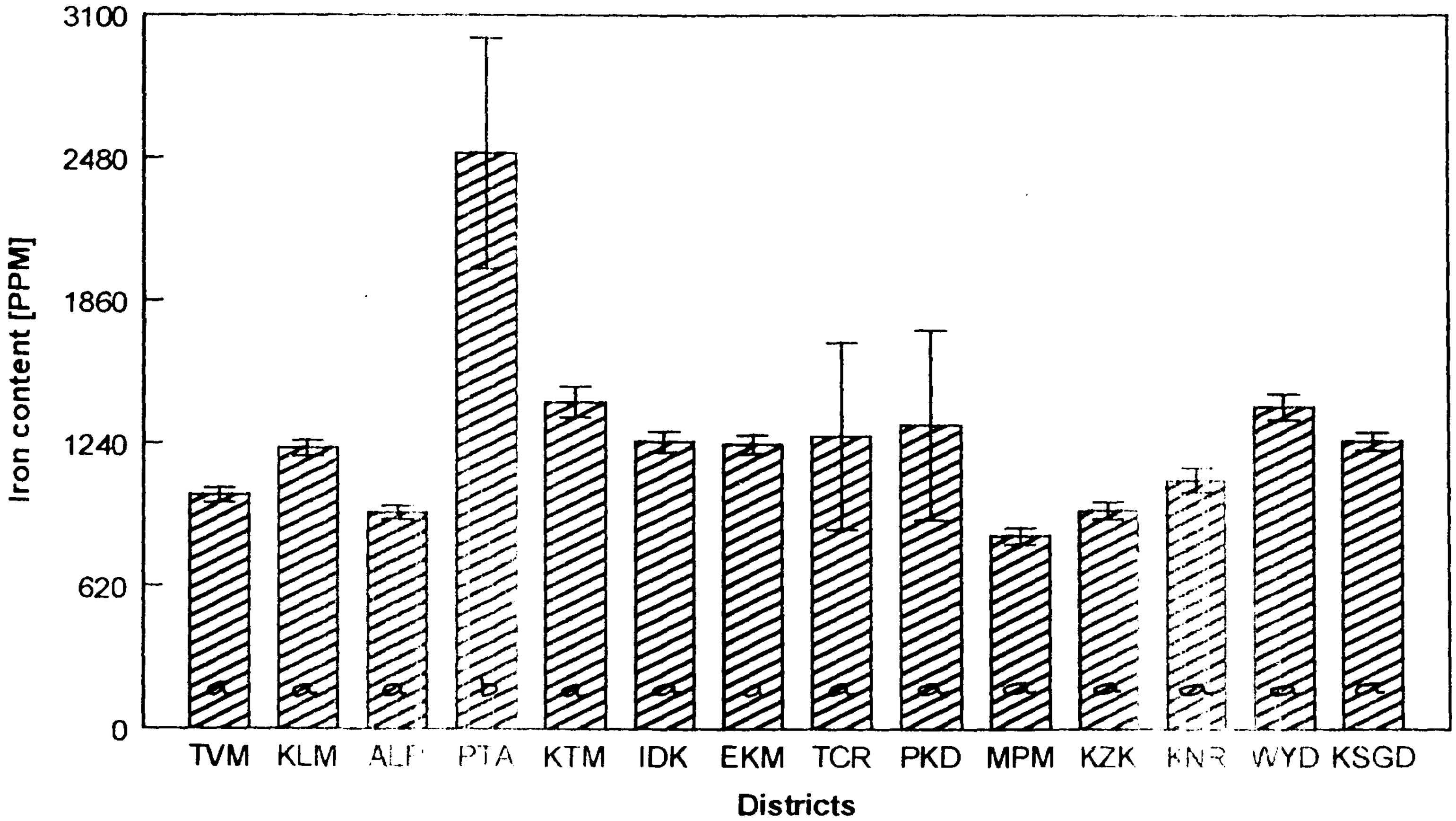
Bars with different letters differ (P <0.01)

Fig.14.Zinc content of concentrate mixtures from different districts



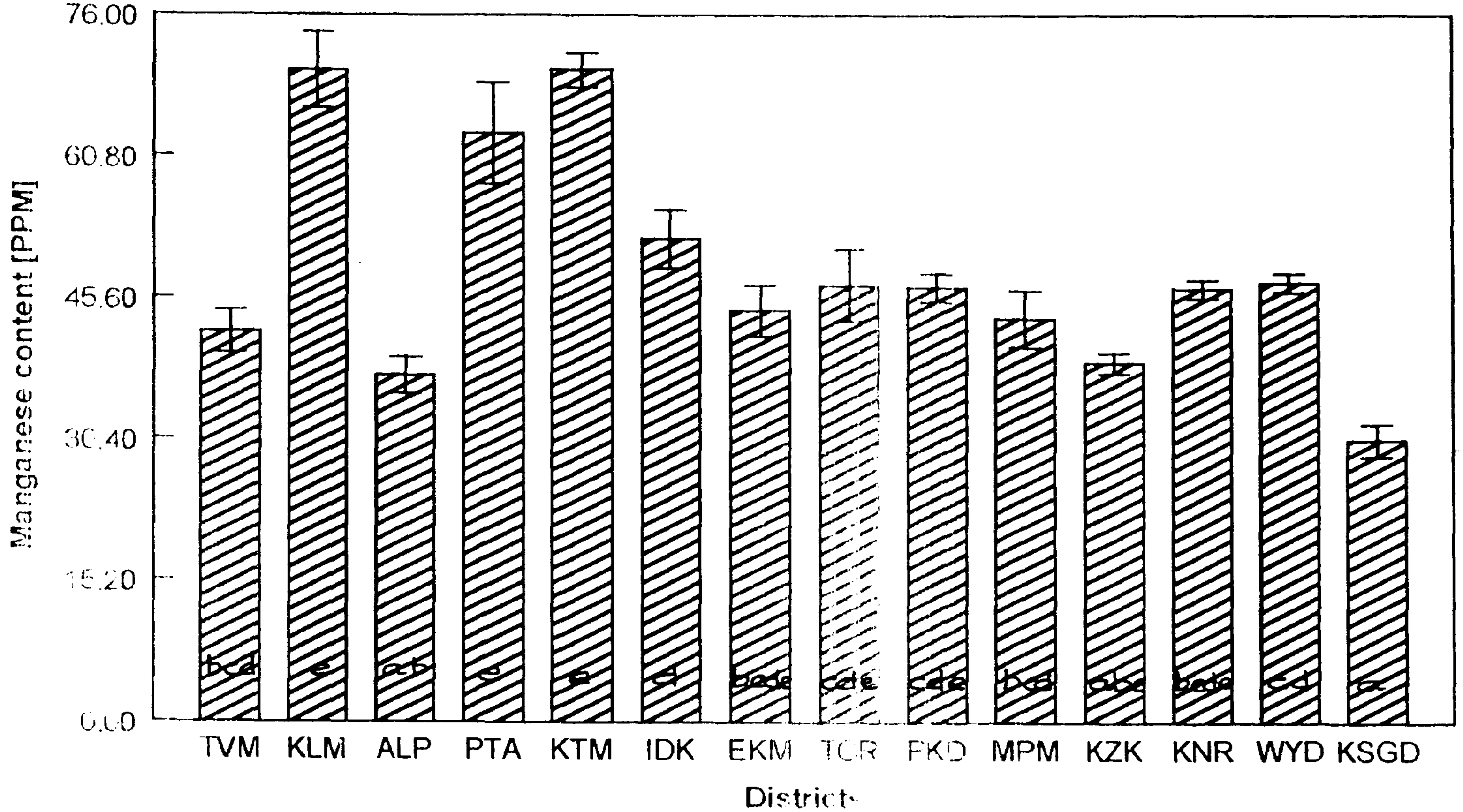
Bars with different letters differ (P< 0.01)

Fig. 15. Iron content of concentrate mixtures from different districts



Bars with different letters differ (P< 0.01)

Fig.16 Manganese content of concentrate mixtures from different districts



Bars with different letters differ (P< 0.01)

Table 5. Average mineral concentration in commonly used feed ingredients collected from different districts

District	Calcium (%)	Phosphorus (%)	Magnesium (%)	Sodium (%)	Potassium (%)	Copper (ppm)	Zinc (ppm)	Iron (ppm)	Manganese (ppm)
Groundnut cake	0.19± 0.02	0.54± 0.05	0.33± 0.03	0.09± 0.03	0.83± 0.05	19.88± 3.48	57.64± 5.87	863.56± 125.00	26.77± 4.73
Coconut cake	0.31± 0.04	0.66± 0.02	0.52± 0.04	0.04± 0.02	0.74± 0.04	31.80± 1.41	56.22± 0.08	560.00± 61.00	53.66± 6.19
Gingelly cake (Sesame cake)	2.10± 0.03	1.06± 0.29	0.40± 0.08	0.07± 0.006	0.92± 0.03	38.94± 8.92	73.07± 14.13	468.00± 112.00	28.43± 3.97
Rice bran	0.14± 0.01	0.72± 0.04	0.43± 0.06	0.05± 0.003	1.22± 0.08	10.06± 1.80	78.32± 11.81	1105.00± 120.00	86.18± 6.48
Wheat bran	0.16± 0.01	1.30± 0.04	0.54± 0.10	0.04± 0.002	1.32± 0.20	15.07± 0.65	82.28± 9.38	333.00± 45.00	132.12± 11.35
Rice grain	0.13± 0.01	0.42± 0.06	0.07± 0.01	0.05± 0.02	0.53± 0.04	3.30± 0.62	20.00± 1.05	285.00± 32.60	18.42± 3.24
Tamarind seed	0.07± 0.03	0.58± 0.02	0.01± 0.04	0.02± 0.003	0.70± 0.03	7.28± 1.90	8.30± 4.48	248.00± 42.00	13.38± 2.64

Table 6. Percentage mineral composition of various mineral mixtures collected from different districts

	With salt (DM basis)				Without salt (DM basis)				BIS standard	
	A	B	C	D	E	F	G	H	With salt	Without salt
Dry matter	93.3	95.7	96.2	92.4	96.3	95.2	93.3	92.8	95.00	95.10
Acid linsoluble ash (%)	3.50	2.90	2.70	4.80	5.35	0.57	2.75	3.70	3.00	2.50
Calcium	26.73	25.28	26.73	26.79	32.34	27.36	32.11	31.27	22.00	28.00
Phosphorus	9.63	7.37	10.36	7.44	12.68	6.14	8.55	8.16	9.00	12.00
Magnesium	5.89	4.18	3.49	5.23	1.12	0.98	2.61	1.47	-	-
Copper	0.07	0.43	0.11	0.20	0.05	0.11	0.26	0.09	0.06	0.08
Zinc	0.06	0.03	0.04	0.07	0.17	0.05	0.09	0.19	0.15	0.18
Iron	0.93	0.65	0.24	0.83	0.82	0.72	0.43	1.23	0.40	0.50
Manganese	0.10	0.39	0.56	0.07	0.07	0.11	0.02	0.41	0.09	0.12

Table 7. Average mineral concentration in the natural (local) grass collected from different districts

District	Calcium (%)	Phosphorus (%)	Magnesium (%)	Sodium (%)	Potassium (%)	Copper (ppm)	Zinc (ppm)	Iron (ppm)	Manganese (ppm)
Thiruvananthapuram	0.36± 0.02	0.19± 0.02	0.18± 0.01	0.09± 0.10	0.53± 0.03	7.26± 0.40	42.18± 1.34	336.09± 6.83	14.59± 0.78
Kollam	0.42± 0.02	0.26± 0.02	0.18± 0.01	0.06± 0.01	0.76± 0.07	7.32± 1.02	49.26± 1.02	436.49± 9.41	16.04± 0.93
Alleppey	0.39± 0.013	0.31± 0.011	0.22± 0.02	0.07± 0.01	0.94± 0.09	10.17± 1.14	51.74± 2.66	812.36± 14.61	20.62± 0.49
Pathanamthitta	0.33± 0.02	0.24± 0.01	0.22± 0.01	0.11± 0.04	0.75± 0.04	18.19± 0.89	81.70± 4.57	396.87± 16.79	18.86± 1.41
Kottayam	0.26± 0.013	0.23± 0.013	0.22± 0.01	0.05± 0.01	0.74± 0.04	9.27± 0.40	34.03± 1.74	895.99± 41.05	56.10± 0.59
Idukki	0.23± 0.013	0.25± 0.013	0.22± 0.01	0.08± 0.02	0.76± 0.03	23.95± 4.75	80.48± 1.13	765.04± 31.78	14.02± 0.59
Ernakulam	0.32± 0.02	0.21± 0.01	0.26± 0.03	0.07± 0.01	0.66± 0.04	5.21± 0.49	39.24± 1.52	430.77± 13.3	15.34± 0.96
Thrissur	0.33± 0.03	0.24± 0.013	0.23± 0.01	0.10± 0.01	0.64± 0.05	16.13± 1.59	52.08± 1.96	516.81± 17.73	14.98± 0.45
Palakkad	0.58± 0.10	0.24± 0.01	0.26± 0.01	0.06± 0.004	0.56± 0.05	15.54± 0.44	38.85± 1.51	515.02± 33.44	25.00± 0.48
Malappuram	0.28± 0.03	0.2 ± 0.02	0.27± 0.02	0.07± 0.01	0.53± 0.02	11.21± 1.02	71.41± 2.66	852.43± 19.69	22.71± 0.78
Kozhikode	0.36± 0.02	0.24± 0.02	0.17± 0.01	0.06± 0.004	1.26± 0.07	4.19± 0.33	11.01± 3.01	917.94± 10.52	19.93± 0.61
Kannur	0.24± 0.013	0.26± 0.02	0.18± 0.013	0.06± 0.01	0.98± 0.11	5.42± 0.38	71.89± 1.57	844.76± 20.06	21.70± 0.87
Wyanad	0.31± 0.04	0.32± 0.02	0.24± 0.02	0.07± 0.01	0.79± 0.05	9.00± 1.41	57.43± 2.53	599.49± 41.69	9.71± 0.62
Kasargod	0.22± 0.04	0.23± 0.01	0.24± 0.01	0.06± 0.01	0.99± 0.05	4.38± 0.16	30.31± 1.02	670.23± 23.97	14.45± 0.35

Table 7.1 Analysis of variance - Calcium content of natural grass

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	1.979	0.152	6.592**	0.0000
Within	236	5.450	0.023		
Total	249	7.429			

** $P<0.01$

Table 7.2 Analysis of variance - Phosphorus content of natural grass

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	0.288	0.022	6.807**	0.0000
Within	236	0.767	0.003		
Total	249	1.054			

** $P<0.01$

Table 7.3 Analysis of variance - Magnesium content of natural grass

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	0.256	0.020	6.023**	0.0000
Within	236	0.773	0.003		
Total	249	1.029			

** $P<0.01$

Table 7.4 Analysis of variance - Sodium content of natural grass

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	0.077	0.006	0.644NS	
Within	236	2.160	0.009		
Total	249	2.237			

NS - Non-significant

Table 7.5 Analysis of variance - Potassium content of natural grass

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	10.241	0.788	14.252**	0.0000
Within	236	13.046	0.055		
Total	249	23.287			

** P<0.01

Table 7.6 Analysis of variance - Copper content of natural grass

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	8340.321	641.563	12.977**	0.0000
Within	236	11667.714	49.439		
Total	249	20008.036			

** P<0.01

Table 7.7 Analysis of variance - Zinc content of natural grass

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	98674.085	7590.314	76.000**	0.0000
Within	236	23570.059	99.873		
Total	249	122244.143			

** P<0.01

Table 7.8 Analysis of variance - Iron content of natural grass

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	10451899.922	803992.302	82.172*	0.0000
Within	236	2309082.190	9784.247		
Total	249	12760982.112			

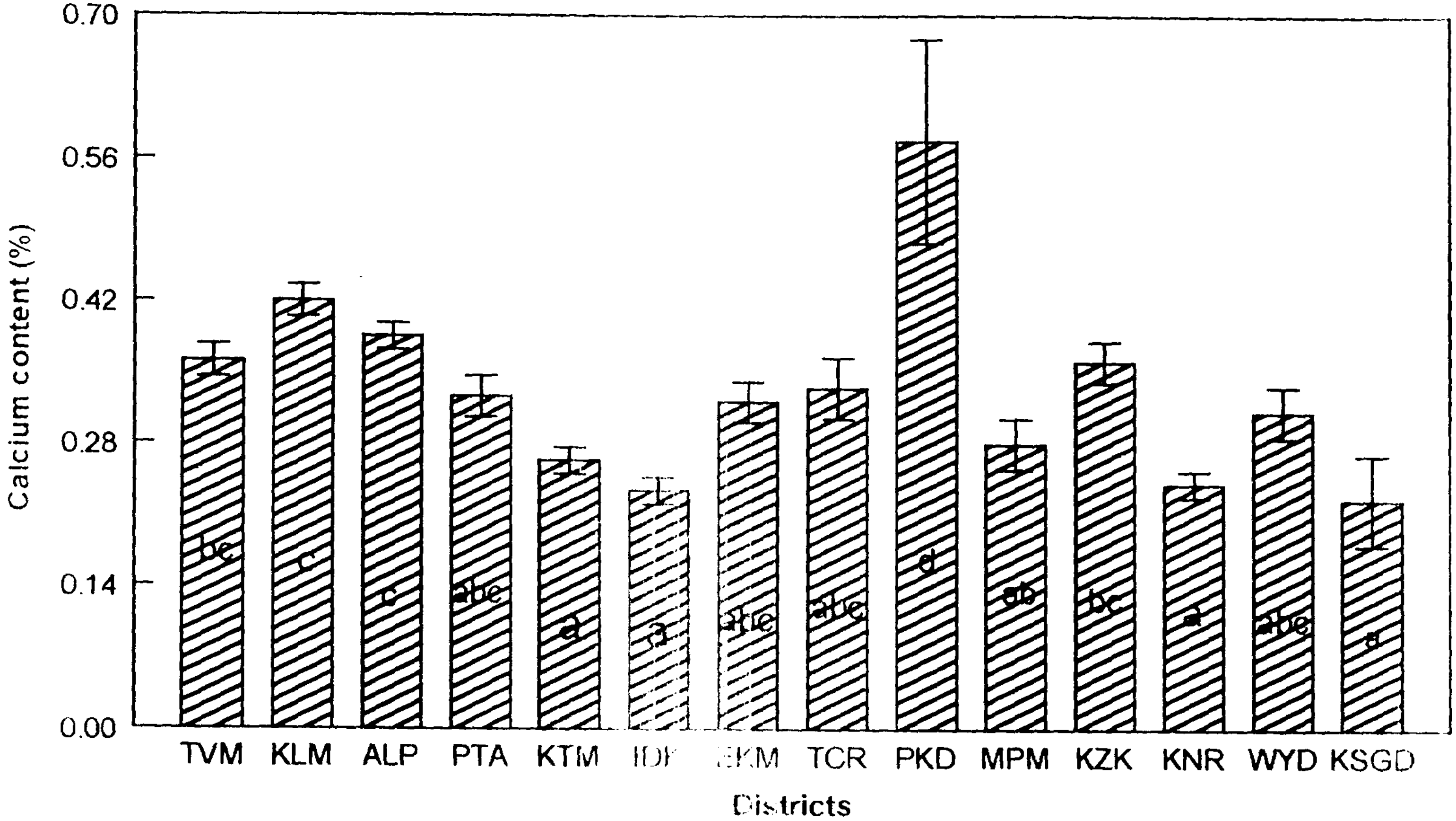
** P<0.01

Table 7.9 Analysis of variance - Manganese content of natural grass

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	30487.939	2345.226	0.800NS	
Within	236	691706.405	2930.959		
Total	249	722194.344			

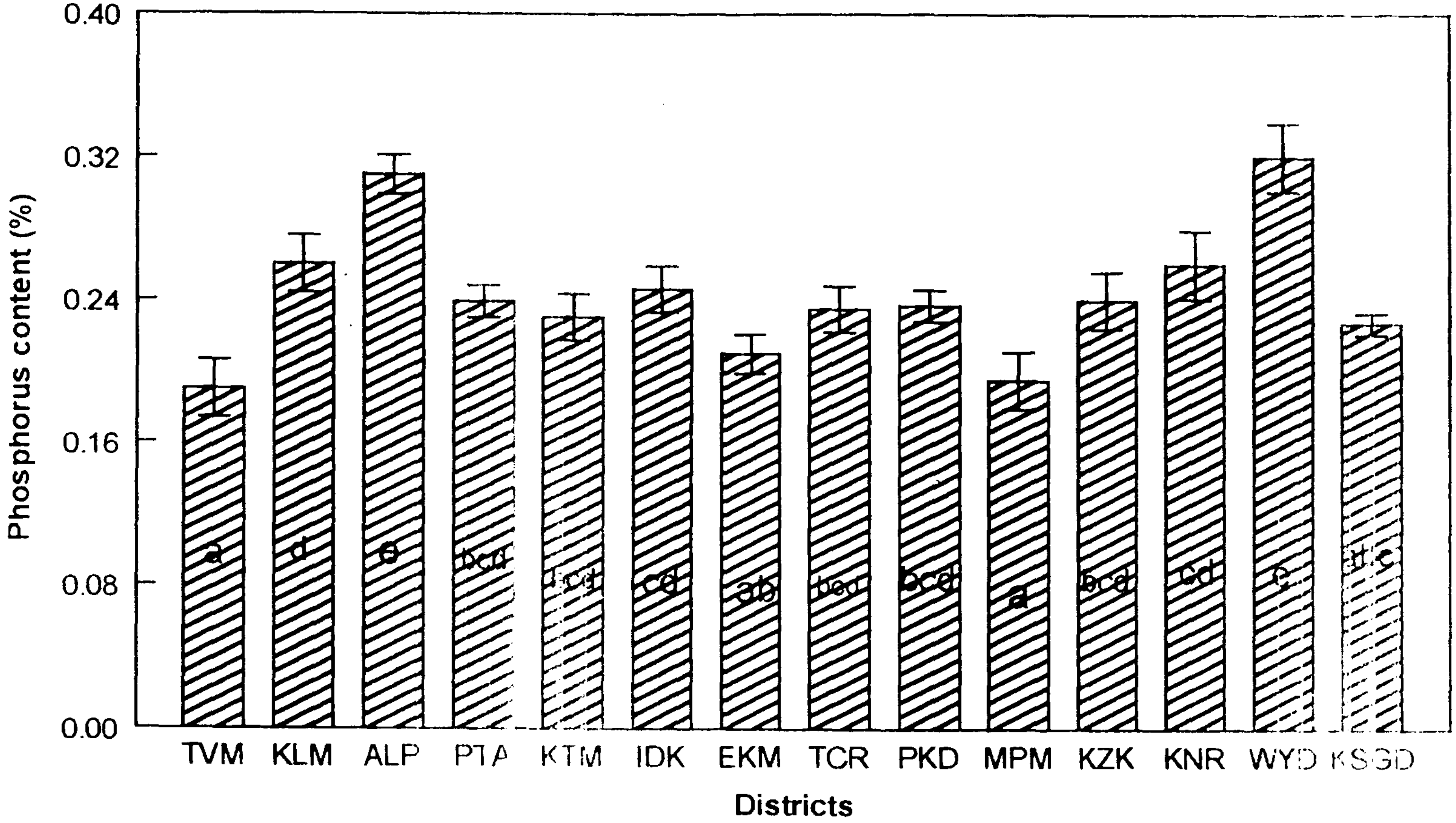
NS - Non-significant

Fig.17 Calcium content of natural grass collected from different districts



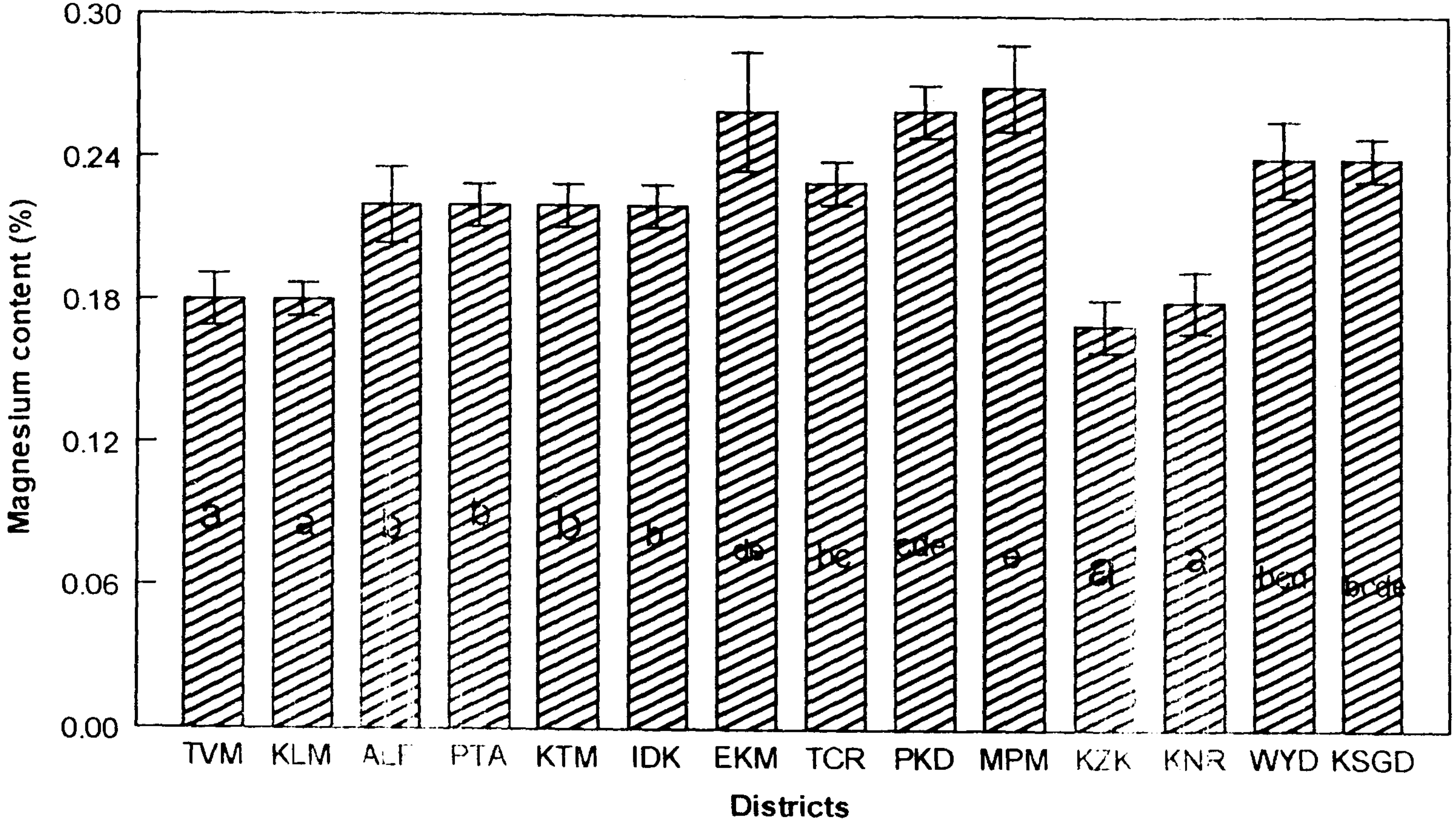
Bars with different letters differ (P< 0.01)

Fig. 18 Phosphorus content of natural grass collected from different districts



Bars with different letters differ (P < 0.01)

Fig.19 Magnesium content of natural grass collected from different districts



Bars with different letters differ (P< 0.01)

Fig.20 Sodium content of natural grass collected from different districts

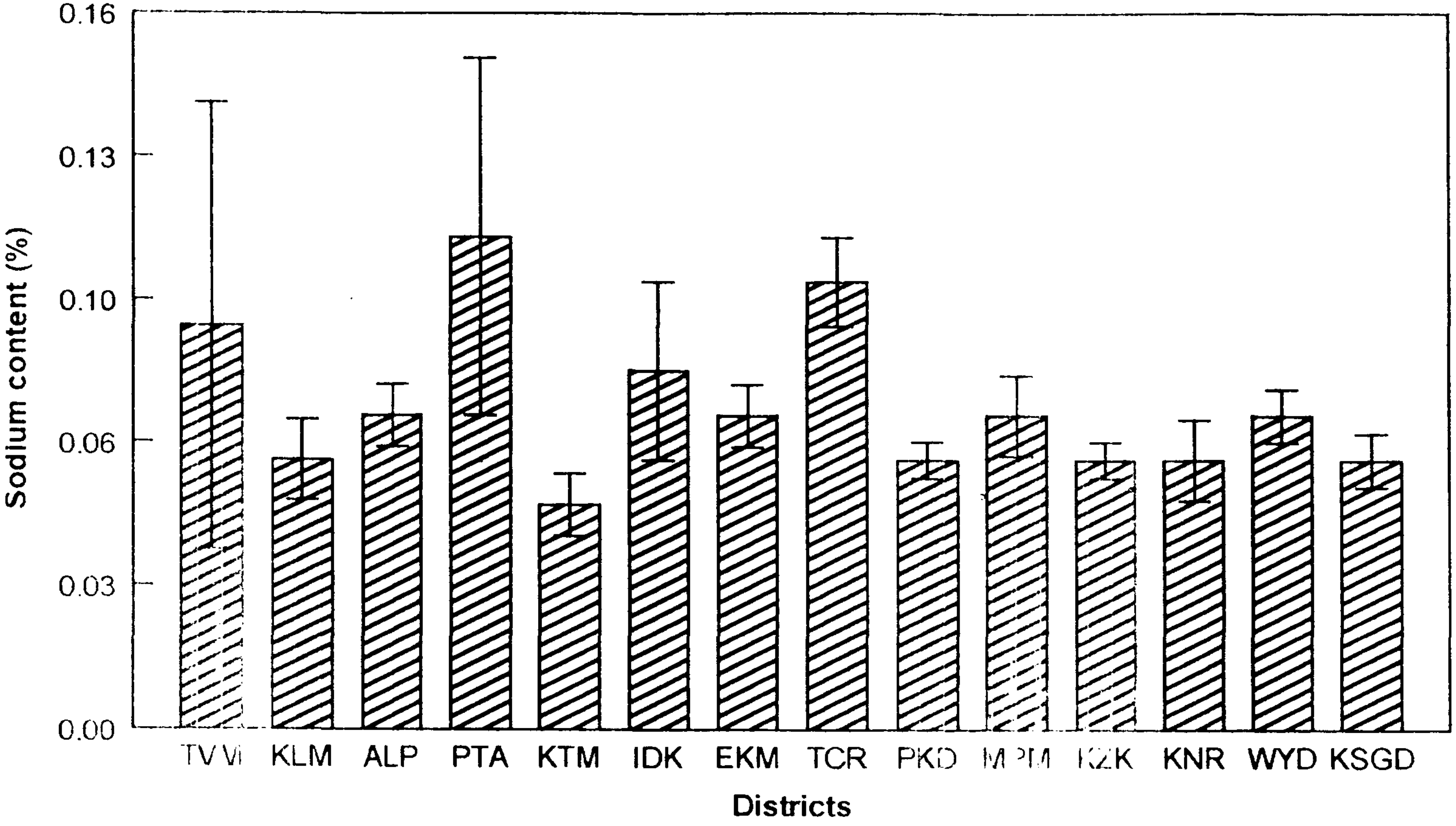
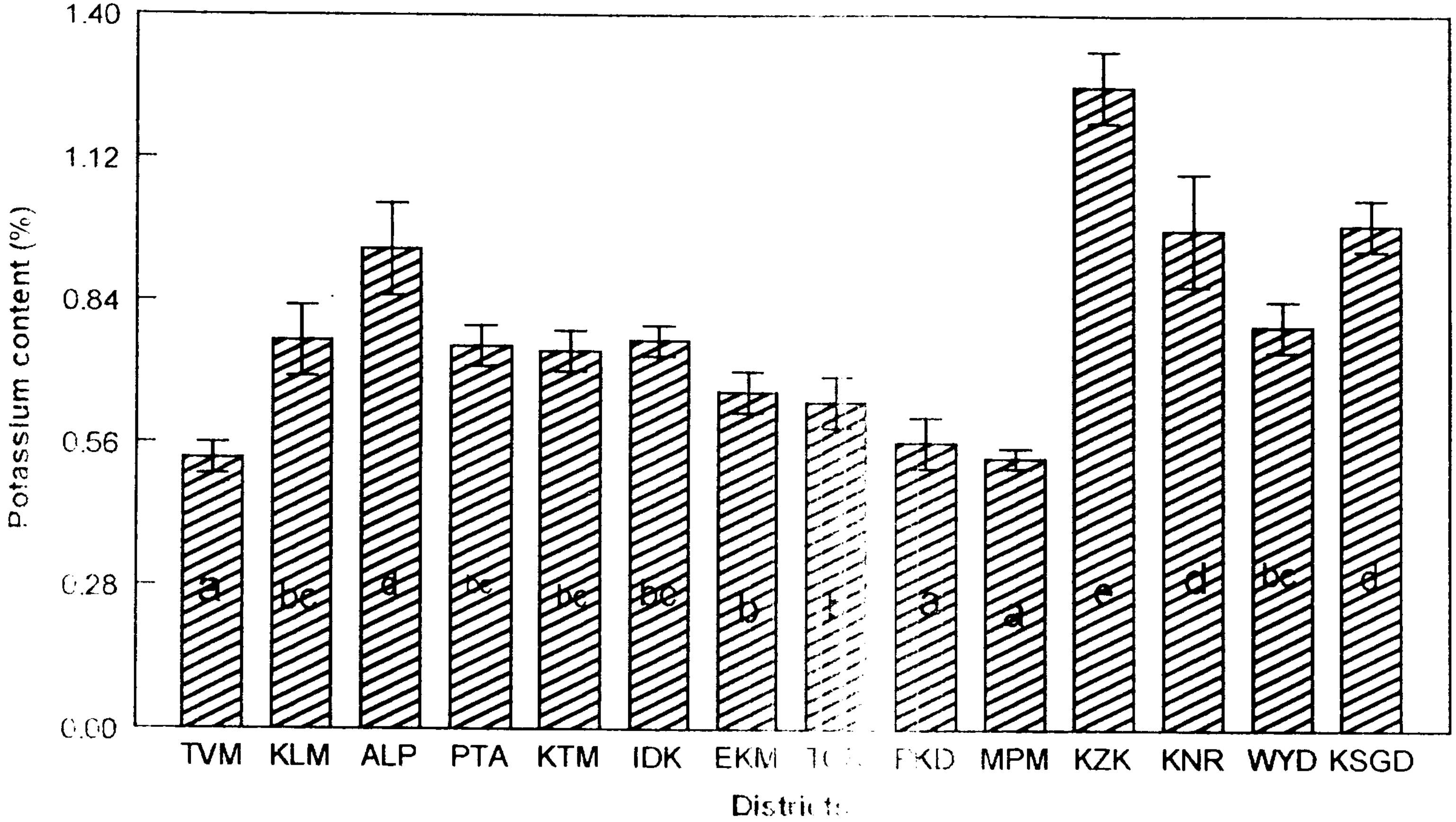
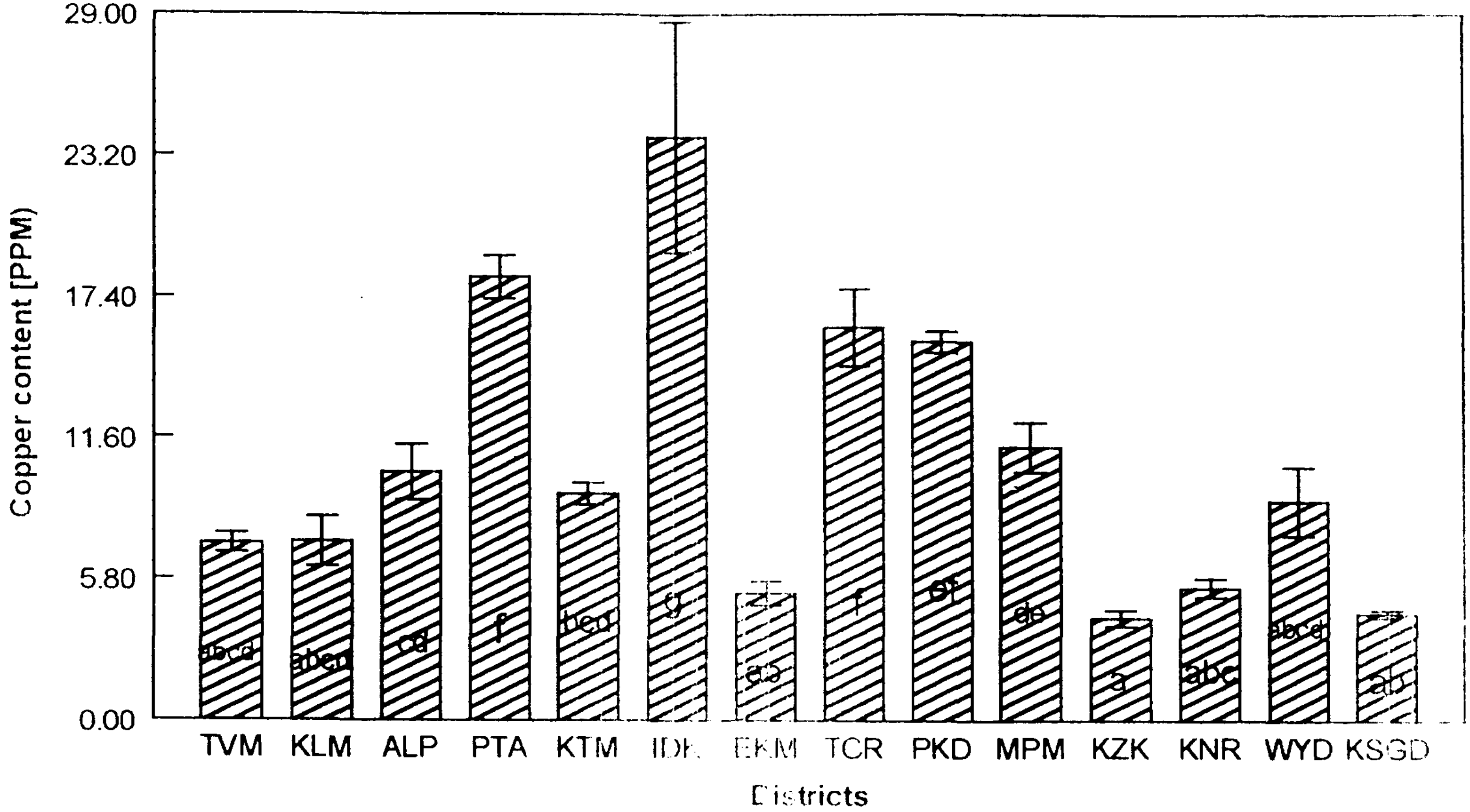


Fig.21 Potassium content of natural grass collected from different districts



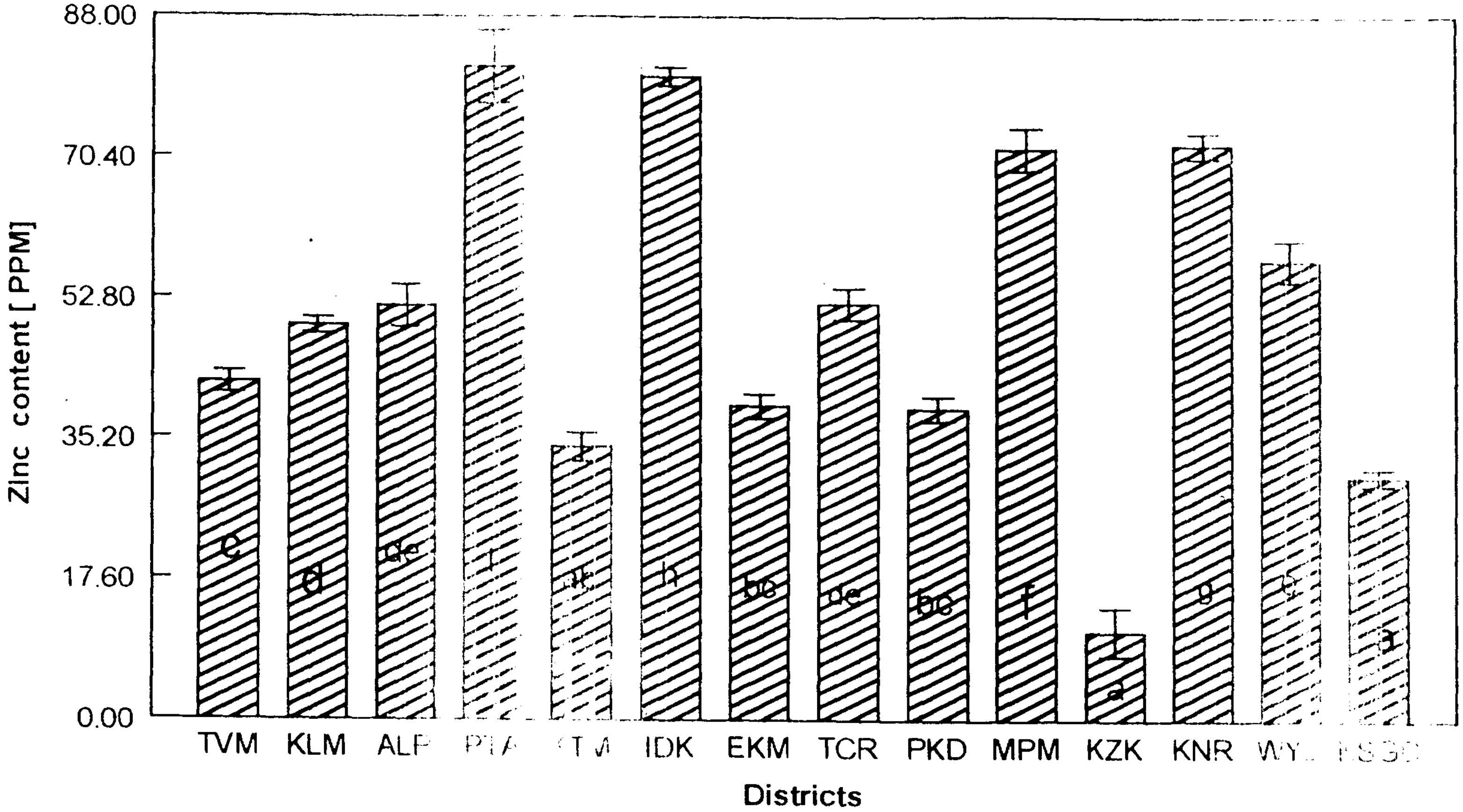
Bars with different letters differ (P<0.01)

Fig.22 Copper content of natural grass collected from different districts



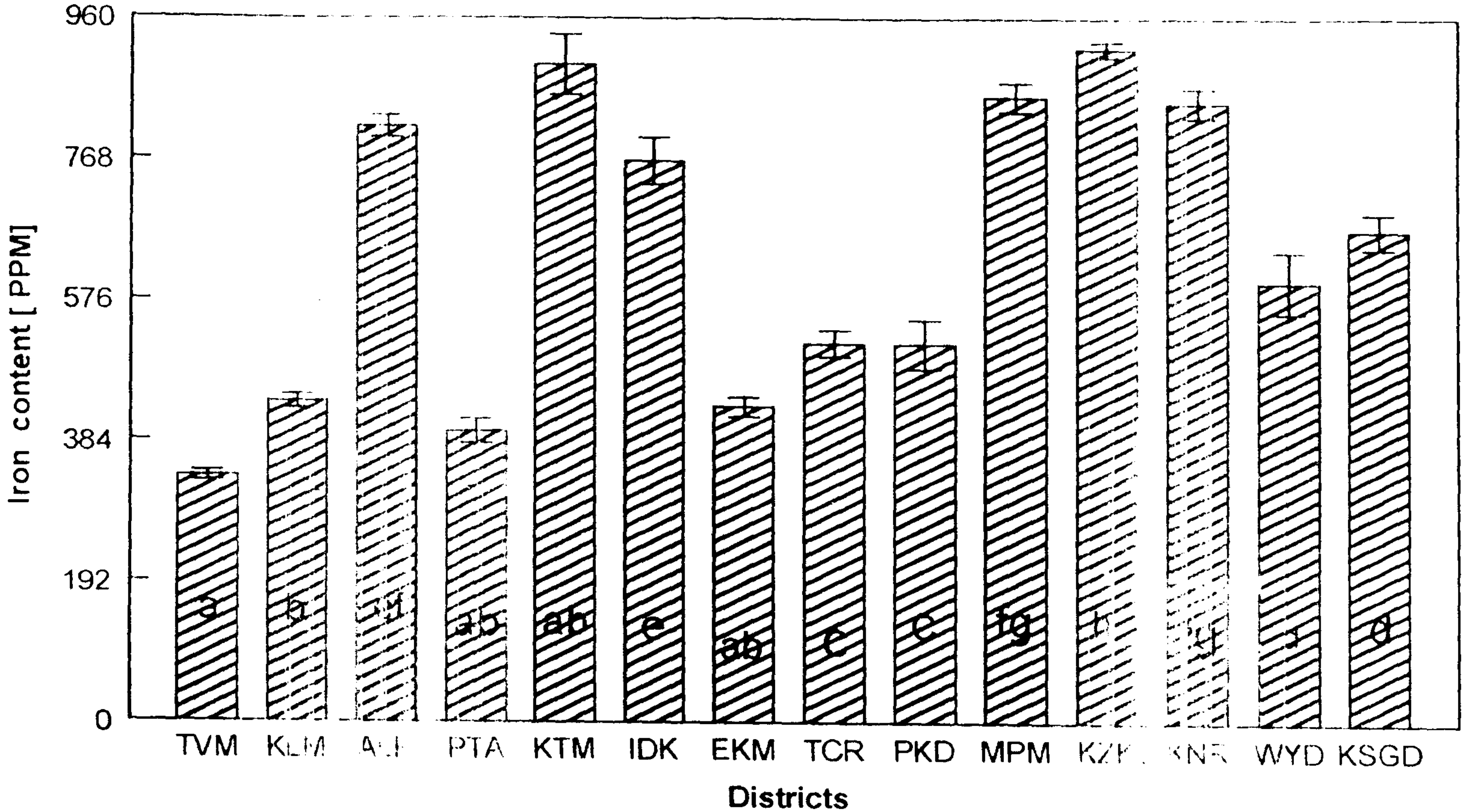
Bars with different letters differ (P< 0.01)

Fig .23 Zinc content of natural grass collected from different districts



Bars with different letters differ (P< 0.01)

Fig .24 Iron content of natural grass collected from different districts



Bars with different letters differ (P< 0.01)

Fig .25 Manganese content of natural grass collected from different districts

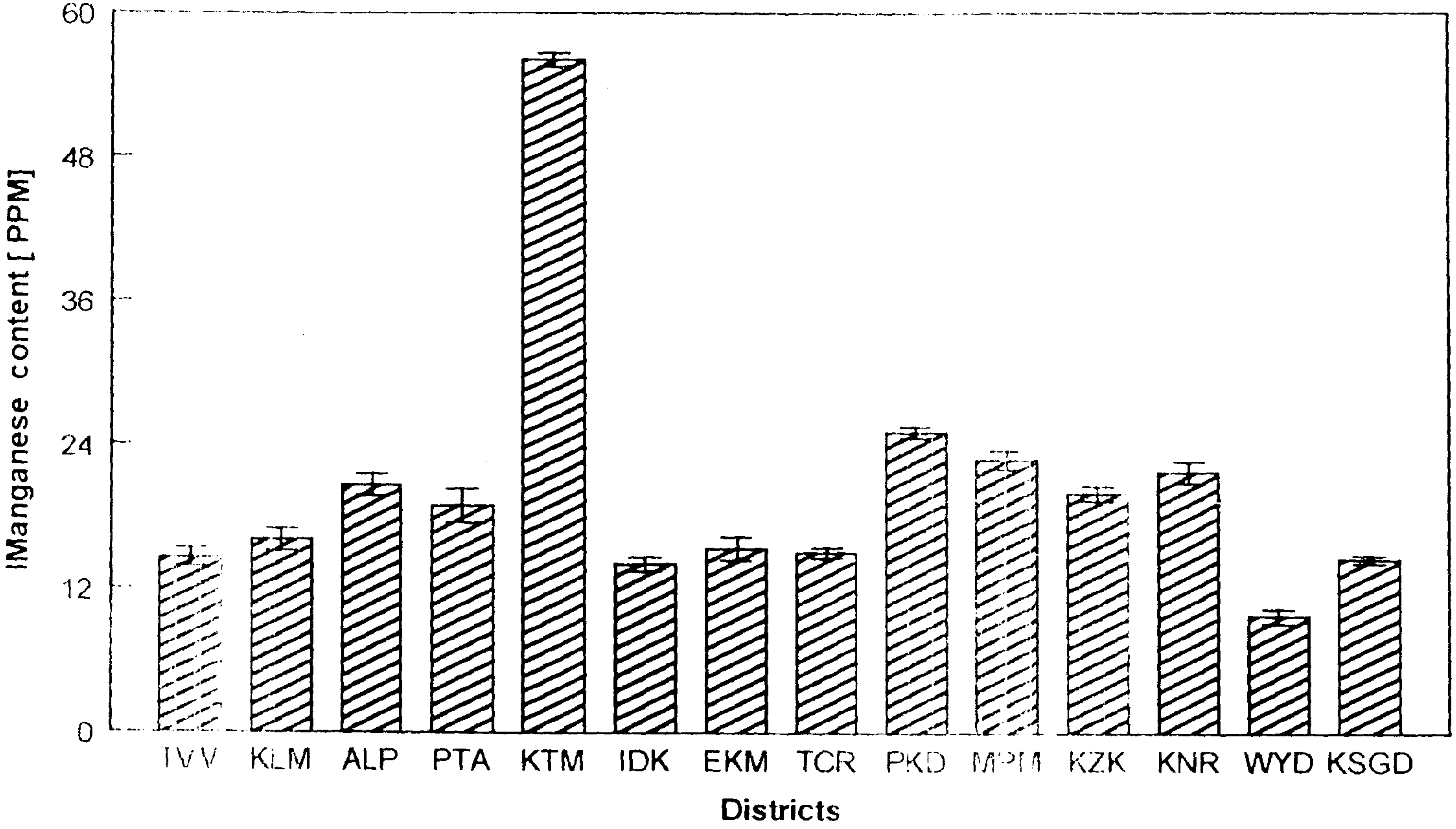


Table 8. **Average mineral concentration in samples of paddy straw collected from different districts**

District	Calcium (%)	Phosphorus (%)	Magnesium (%)	Sodium (%)	Potassium (%)	Copper (ppm)	Zinc (ppm)	Iron (ppm)	Manganese (ppm)
Thiruvananthapuram	0.28± 0.03	0.13± 0.02	0.19± 0.02	0.25± 0.002	1.12± 0.03	6.29± 0.62	51.43± 2.58	583.41± 15.03	83.45± 1.43
Kollam	0.36± 0.01	0.09± 0.01	0.22± 0.01	0.24± 0.01	1.36± 0.03	7.41± 0.68	66.11± 1.19	728.01± 42.10	84.10± 1.38
Alleppey	0.24± 0.02	0.09± 0.01	0.18± 0.01	0.23± 0.004	1.20± 0.02	10.86± 0.52	53.47± 2.48	669.41± 15.51	83.75± 1.40
Pathanamthitta	0.48± 0.01	0.07± 0.004	0.26± 0.01	0.24± 0.004	1.10± 0.02	23.43± 2.66	61.65± 0.65	2003.05± 45.33	86.20± 2.40
Kottayam	0.24± 0.004	0.07± 0.004	0.18± 0.002	0.29± 0.01	1.29± 0.03	7.52± 0.47	39.89± 1.16	1266.35± 36.49	84.45± 1.76
Idukki	0.19± 0.01	0.06± 0.002	0.27± 0.01	0.22± 0.01	1.40± 0.18	22.95± 0.50	61.24± 0.82	1190.70± 101.94	98.10± 2.60
Ernakulam	0.26± 0.01	0.14± 0.01	0.19± 0.01	0.25± 0.01	1.28± 0.01	5.82± 0.57	62.86± 2.68	539.28± 10.68	83.10± 1.80
Thrissur	0.18± 0.004	0.10± 0.004	0.15± 0.01	0.21± 0.01	1.58± 0.02	8.02± 0.11	39.71± 1.14	469.96± 5.83	107.90± 3.21
Palakkad	0.17± 0.01	0.08± 0.002	0.19± 0.004	0.20± 0.002	1.58± 0.01	12.39± 0.57	41.23± 0.40	344.37± 16.96	107.20± 2.26
Malappuram	0.24± 0.01	0.08± 0.01	0.21± 0.03	0.21± 0.004	1.53± 0.03	12.43± 1.00	44.43± 1.17	612.86± 10.39	78.30± 1.32
Kozhikode	0.28± 0.02	0.13± 0.02	0.24± 0.01	0.22± 0.002	1.10± 0.01	6.16± 0.72	56.72± 1.10	419.33± 7.18	80.30± 1.86
Kannur	0.19± 0.02	0.10± 0.01	0.18± 0.02	0.22± 0.01	1.52± 0.05	4.39± 0.72	62.73± 7.66	712.97± 16.77	40.20± 1.27
Wyanad	0.27± 0.03	0.07± 0.01	0.23± 0.01	0.22± 0.01	1.45± 0.02	9.07± 1.11	57.81± 4.23	592.06± 16.98	51.30± 1.22
Kasargod	0.23± 0.01	0.08± 0.003	0.22± 0.01	0.19± 0.01	1.31± 0.03	7.54± 0.17	61.98± 1.15	1094.20± 22.98	50.70± 1.32

Table 8.1 Analysis of variance - Calcium content of straw

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	1.599	0.123	30.516**	0.0000
Within	236	0.951	0.004		
Total	249	2.550			

** P<0.01

Table 8.2 Analysis of variance - Phosphorus content of straw

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	0.148	0.011	4.886**	0.0000
Within	236	0.552	0.002		
Total	249	0.700			

** P<0.01

Table 8.3 Analysis of variance - Magnesium content of straw

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	0.287	0.022	6.138**	0.0000
Within	236	0.849	0.004		
Total	249	1.137			

** P<0.01

Table 8.4 Analysis of variance - Sodium content of straw

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	0.151	0.012	21.497**	0.0000
Within	236	0.127	0.001		
Total	249	0.278			

** P<0.01

Table 8.5 Analysis of variance - Potassium content of straw

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	7.410	0.570	9.604**	0.0000
Within	236	14.007	0.059		
Total	249	21.417			

** P<0.01

Table 8.6 Analysis of variance - Copper content of straw

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	8726.794	671.292	37.078**	0.0000
Within	236	4272.801	18.105		
Total	249	12999.595			

** P<0.01

Table 8.7 Analysis of variance - Zinc content of straw

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	21676.379	1667.414	22.358**	0.0000
Within	236	17600.428	74.578		
Total	249	39276.807			

** P<0.01

Table 8.8 Analysis of variance - Iron content of straw

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	50393205.548	3876400.427	142.62**	0.0000
Within	236	6414177.151	27178.717		
Total	249	56807382.700			

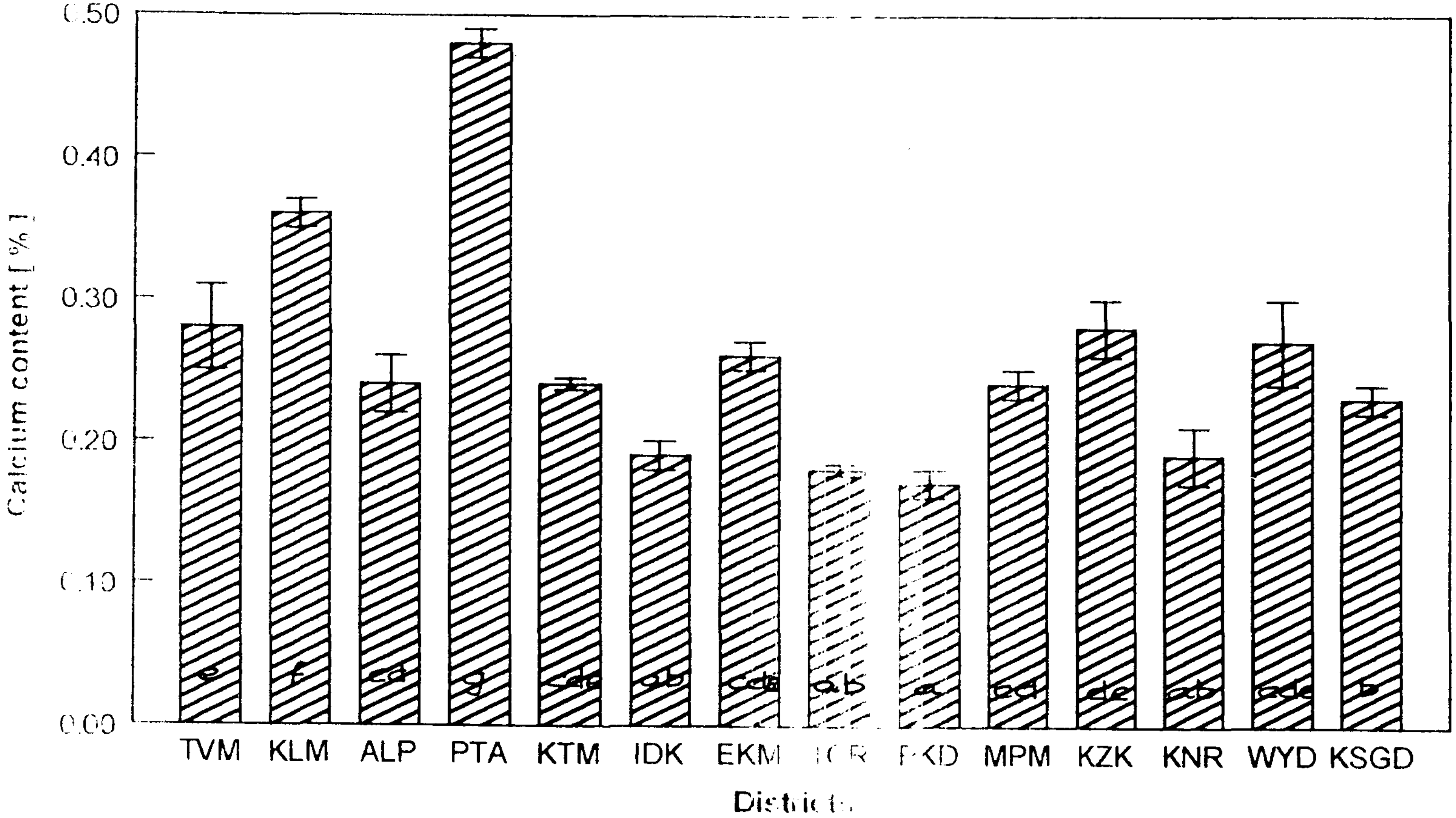
** P<0.01

Table 8.9 Analysis of variance - Manganese content of straw

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	732.450	56.342	22.071**	0.0000
Within	236	602.450	2.553		
Total	249	1334.900			

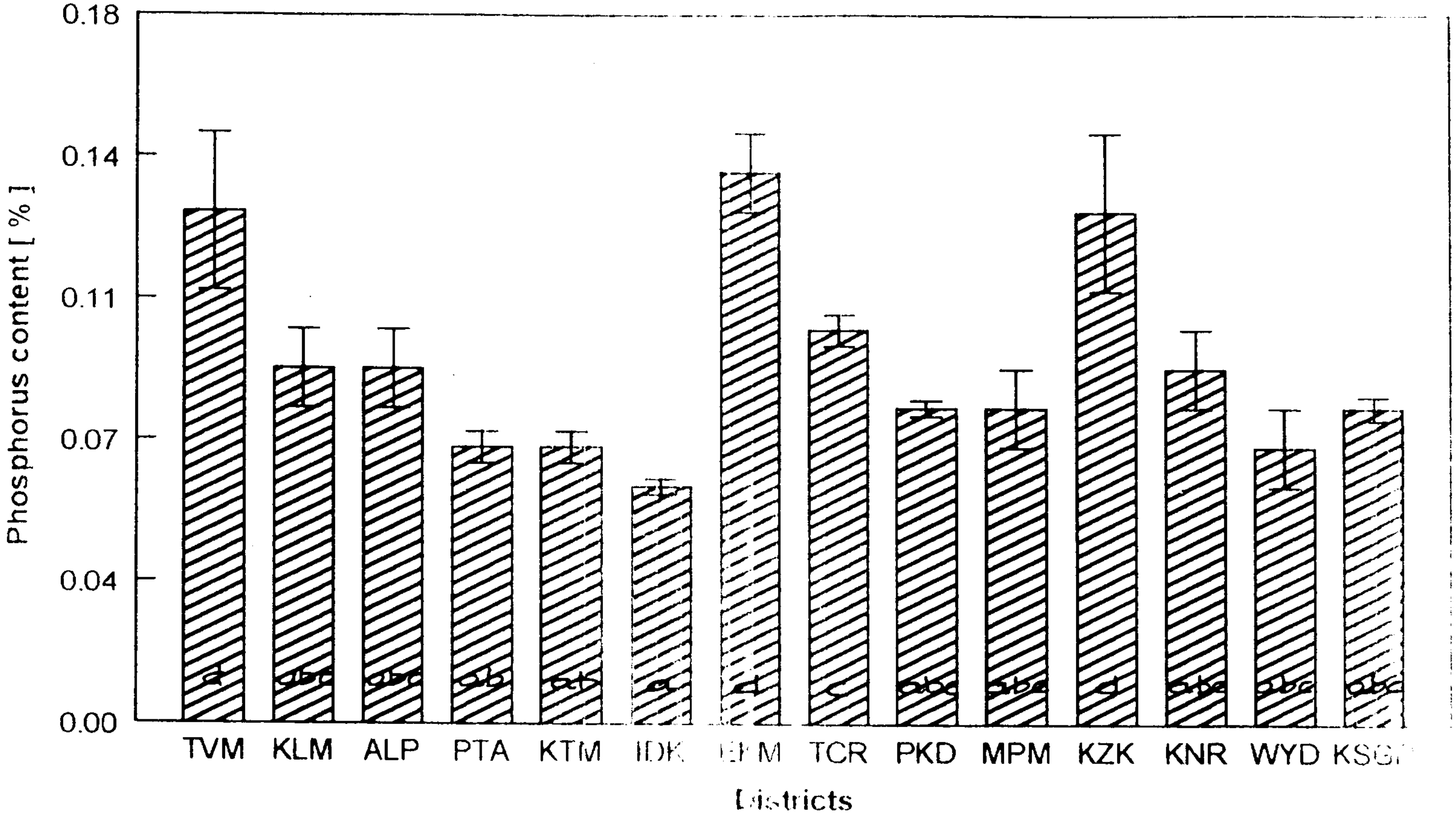
** P<0.01

Fig. 26 Calcium content of straw collected from different districts



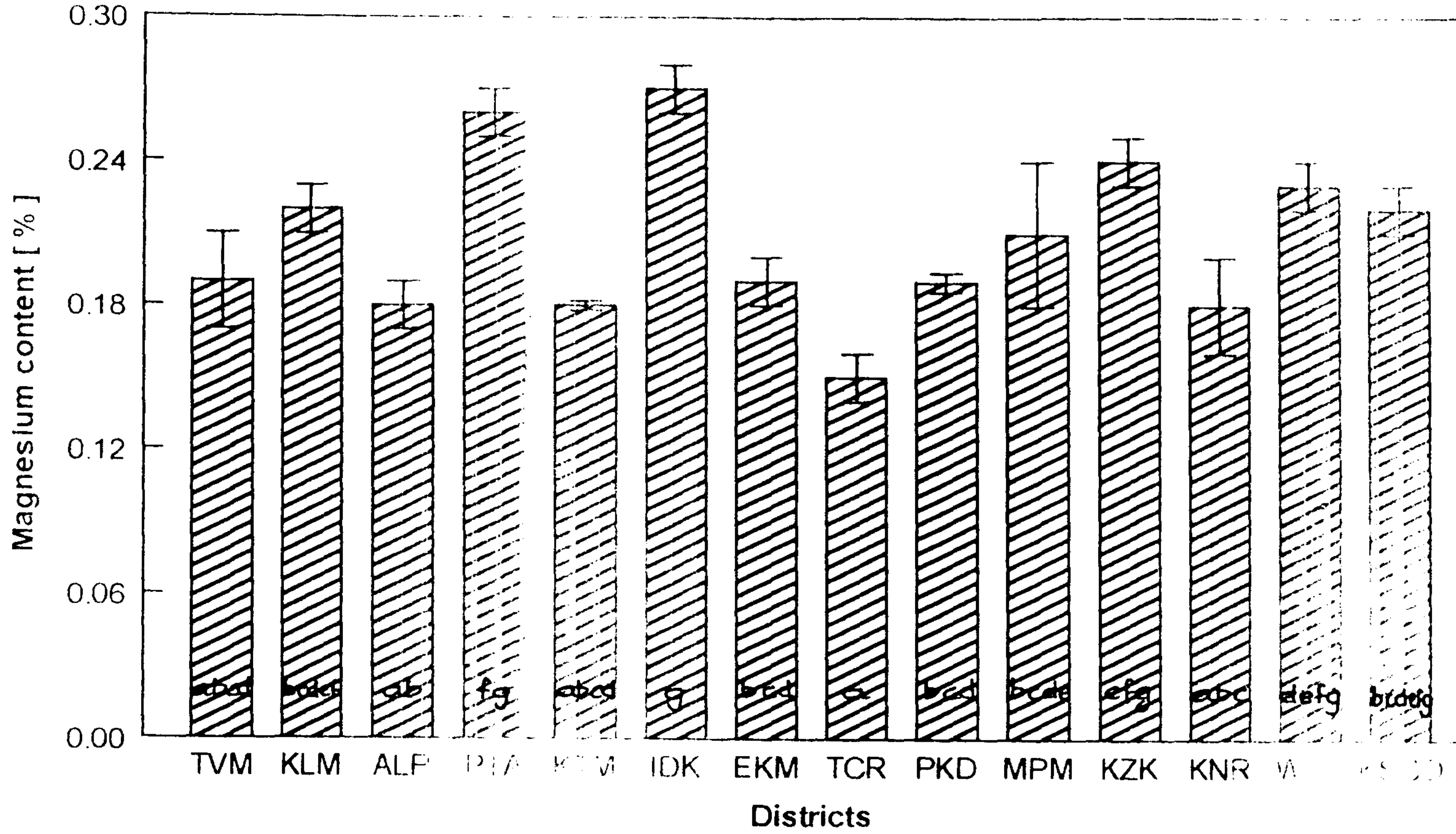
Bars with different letters differ [P<0.01]

Fig.27 Phosphorus content of straw collected from different districts



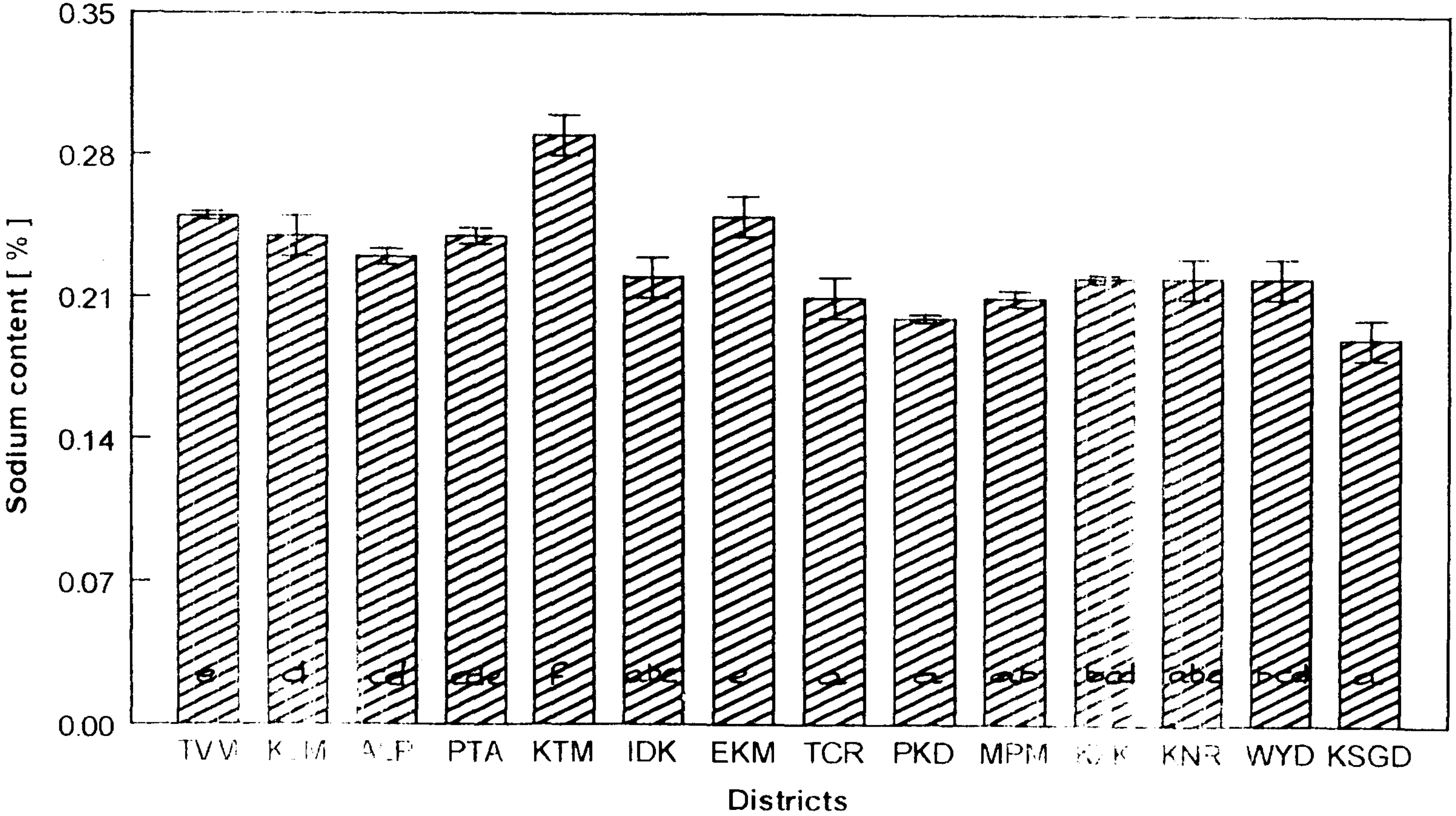
Bars with different letters differ [P<0.01]

Fig. 28 Magnesium content of straw collected from different districts



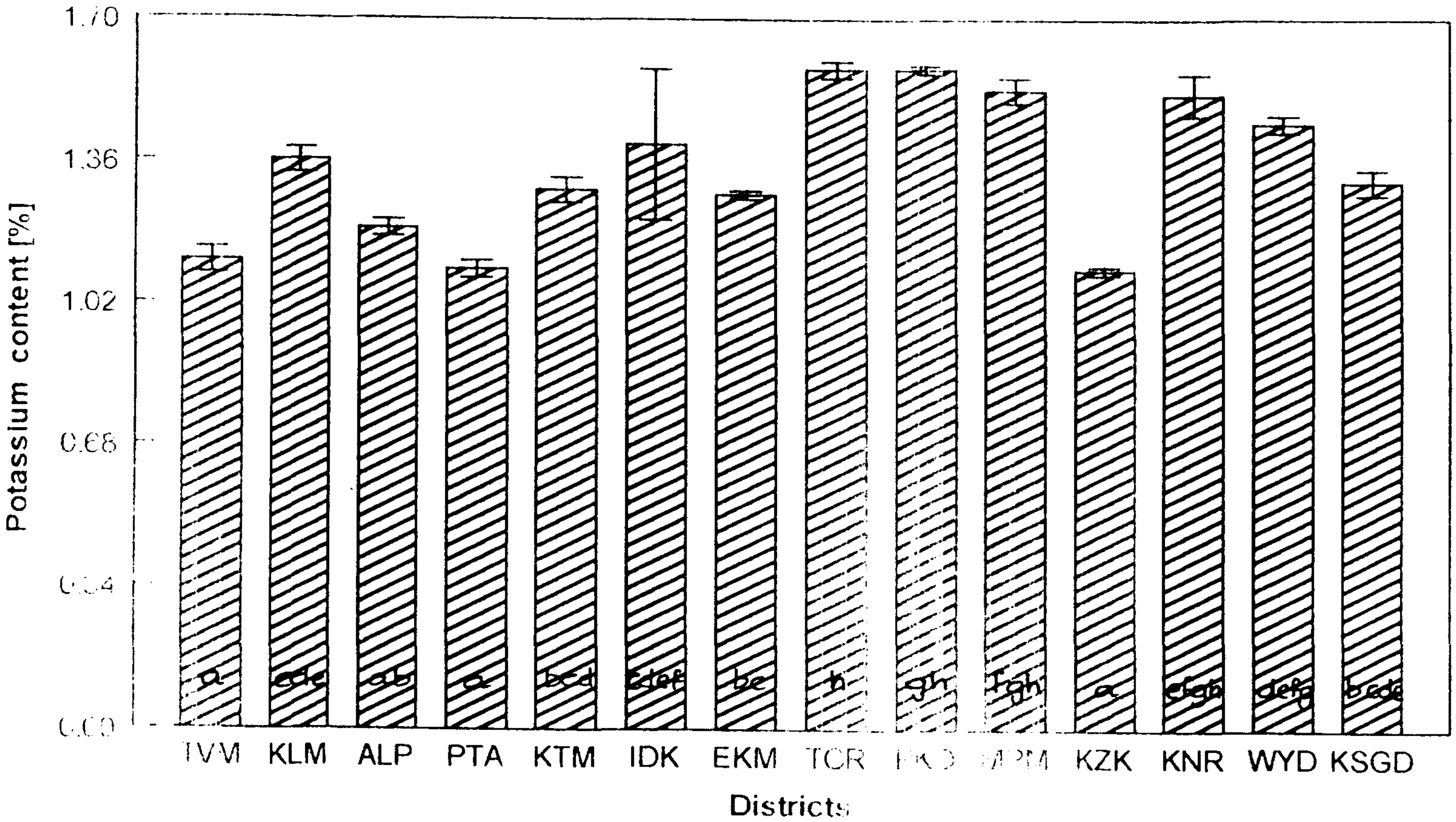
Bars with different letters differ [P<0.01]

Fig.29 Sodium content of straw collected from different districts



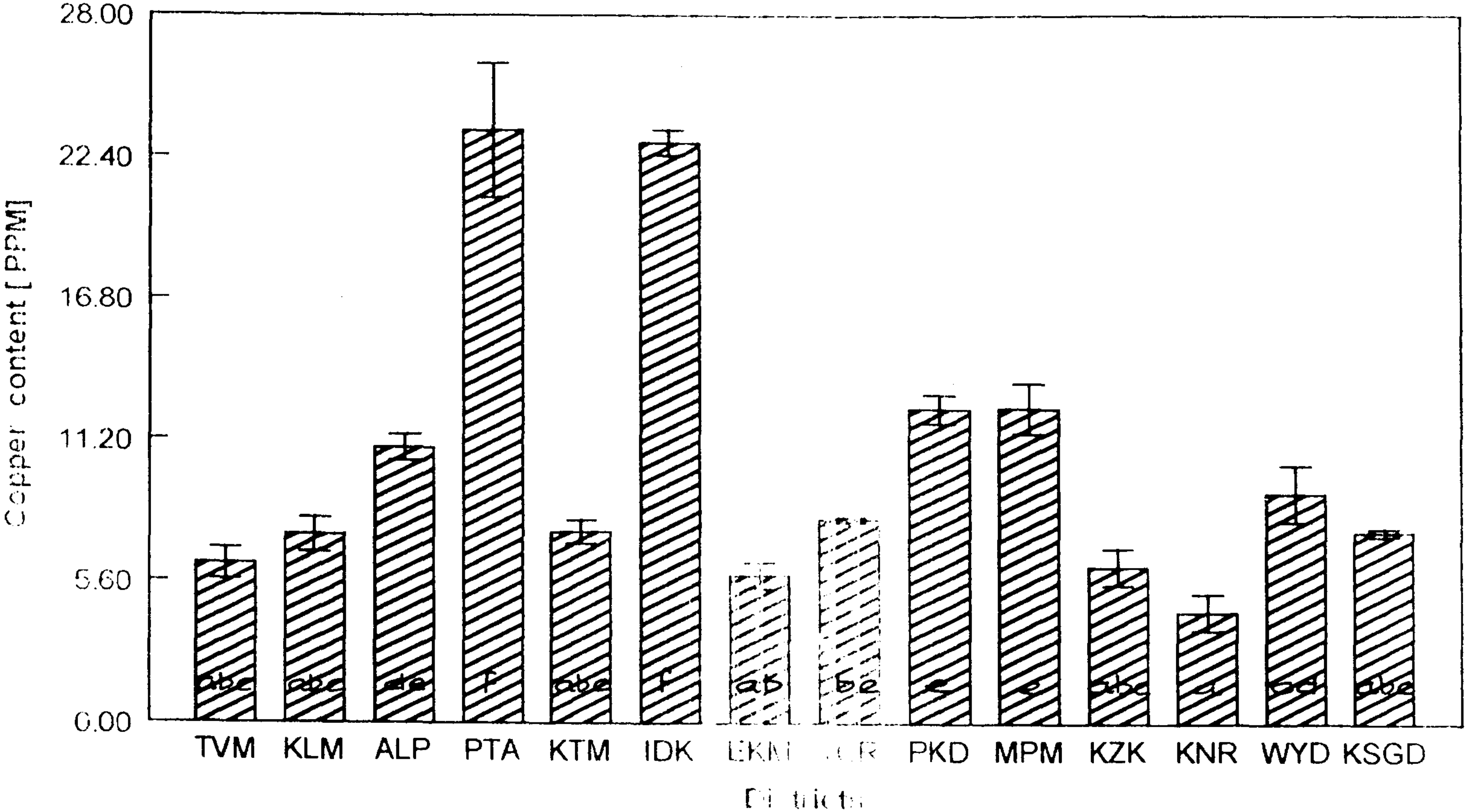
Bars with different letters differ [P<0.01]

Fig .30 Potassium content of straw collected from different districts



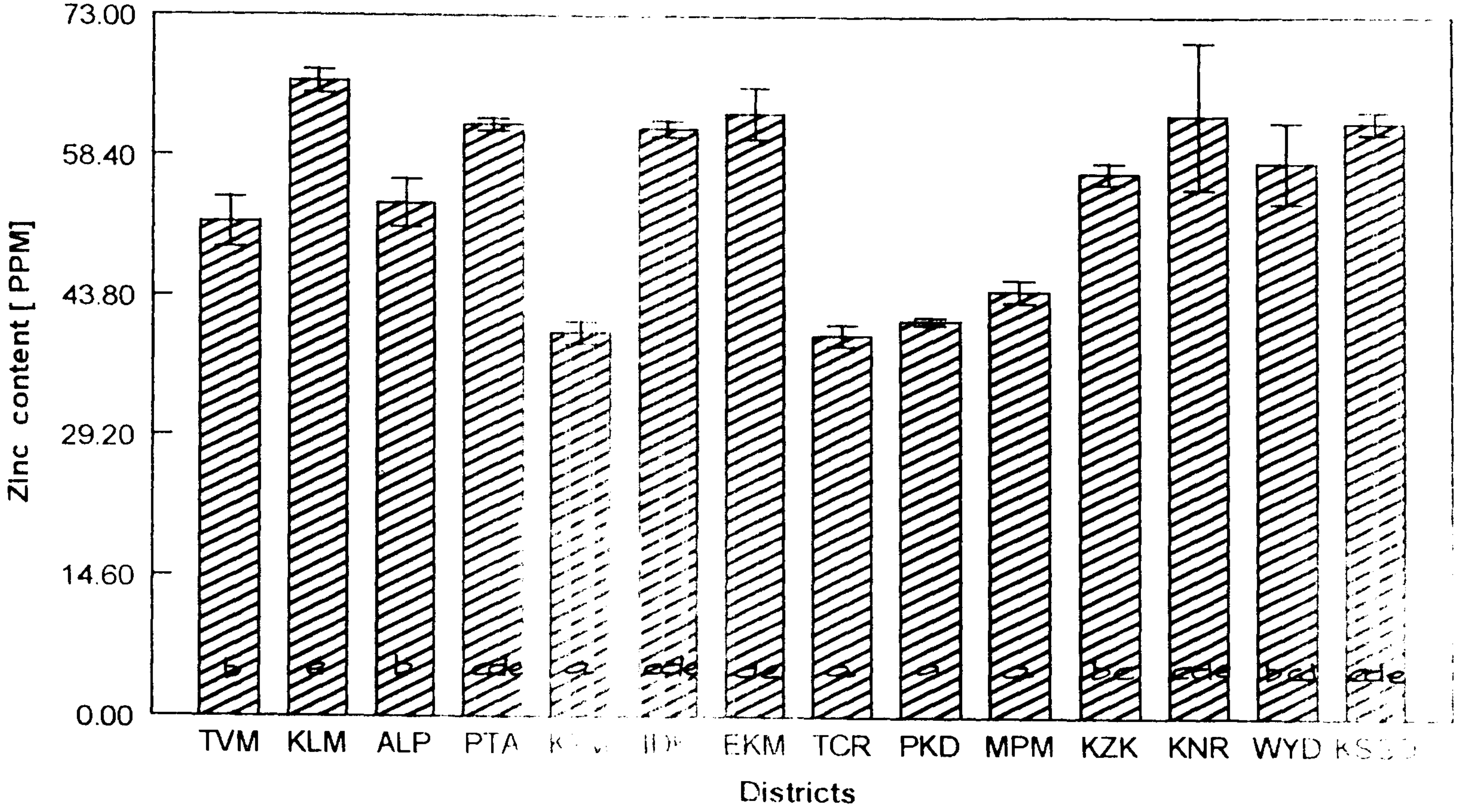
Bars with different letters differ [P<0.01]

Fig . 31 Copper content of straw collected from different districts



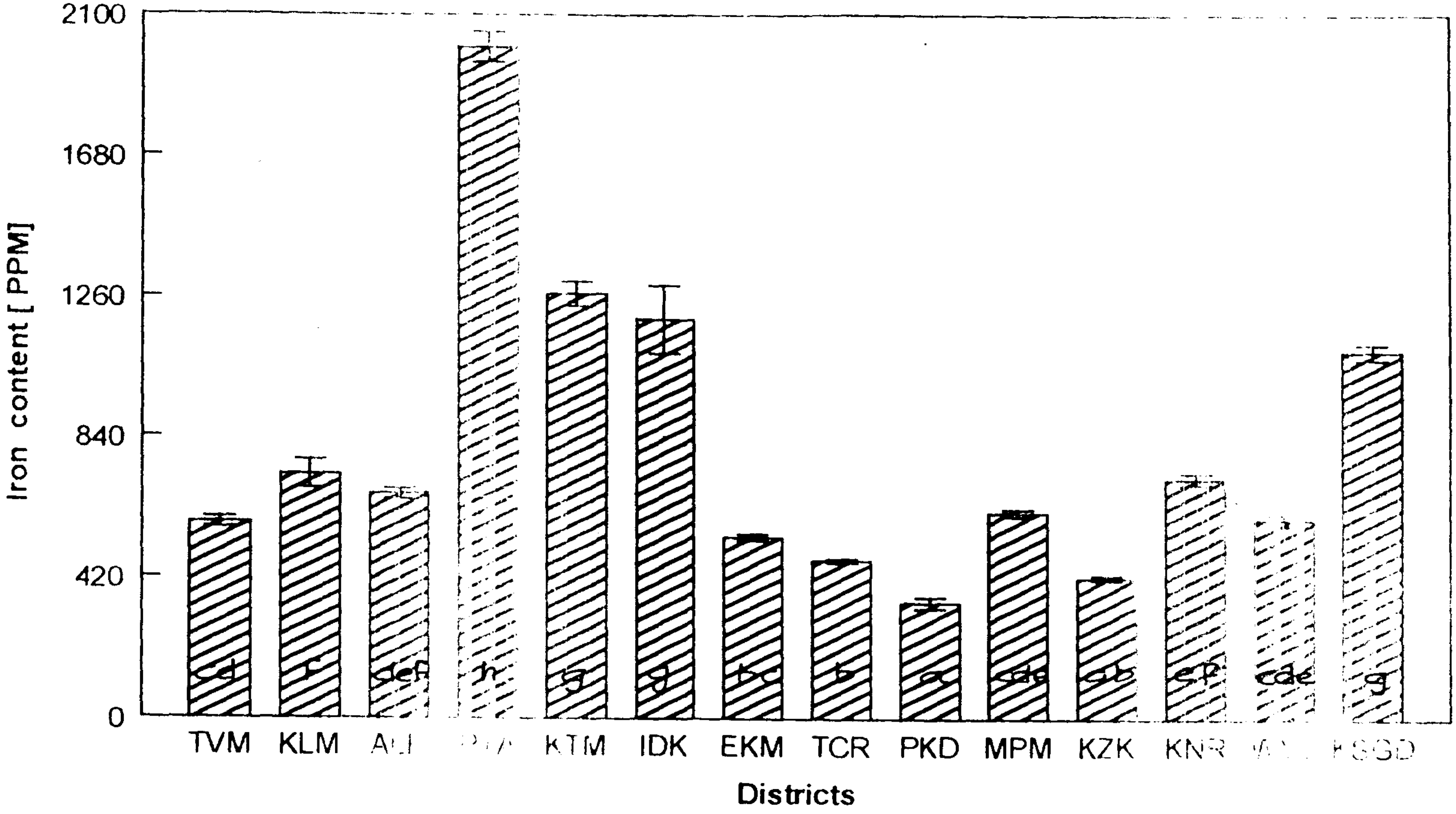
Bars with different letters differ [P<0.01]

Fig 32 Zinc content of straw collected from different districts



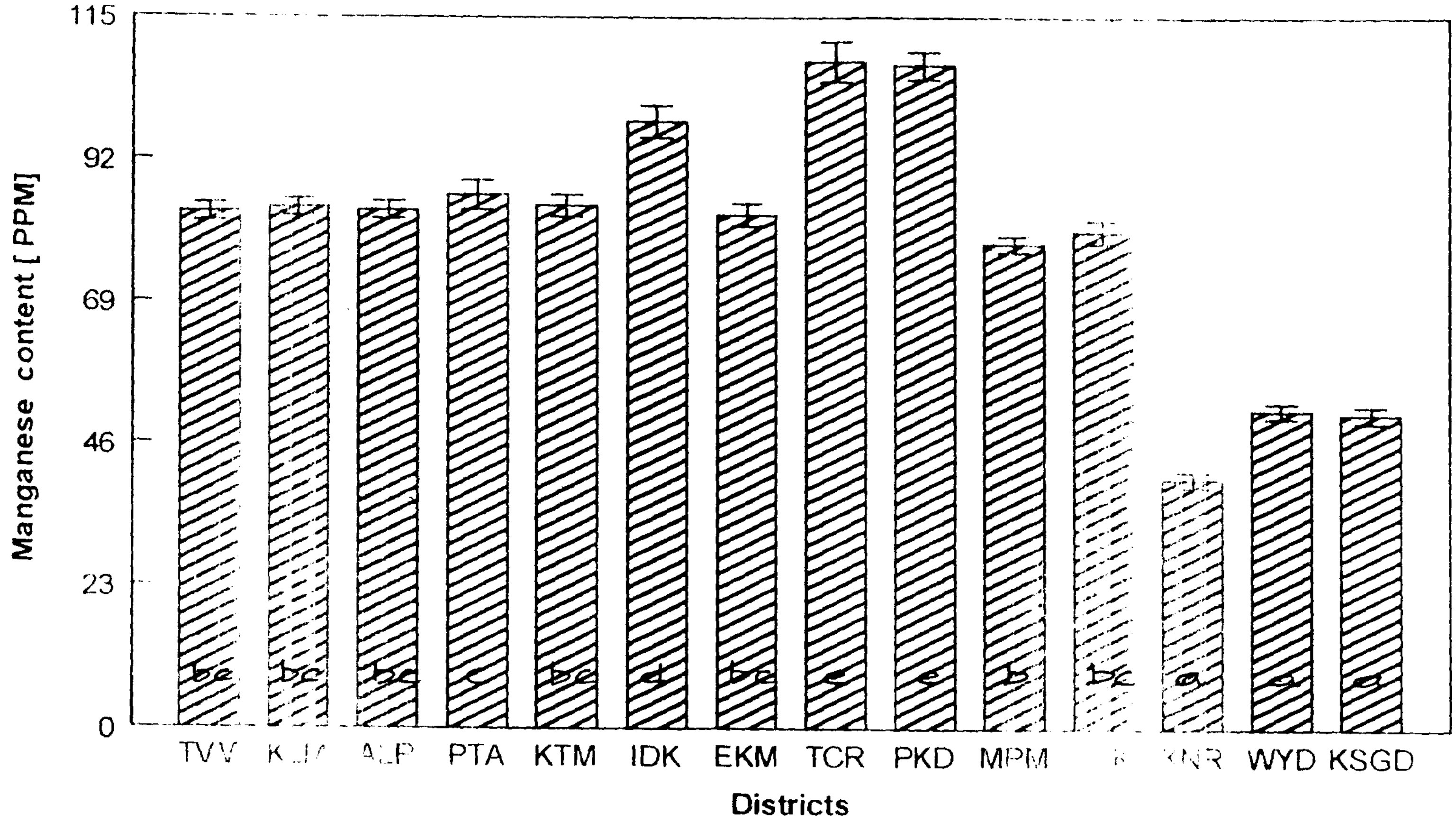
Bars ... different letters differ [P<0.01]

Fig. 33 Iron content of straw collected from different districts



Bars with different letters differ [P<0.01]

Fig . 34 Manganese content of straw collected from different districts



Bars with different letters differ [P<0 0]

Table 9. Average mineral concentration in the serum of lactating cattle collected from different districts

District	Calcium (mg%)	Phosphorus (mg%)	Magnesium (mg%)	Sodium (meq/l)	Potassium (meq/l)	Copper (ppm)	Zinc (ppm)	Iron (ppm)	Manganese (ppm)
Thiruvananthapuram	10.19± 0.12	4.45± 0.16	2.39± 0.07	138.75± 2.08	4.49± 0.05	0.86± 0.05	1.41± 0.06	1.62± 0.05	0.03± 0.001
Kollam	9.36± 0.08	5.56± 0.09	2.96± 0.06	127.53± 1.28	5.01± 0.05	0.91± 0.04	1.38± 0.06	1.49± 0.05	0.03± 0.001
Alleppey	8.00± 0.22	5.19± 0.11	2.11± 0.14	126.81± 0.99	3.97± 0.02	1.41± 0.05	1.61± 0.05	1.83± 0.06	0.03± 0.001
Pathanamthitta	9.15± 0.13	5.52± 0.12	1.75± 0.07	145.83± 27.87	3.87± 0.04	0.73± 0.03	0.96± 0.05	1.05± 0.04	0.04± 0.005
Kottayam	7.06± 0.19	4.80± 0.14	1.88± 0.11	134.47± 0.90	5.53± 0.04	1.00± 0.07	1.89± 0.05	1.58± 0.04	0.03
Idukki	9.32± 0.16	5.88± 0.13	2.09± 0.05	141.86± 0.89	4.39± 0.04	0.77± 0.02	1.15± 0.04	1.26± 0.04	0.05± 0.01
Ernakulam	9.25± 0.05	5.78± 0.07	1.92± 0.05	127.64± 0.67	5.02± 0.02	0.91± 0.03	1.11± 0.03	1.71± 0.03	0.03± 0.001
Thrissur	8.72± 0.20	5.05± 0.09	2.49± 0.06	128.11± 0.59	4.72± 0.03	1.27± 0.03	1.34± 0.05	1.76± 0.04	0.04
Palakkad	9.22± 0.15	4.78± 0.06	2.56± 0.05	152.69± 27.59	4.63± 0.05	0.98± 0.03	1.24± 0.03	1.70± 0.04	0.04
Malappuram	10.03± 0.05	4.76± 0.05	2.05± 0.05	118.06± 0.82	5.46± 0.04	0.83± 0.04	1.43± 0.05	1.87± 0.03	0.03± 0.001
Kozhikode	8.43± 0.10	6.19± 0.08	1.89± 0.06	127.06± 1.02	4.69± 0.03	0.71± 0.03	0.93± 0.03	1.34± 0.06	0.03± 0.001
Kannur	9.20± 0.12	4.12± 0.54	2.63± 0.15	142.11± 1.18	3.93± 0.04	0.85± 0.03	1.52± 0.08	1.55± 0.04	0.03± 0.002
Wyanad	7.56± 0.26	4.95± 0.23	1.76± 0.10	130.78± 1.20	5.00± 0.12	0.98± 0.03	1.92± 0.06	1.52± 0.08	0.04± 0.002
Kasargod	7.74± 0.37	4.86± 0.23	2.14± 0.21	128.89± 0.97	4.94± 0.06	1.01± 0.06	1.66± 0.11	1.36± 0.04	0.05± 0.002

Table 9.1 Analysis of variance - Calcium content of serum

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	348.397	26.800	34.669**	0.0000
Within	436	337.038	0.773		
Total	449	685.435			

** P<0.01

Table 9.2 Analysis of variance - Phosphorus content of serum

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	136.297	10.484	24.658**	0.0000
Within	436	185.386	0.425		
Total	449	321.683			

** P<0.01

Table 9.3 Analysis of variance - Magnesium content of serum

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	55.385	4.260	18.897**	0.0000
Within	436	98.296	0.225		
Total	449	153.680			

** P<0.01

Table 9.4 Analysis of variance - Sodium content of serum

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	39392.348	3030.181	0.677NS	
Within	436	1952295.583	4477.742		
Total	449	1991687.931			

NS - Non-significant

Table 9.5 Analysis of variance - Potassium content of serum

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	115.410	8.878	136.808**	0.0000
Within	436	28.293	0.065		
Total	449	143.702			

** P<0.01

Table 9.6 Analysis of variance - Copper content of serum

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	17.610	1.355	26.466**	0.0000
Within	436	22.316	0.051		
Total	449	39.926			

** P<0.01

Table 9.7 Analysis of variance - Zinc content of serum

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	37.019	2.848	32.565**	0.0000
Within	436	38.125	0.087		
Total	449	75.144			

** P<0.01

Table 9.8 Analysis of variance - Iron content of serum

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	24.533	1.887	26.918**	0.0000
Within	436	30.568	0.070		
Total	449	55.101			

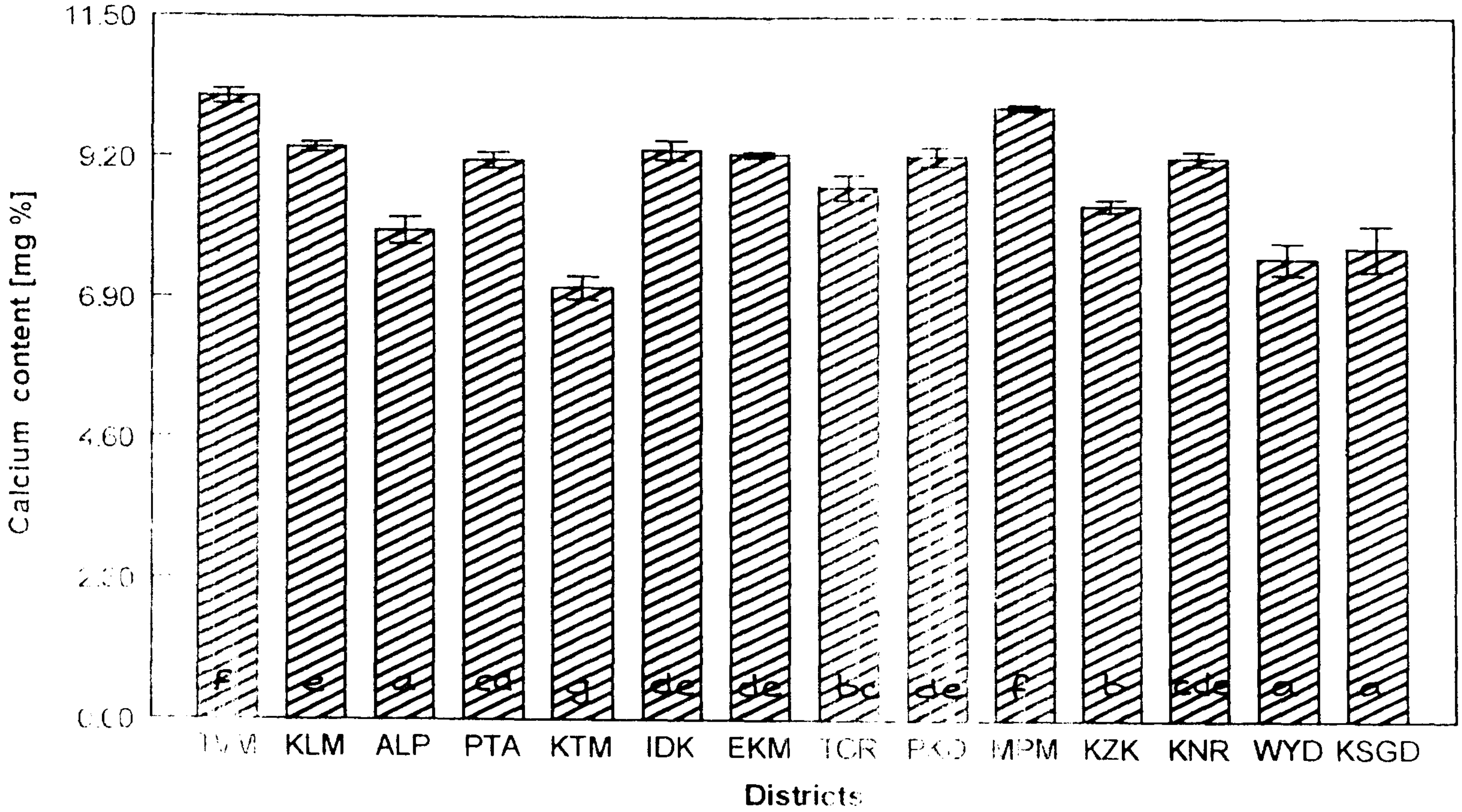
** P<0.01

Table 9.9 Analysis of variance - Manganese content of serum

	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Between	13	0.467	0.036	1.845NS	0.0346
Within	436	8.497	0.019		
Total	449	8.964			

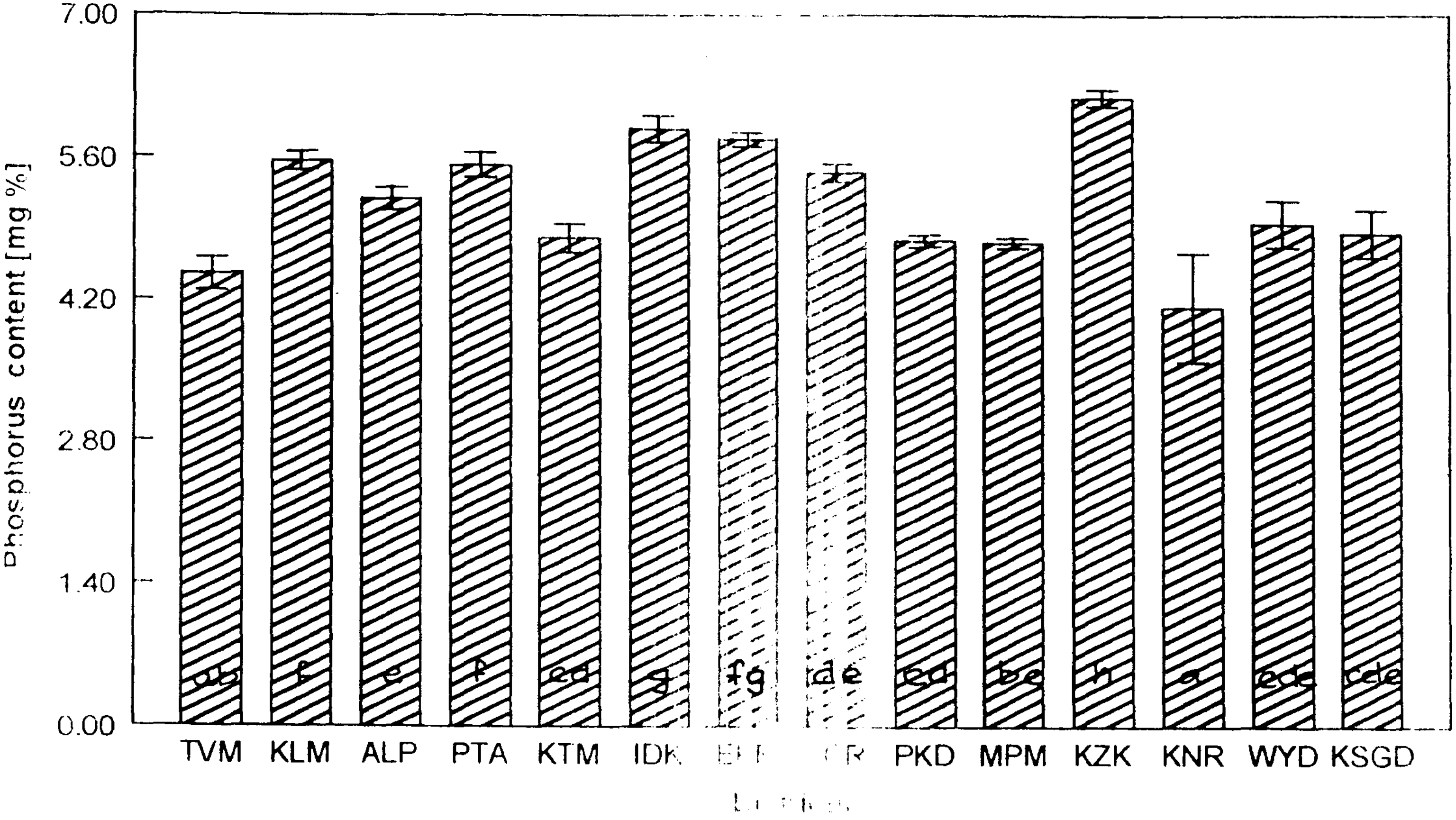
NS - Non-significant

Fig. 35 Calcium content of serum collected from different districts



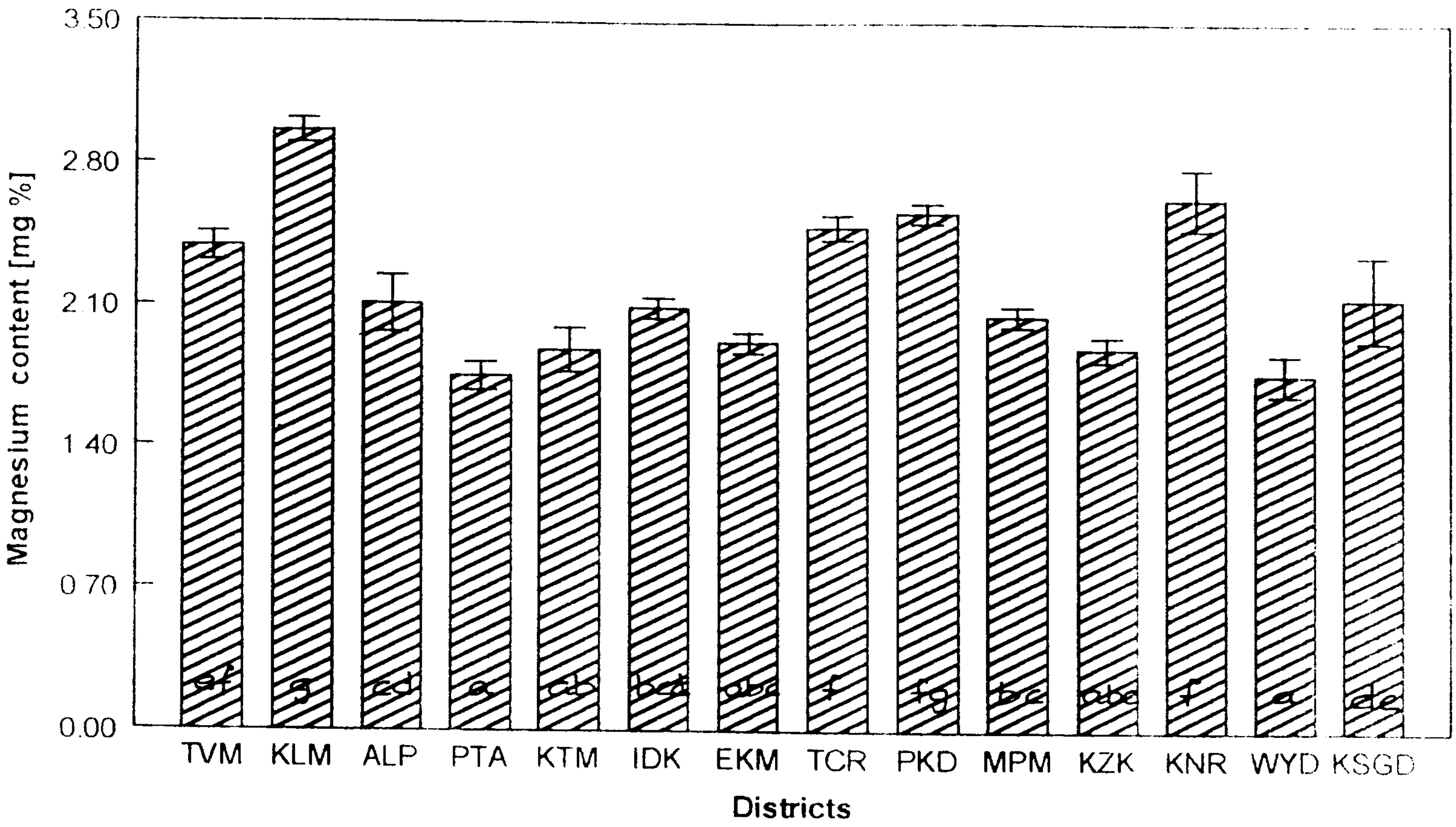
Bars with different letters d[illegible] 0.01)

Fig. 36 Phosphorus content of serum collected from different districts



Bars with diffe... differ (P< 0.01)

Fig. 37 Magnesium content of serum collected from different districts



Bars with different letters differ (P< 0.01)

Fig.38 Sodium content of serum collected from different districts

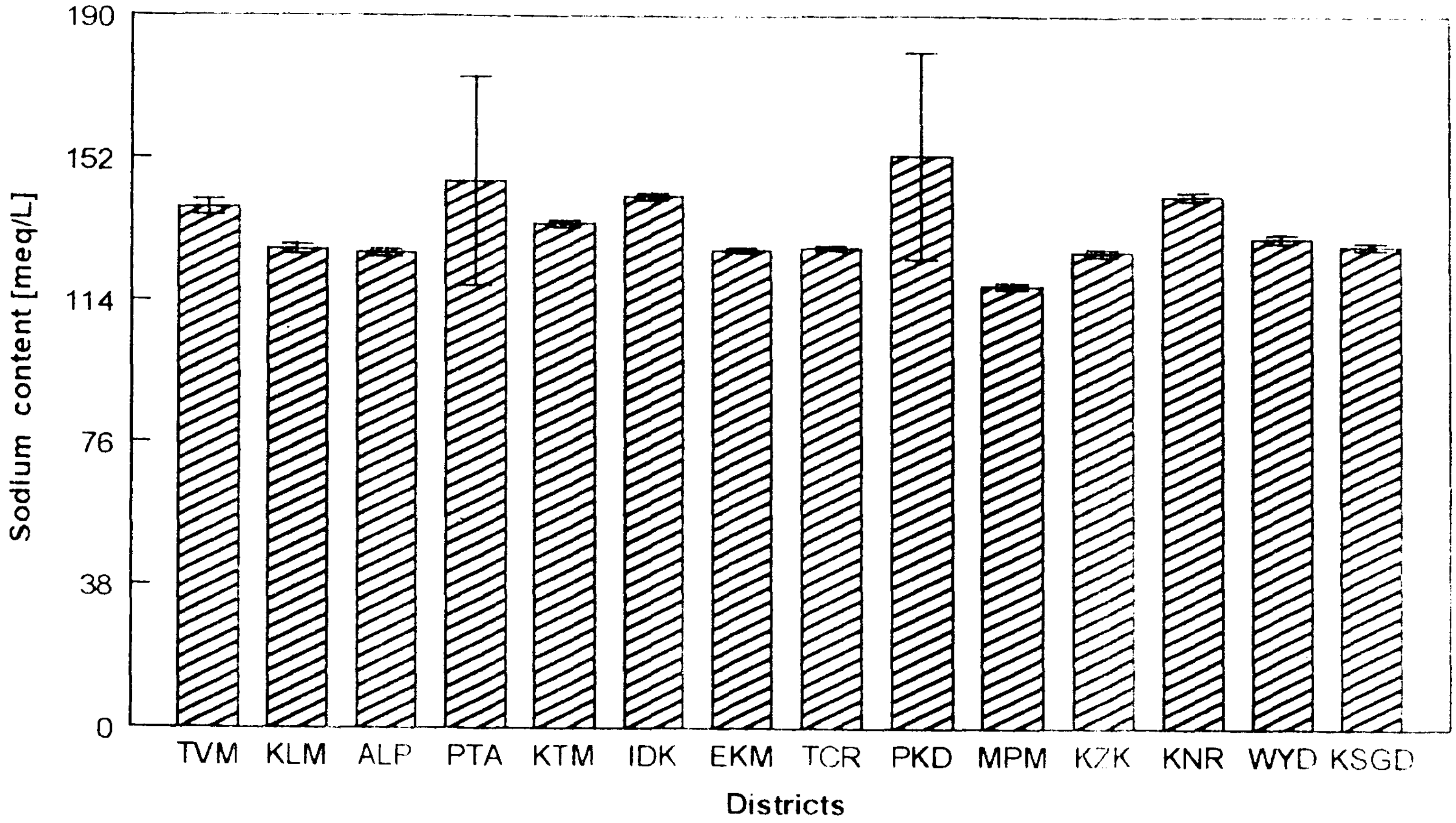
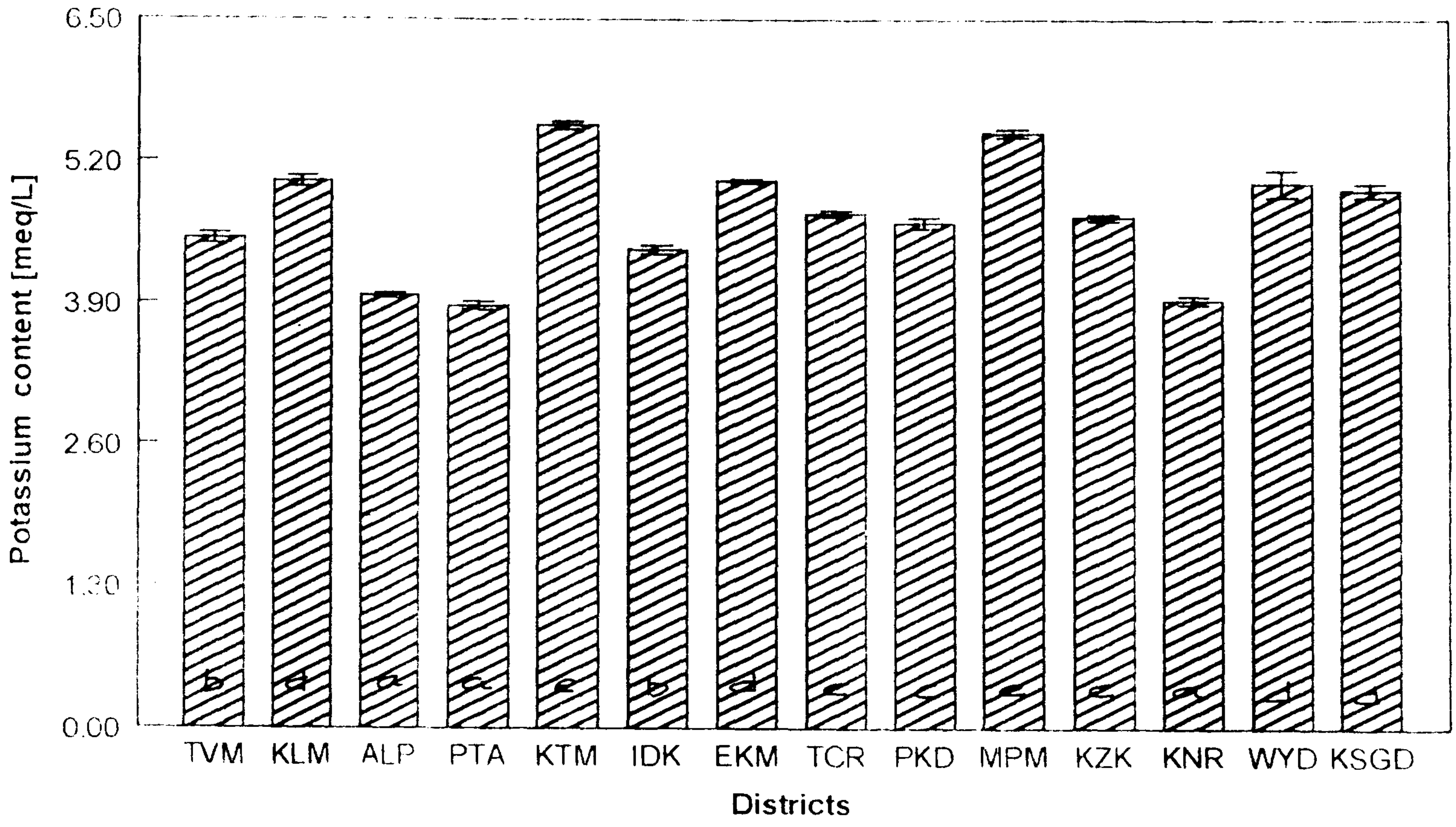
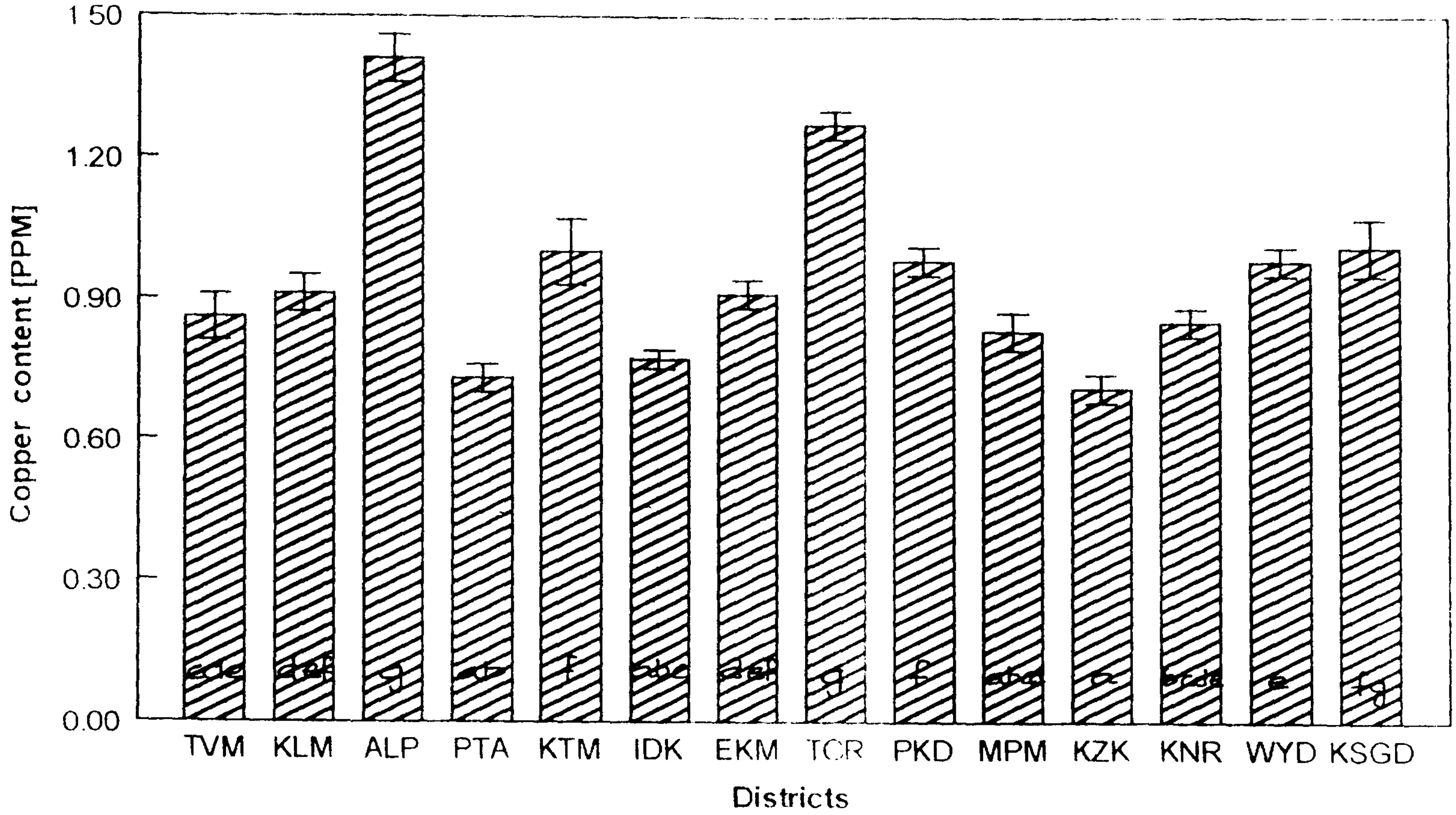


Fig. 39 Potassium content of serum collected from different districts



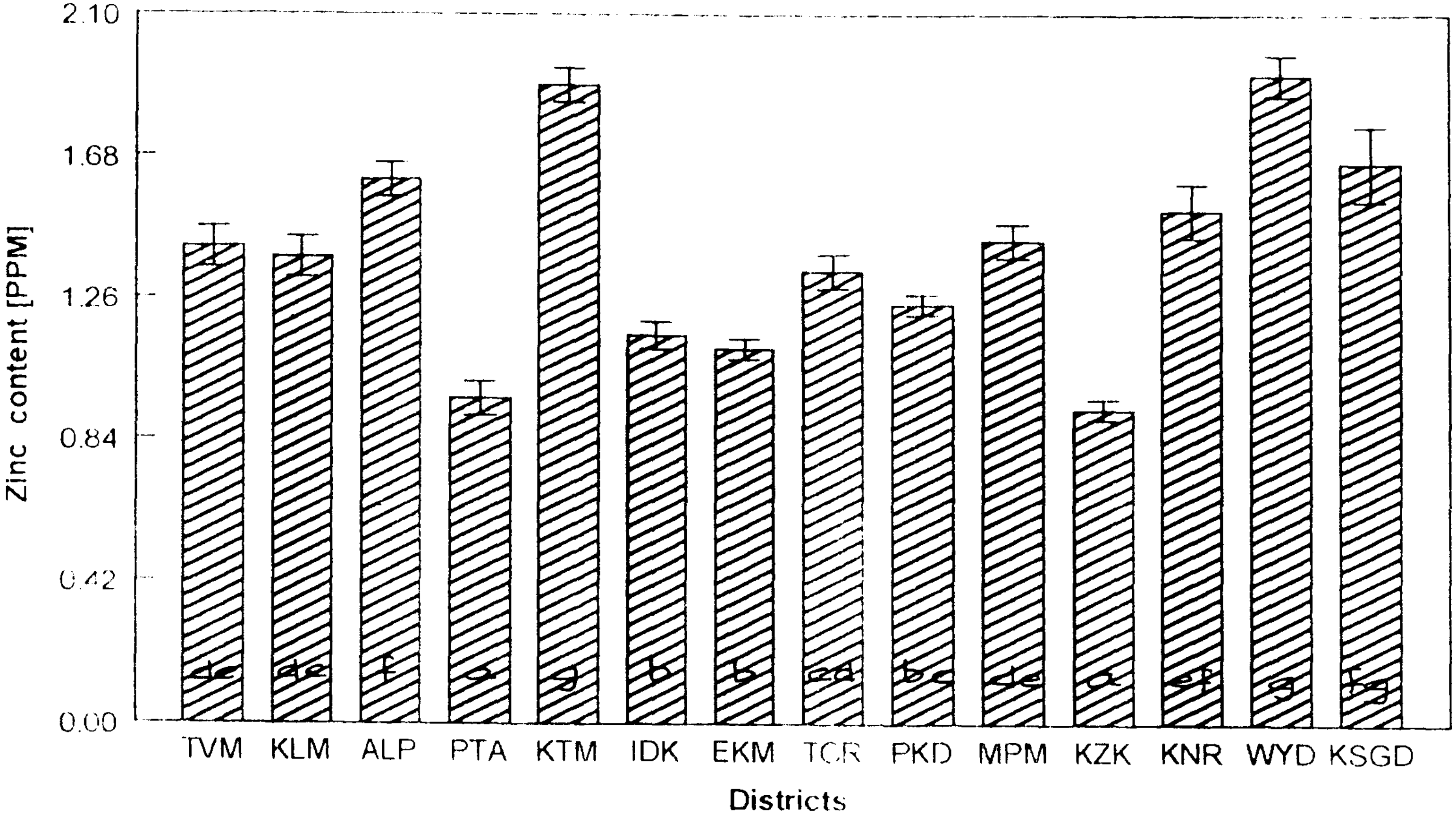
Bars with different letters differ (P<0.01)

Fig. 40 Copper content of serum collected from different districts



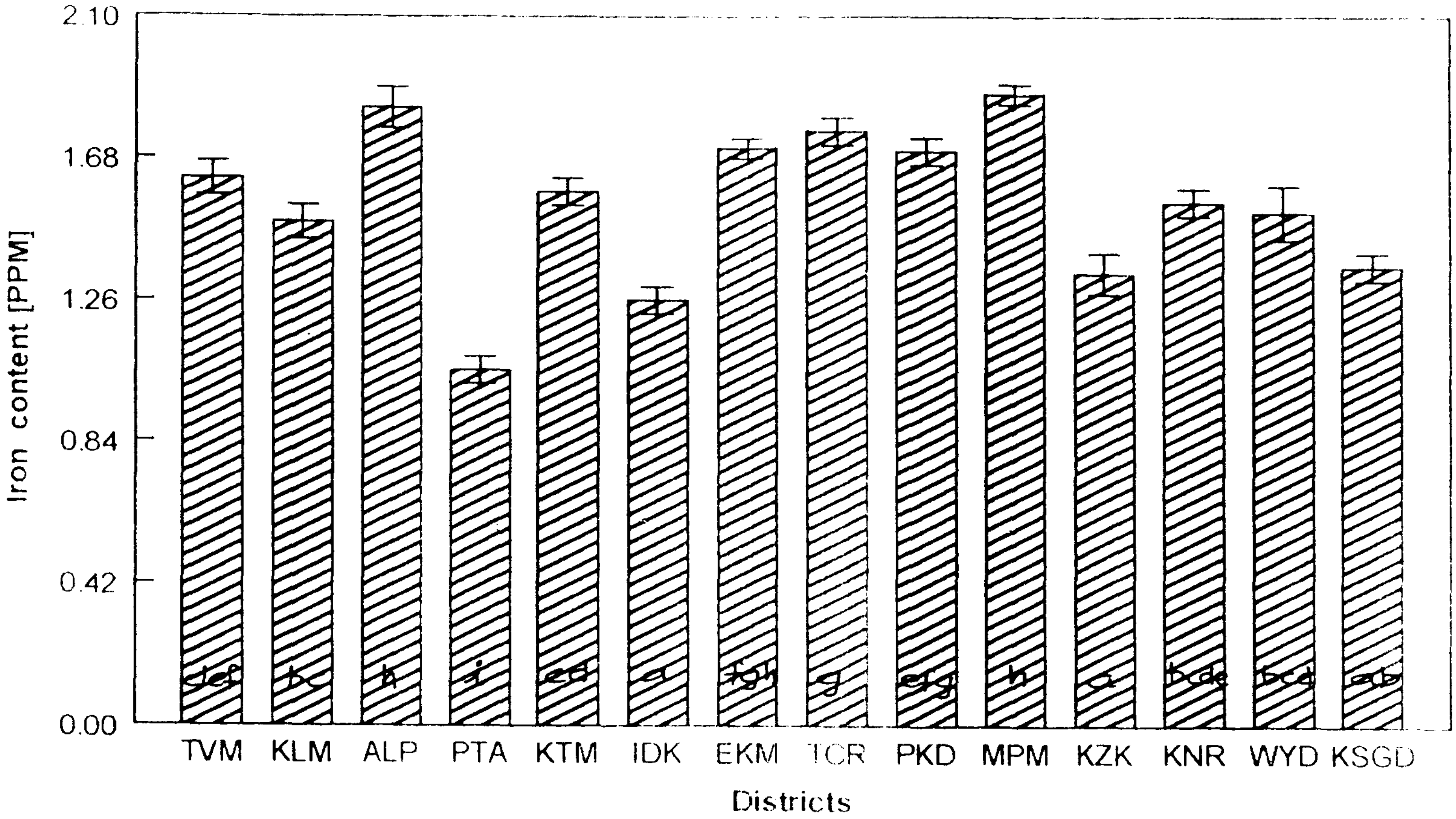
Bars with different letters differ (P<0.01)

Fig. 41 Zinc content of serum collected from different districts:



Bars with different letters differ[P<0.01]

Fig. 42 Iron content of serum collected from different districts



Bars with different letters differ [P<0.01]

Fig. 43 Manganese content of serum collected from different districts

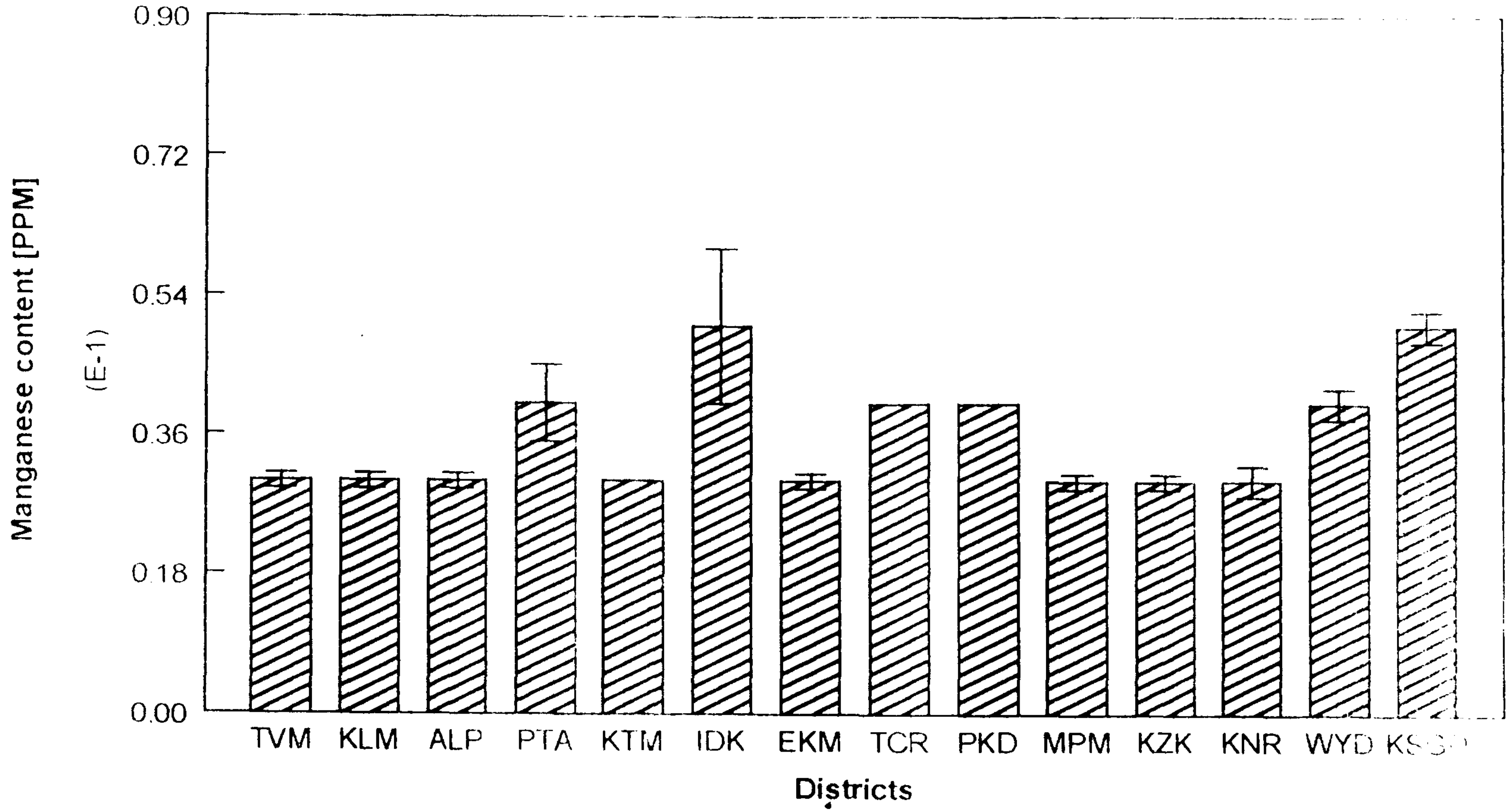


Table 10. Data on deficiency/metabolic/reproductive cases recorded in Veterinary Institutions in the districts surveyed for a period of previous six months

District	Species	Metabolic diseases (%)	Deficiency diseases (%)	Reproductive disorders other than abortions/ dystocia (%)
Thiruvananthapuram	Cattle	3.51	1.27	9.39
Kollam	Cattle	3.76	1.46	11.16
Alleppey	Cattle	2.89	1.96	8.67
Pathanamthitta	Cattle	2.93	2.54	8.70
Kottayam	Cattle	3.25	2.81	8.34
Idukki	Cattle	2.82	2.03	10.42
Ernakulam	Cattle	2.89	2.12	9.83
Thrissur	Cattle	2.64	1.58	13.16
Palakkad	Cattle	3.23	1.61	11.75
Malappuram	Cattle	2.93	1.86	10.87
Kozhikode	Cattle	2.83	2.45	8.77
Kannur	Cattle	3.30	2.09	12.57
Wyanad	Cattle	3.48	1.86	12.74
Kasargod	Cattle	3.43	2.21	10.13

Table 11. Data on mean dietary intake of minerals by lactating cows in the surveyed areas of different districts

District	Daily dry matter intake (kg)	Average milk yield L/day	Mineral intake						
			Ca (g)	P (g)	Mg (g)	Cu (mg)	Zn (mg)	Fe (mg)	Mn (mg)
Thiruvananthapuram	8.60± 0.12	7.06± 0.27	48.79± 2.01	42.29± 1.59	27.53± 0.69	149.70± 14.10	436.00± 7.98	4933.00± 147.00	529± 4.32
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	6935.00± 218.00	426± 8.93
Alleppey	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	6958.00± 293.00	359± 11.23
Pathanamthitta	10.35± 0.24	8.17± 0.37	41.00± 1.15	43.07± 2.00	34.40± 1.30	233.33± 14.28	615.72± 14.77	10073.00± 334.00	493± 10.19
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	8796.00± 330.00	537± 8.42
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	8221.00± 300.00	471± 7.39
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	6317.00± 157.00	396± 12.62
Thrissur	9.85± 0.18	6.51± 0.30	41.46± 1.89	42.61± 1.50	29.86± 0.9	190.65± 12.72	497.35 10.51	5930.00± 0.18	423± 5.26
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	503.6 ± 15.34	6051.00± 239.00	499± 7.39
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	4963.00± 147.00	463± 7.19
Kozhikode	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	7416.00± 213.00	352± 8.26
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	7260.00± 239.00	423± 8.15
Wyanad	8.85± 0.17	7.22± 0.63	37.47± 1.74	39.87± 2.24	31.31± 1.45	195.00± 22.4	546.00± 14.51	7207.00± 254.00	516± 7.26
Kasargod	9.06± 0.25	5.92± 0.46	26.83± 1.35	28.54± 2.27	28.21± 1.34	133.32± 19.01	433.00± 25.00	8160.00± 395.00	386± 7.28

Table 12. Normal rainfall in Kerala - District wise/monthwise details

(in millimetres)

District	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Thiruvananthapuram	22	19	45	120	225	377	279	157	170	280	182	67	1943
Kollam	24	31	75	166	242	487	428	273	212	350	216	60	2554
Alleppey	28	41	99	202	306	585	550	372	272	339	242	62	3098
Pathanamthitta	25	27	56	129	323	637	547	327	271	333	228	61	2964
Kottayam	24	24	52	125	310	397	640	400	285	331	188	55	3137
Idukky	19	23	47	129	228	638	831	518	305	310	167	50	3265
Ernakulam	15	17	41	134	318	740	721	451	288	312	172	45	3254
Thrissur	7	10	27	86	296	769	759	443	257	301	144	31	3130
Palakkad	8	9	27	87	161	477	633	349	165	249	136	28	2329
Malappuram	5	7	21	86	221	688	797	399	205	291	157	30	2907
Kozhikode	9	7	21	93	297	925	1034	547	257	284	157	36	3667
Kannur	7	9	23	99	183	762	1261	644	252	226	99	23	3588
Wyanad	4	4	8	64	244	891	1085	570	249	226	99	23	3467
Kasargod	5	3	9	51	226	1004	1081	610	269	209	91	23	3581
State average	14	17	39	112	256	691	760	433	247	288	163	42	3063

Discussion

DISCUSSION

5.1. Nutritional survey

During the survey work conducted in the farmer's homesteads in different districts of the state, it was observed that majority of the farmers maintained crossbred cows with an average milk yield ranging from 6.0 to 8.0 kg (Table 1). It was further observed that many of the households were also having other animals such as goats and buffaloes in addition to cows, the percentage of households rearing goats varying from 11 to 50, the minimum percentage being noticed in Ernakulam and Kannur districts while about 50 per cent of the farmers in Malappuram and Kozhikode districts reared goats in addition to cows. A small proportion of farmers in some of the districts also maintained buffaloes in addition to cows and goats, the percentage of households rearing buffaloes ranging from 8 to 17.6. Among the households surveyed, a small proportion of the farmers in all the districts except Kollam and Thrissur were found to practise fodder cultivation for feeding their animals, the percentage varying from 6 to 19. The details collected on the type of fodder fed to cattle in different districts indicate that majority of households were using grass and straw as the roughage, the percentage ranging from 38.90 to 100. In 12 districts, 16.7 to 50.0 per cent of households were using grass as the only roughage while in seven districts only 5 to 34 per cent of the households were seen feeding straw as the sole roughage for their cattle. It was further observed that the farmers in the southern districts (5.6 to 36.0%) viz., Thiruvananthapuram, Kollam, Pathanamthitta and Alleppey used unconventional feeds such as treeleaves, banana leaves, weeds, tapioca stem and leaves for feeding their animals. The details collected on the type of concentrate feeds fed to the animals in the surveyed area indicate that majority of farmers used a mixture of ready to feed compounded feed and feed ingredients except in Pathanamthitta and Ernakulam districts, the percentage of such farmers ranging from 44.0 to 78.0. Farmers in all districts except Kannur used individual concentrate feed ingredients for feeding their animals, but the proportion of such farmers being less to the extent of 13.9 to 45.0 per cent only. Ready to feed compounded feeds purchased from market was seen used by farmers of only 10 districts, the proportion of such farmers being 14.0 to 41.7 per cent which is almost similar to those who practice feeding of individual feed ingredients. However, compounded feed was alone was not fed by farmers in the districts of Pathanamthitta, Palakkad, Wyanad and Kasargod.

The results of the survey also reveal that feeding of separate mineral mixture was practised by farmers in all the districts though the percentage of such farmers ranged from

17 to 58, the lowest percentage being noticed in Kottayam district and the highest in Pathanamthitta district. The percentage of households which reported reproductive/ nutritional disorders also varied from 16.5 to 52.8 in different districts, the lowest being from Palakkad and the highest from Kozhikode.

5.2 Soil

5.2.1 Characteristics

The data presented in Table 2 on the soil characteristics of different districts in Kerala reveal that texture of surface layers of soil in Kerala covers a wide range of sandy to clay, their relative proportion being 4 per cent sandy, 59 per cent loamy and 30 per cent clay. About 82 per cent of the area in Kerala has moderately or well drained soils.

5.2.2 Analysis

The data on the average mineral concentration of soil in different districts of Kerala are presented in Table 3.

5.2.2.1 Calcium

The figures presented in Table 3 in regard to the calcium content of soils in different districts show that the level of calcium ranged from 0.03 to 0.1 per cent, the least value being recorded for Wayanad district and the highest for Kasargod district. The levels of soil calcium in all the districts were below the critical limit of 0.1 per cent (Kanwar, 1979) except for Kasaragod district. The calcium level of soils in the different districts of Kerala was found to be comparatively much less than that reported by Jackson (1967) who observed a level of 0.1 to 0.7 per cent calcium in the tropical soils.

Statistical analysis of the results presented in Table 3.1 and represented in Fig.1 indicate that significant difference ($P<0.01$) exists in the calcium content of soils between the different districts of Kerala.

5.2.2.2 **Phosphorus**

It can be seen from the table that the level of soil phosphorus in different districts in Kerala ranged from 40.29 to 124.65 ppm, the lowest value being noticed for Kottayam district and the highest value for Thrissur district. The soil phosphorus level was found to be within the normal range of 45 to 130 ppm reported by Jackson (1967). The values observed in the different districts in the present study were also, in general agreement with those reported by Das *et al.* (1992) except for Kottayam district which recorded a slightly low value. The results are also in keeping with those of

Muralidharan (1992) and Sakeer (1997) who reported normal levels of phosphorus in soils in Northern Kerala.

Statistical analysis of the results presented in Table 3.2 and its graphic representation in Fig.2 indicate that significant difference ($P<0.01$) exists in the phosphorus contents of soils between the districts.

5.2.2.3 **Magnesium**

The results obtained in the present study in regard to the magnesium content of soil presented in Table 1 reveal that the lowest concentration of magnesium was reported from Alleppey district (0.01%) and the highest concentration from Thiruvananthapuram district (0.061%).

The data further reveal that the levels of magnesium noticed in the present study were within the normal range in all districts when compared to the critical limit of 0.012 per cent reported by Kanwar (1979). Further, the values obtained for the districts of Thiruvananthapuram, Kollam, Pathanamthitta, Idukki, Ernakulam and Kannur were also found to agree well with those reported by Jackson (1967) who observed a level of 0.03 to 0.12 per cent in soils of Hissar. However, the other districts recorded a lower value for soil magnesium.

Statistical analysis of the results presented in Table 3.3 and represented in Fig.3 indicate that significant difference (P<0.01) exists in the magnesium contents of soil between the districts.

5.2.2.4 Copper

A perusal of the data presented in Table 1 on the copper content of soils in the different districts reveals that the values ranged from 2.01 to 8.10 ppm, the least value being recorded in Waynad and the highest value in Thrissur district. The levels in different districts were well below the critical level of 9 ppm reported by Kanwar (1979). The results obtained in the present study in regard to the copper content of soil are in agreement with those reported by Jose *et al.* (1985) who reported deficiency of available copper in soils of Kerala. Further, the levels obtained for districts other than Alleppey and Thrissur are also in keeping with the values observed by Das *et al.* (1990). However, Lall *et al.* (1994) recorded a value similar to the soil copper level observed in Kottayam district in the present study.

Statistical analysis of the results presented in Table 3.4 and represented in Fig.4 indicate that significant differences (P<0.01) exist in the copper content of soils between the different districts of Kerala.

5.2.2.5 Zinc

Soil zinc levels presented in Table 3 reveal that the values for different districts in Kerala ranged from 3.39 ppm (Kozhikode district) to 7.77 ppm (Alleppey district), all the districts having a level well above the critical level of 1.5 ppm reported by NRC (1980). It is seen that the results obtained in the present study are in keeping with those of Das *et al.* (1990), Muralidharan (1992) and Sakeer (1997) while at variance with that of Lall *et al.* (1994) who recorded a lower value of 1.09 to 3.81 ppm in soils of Hissar. However, the results obtained in the present study are also at variance with those of Rajagopal *et al.* (1977) who reported zinc deficiency in soils from Thiruvananthapuram, Alleppey, Kottayam, Thrissur, Palakkad and Kozhikode districts and Jose *et al.* (1985) who reported deficiency of zinc in soil throughout Kerala.

From Table 3.5 on the statistical analysis of the results and Fig.5, it can be seen that the differences in the zinc levels observed between the different districts are statistically significant ($P<0.01$).

5.2.2.6 Iron

Data presented on soil iron contents in Table 3 reveal that wide variations existed in the iron content of soils in different districts of Kerala, Thrissur recording the highest value of 295.69 ppm and Kasargod, the least value of 47.78 ppm, all the districts having a level much above the critical level of 20 ppm (NRC, 1980). The results obtained in the present study in this regard are in keeping with those reported by Jose *et al.* (1985) and Das *et al.* (1990) except for the district of Kasargod while they are at variance with those of Bedi and Khan (1989) and Lall *et al.* (1994) who observed a very low value of about 5 to 8 ppm. Statistical analysis of the results presented in Table 3.6 and its graphic representation in Fig.6 indicate significant difference ($P<0.01$) in the iron content of soils of different districts.

5.2.2.7 Manganese

Manganese content of soils presented in Table 3 indicate that the lowest value of 13.9 ppm was recorded from Idukki district and the highest value of 62.5 ppm from Kozhikode district, the levels in all the districts being much below the critical level of 200 ppm (Kanwar, 1979). The results obtained in this regard are in agreement with those of Rajagopal *et al.* (1977) who reported deficiency of manganese in soils from some of the districts in Kerala and Das *et al.* (1990). The levels obtained for districts other than Pathanamthitta, Idukki and Thrissur are also in keeping with those recorded by Bedi and Khan (1989).

Statistical analysis of the results presented in Table 3.7 and its graphic representation in Fig.7 indicate that significant differences (P<0.01) exist in the manganese content of soils between the different districts.

From a critical evaluation of the soil levels of different minerals in different districts and a comparison of the same with that of the critical limit reported for the same in literature, it can be seen that the level of iron in soil from all the districts was much higher than the critical limit, while there was a general deficiency of copper and manganese throughout the state, the level of magnesium and zinc being adequate in all districts. The soils from all districts were found to be low in calcium except Kasargod while phosphorus deficiency was noticed only in Kottayam district.

The variations observed in the soil mineral levels in different districts are partly attributable to the different agroclimatic zones in which the districts are situated and partly due to the difference in season in which the survey and collection of the materials for analysis were carried out.

5.3 Analysis of concentrate mixtures and feed ingredients

5.3.1 Concentrate mixtures

The concentrate mixtures collected for mineral analysis from farmers' homesteads during the survey work in different districts included:

1. Ready to feed compounded feeds purchased from the market which were fed as the sole source of concentrates for the animals.

2. A mixture of ready to feed compounded feeds and protein supplements like oil cakes or other feeds, the selection of other feeds being made depending upon the choice of the farmer which varied from place to place.

The data on the average mineral content of concentrate mixtures are summarised and presented in Table 4.

5.3.1.1 Calcium

The data presented in Table 4 on the calcium content of concentrate mixtures indicate that wide variation existed in the calcium content from district to district, the range in calcium levels being 0.33 to 0.96 per cent, Kasaragod having the least amount of calcium and Alleppey, the highest level.

It can be further seen that the levels of calcium in feeds collected from Idukki and Kasaragod were well below 0.45 per cent, the level fixed as the dietary requirement of calcium for dairy cattle by NRC (1989a).

Statistical analysis of the results presented in Table 4.1 and the graphic representation in Fig.8 indicate significant differences (P<0.01) in the calcium content of concentrate mixtures collected from different districts.

5.3.1.2 Phosphorus

A perusal of Table 4 presenting the data on phosphorus content of concentrate mixtures indicates that in different districts the levels of phosphorus ranged from 0.59 (Wayanad district) to 0.92 per cent (Thrissur district), the levels in all districts being adequate when compared with the dietary requirement of the element for dairy cattle (0.3%) reported by NRC (1989a).

Statistical analysis of the results presented in Table 4.2 and its graphic representation in Fig.9 indicate significant difference (P<0.01) in the phosphorus content of concentrate mixtures collected from different districts.

5.3.1.3 Magnesium

Magnesium content of concentrate mixtures collected during the survey work presented in Table 4 shows that the level in different districts varied from 0.4 to 0.65 per cent, the lowest level being recorded from Idukki district and the highest level from Thrissur district. The data, further, reveal that magnesium level in the feeds collected from all the districts was much higher than the dietary requirement of 0.2 per cent set by NRC (1989a).

Statistical analysis of the results presented in Table 4.3 and represented in Fig.10 indicate significant difference ($P<0.01$) between the magnesium contents of concentrate mixtures collected from different districts.

5.3.1.4 Sodium

The data presented in Table 4 on the sodium content of concentrate mixtures indicate that the levels ranged from 0.04 per cent in Thiruvananthapuram district to 0.11 per cent in Ernakulam district. Comparison of the sodium levels obtained in the present study with that of the dietary requirement of the element for dairy cattle of 0.18 per cent reported by NRC (1989a) indicates that feeds from all districts had a much lower content of the element.

Statistical analysis of the results presented in Table 4.4 and its graphic representation in Fig.11 indicate that significant differences (P<0.01) exist in the sodium content of concentrate mixtures collected from different districts.

5.3.1.5 Potassium

The values obtained on potassium content of concentrate feeds collected during the survey work, presented in Table 4 reveal that the least concentration was recorded for Wyanad district (0.41%) and the highest for Idukki district (0.76%). It is, further, observed that the potassium levels in feeds from different districts were much below the dietary requirement of 0.9 per cent reported by NRC (1989a).

Statistical analysis of the results presented in Table 4.5 and represented in Fig.12 indicate that significant difference (P<0.01) exists in the potassium content of concentrate mixtures collected from different districts.

5.3.1.6 Copper

A perusal of the data presented in Table 4 on the copper level of concentrate mixtures collected from different districts indicate that Idukki district had the lowest level of copper (11.72 ppm) and Alleppey the highest level

(21.92 ppm), the feeds collected from all districts having adequate level of copper when compared with the dietary requirement of the element for dairy cattle (10 ppm) set by NRC (1989a).

Statistical analysis of the results presented in Table 4.6 and represented in Fig.13 indicate that significant difference ($P<0.01$) exists in the copper content of concentrate mixtures between the different districts.

5.3.1.7 Zinc

Values on zinc levels of concentrate mixtures presented in Table 4 show that zinc concentration was the least in feeds collected from Palakkad district (16.16 ppm) and highest in Alleppey district, the levels in all districts except Palakkad being adequate when compared with the dietary requirement of 40 ppm, set by NRC (1989a).

Statistical analysis of the results presented in Table 4.7 and represented in Fig.14 indicate that significant difference ($P<0.01$) exist in the zinc content of concentrate mixtures between the different districts.

5.3.1.8 Iron

Data presented in Table 4 on the iron content of concentrate mixtures collected from different districts show wide variation between the districts in this regard, Malappuram district having the lowest concentration of 837 ppm and Pathanamthitta, the highest concentration of 2499.85 ppm. It is, further, observed that the levels in all the districts were much higher than the 50 ppm level set as the dietary requirement of the element by NRC (1989).

Statistical analysis of the results presented in Table 4.8 and its graphic rerepresention in Fig.15 indicate that significant difference ($P<0.01$) exists in the iron content of concentrate mixtures between the different districts.

5.3.1.9 **Manganese**

Levels of manganese estimated in feeds collected from various districts set out in Table 4, indicate that the range in manganese content was from 30.3 ppm observed for feeds from Kasargod district to 70.1 ppm for feeds from Kottayam district. On a comparison of the dietary requirement of the element for dairy cattle (40 ppm) set by NRC (1989a), it can be seen that the levels were satisfactory in all districts except Alleppey, Kozhikode and Kasargod.

Statistical analysis of the results presented in Table 4.9 and graphic representation in Fig.16 indicate that significant difference ($P<0.01$) exists in the manganese content of concentrate mixtures between the different districts.

A critical comparison of the levels of various minerals in the concentrate mixtures collected from the different districts with that of the dietary requirement for them, it can be seen that the levels of iron in feeds from all districts were much higher, the levels of phosphorus, magnesium and copper adequate, the levels of calcium adequate in all districts except Idukki and Kasargod, zinc adequate except in Palakkad and manganese adequate except in Alleppey, Kozhikode and Kasargod. However, the levels of sodium and potassium were found to be lower than their dietary requirements in all the districts. The variations observed in the mineral content of concentrate mixtures procured from different districts is partly accounted by the variation in the nature of feeds collected from farmers homesteads such as compounded feed alone or compounded feed diluted by the addition of other feed ingredients with or without the addition of mineral supplements.

5.3.2 Analysis of feed ingredients

The average mineral concentration of various concentrate feed ingredients collected from different districts during the survey work are presented in Table 5.

5.3.2.1 Groundnut cake

The data presented on the mineral content of groundnut cake indicate that the levels obtained in the present study in regard to the concentration of calcium, phosphorus, sodium, copper and manganese are in accordance with those reported by Ensminger (1990) and McDowell (1992). The concentration of iron and zinc obtained in the present study are much higher than those reported by Ensminger (1990) and McDowell (1992). Almost similar values obtained in the present study have been reported by Morrison (1957) and Arora (1978) in regard to calcium and phosphorus, Banerjee (1985) in regard to phosphorus and Ranjhan (1994) in regard to copper.

5.3.2.2 Coconut cake

The figures presented (Table 5) indicate that the concentration of phosphorus, sodium, zinc and iron obtained in the present study are in general agreement, the concentration of potassium and manganese lower and that of calcium, magnesium and copper higher in comparison to those reported by Ensminger (1990). However, the levels of calcium and phosphorus obtained in the present study were higher than those reported by Arora (1978).

5.3.2.3 Gingelly cake (Sesame cake)

The mineral contents of gingelly cake presented in the table reveal that the values obtained in the present study in regard to the content of calcium, magnesium and sodium are in general agreement, that of phosphorus, potassium, zinc and manganese comparatively lower and the iron content very much higher than those reported by Ensminger (1990). The levels in regard to potassium, zinc and Manganese are in keeping with those of Banerjee (1985).

5.3.2.4 Rice bran

A perusal of the data on the concentration of minerals in rice bran reveals that the levels obtained in regard to of calcium, zinc and iron are much higher, those of phosphorus, potassium and manganese lower while those of sodium and copper in agreement with those of Ensminger (1990) and Mc Dowell (1992).

5.3.2.5 Wheat bran

The figures presented on the mineral concentration of wheat bran indicate that the levels of all minerals except iron are in agreement with those reported in literature (Mc Donald *et al.*, 1987; Ensminger, 1990; Mc Dowell, 1992), the value of iron being very much higher than those observed by the above workers. The levels of calcium and phosphorus obtained in the present study are also in keeping with those of Morrison (1957) and Banerjee (1985).

5.3.2.6 Rice grain

The results presented in table on the mineral concentration of rice grain reveal that the contents of calcium, phosphorus, sodium, potassium and iron are higher, copper and manganese lower and magnesium and zinc almost similar to those reported by Ensminger (1990).

5.3.2.7 Tamarind seed

The mineral concentrations of tamarind seed presented in table reveal that the contents of different minerals are almost similar to that of rice grain. The information regarding the mineral contents of tamarind seed is scanty in literature. However, the phosphorus level observed, in the present study was almost in agreement with those of Kunjikutty (1969) and Anonymous (1993), while the content of calcium was found to be much below the figures reported for the same by the above workers.

5.4 Analysis of mineral mixtures

Data on mineral contents of mineral mixtures collected from different districts during the survey work, set out in Table 6, indicate that the calcium content of the samples (both type I and type II) ranged from 25.28 to 32.34 per cent while the phosphorus content ranged from 6.14 to 12.68 per cent. The range for copper, zinc, iron and manganese contents were 0.05 to 0.43 per cent, 0.03 to 0.19 per cent, 0.24 to 1.23 per cent and 0.02 to 0.56 per cent respectively. A comparison of the mineral concentration of the mineral mixtures obtained in the present study with those of the BIS standard (1982) for the various elements, it can be seen that 37.5 per cent of the samples had an excess calcium content, 75 per cent samples excess in copper, 75 per cent excess in iron and 37.5 per cent samples excess in manganese while 50 per cent of the samples were deficient in Phosphorus, 12.5 per cent deficient in copper, 75 per cent deficient in zinc, 12.5 per cent deficient in iron, and 37.5 per cent of samples deficient in manganese, apart from a higher content of acid insoluble ash in 50 per cent of the samples. None of the mineral mixtures analysed in the present study was found to conform fully to the BIS Standard, the contents of most of the minerals being either high or low in comparison to the standard. The results obtained in the present study in this regard are in accordance with the observations of Lall and

Prasad (1991) who also observed wide variations in the mineral content of mineral mixtures for cattle in India available in the market in that they were either deficient or excess in one or more of the essential elements. The results of the present study warrant strict regulations for quality control of all mineral mixtures marketed in the country.

5.5 Analysis of natural (local) grass

The data on the average mineral concentration of natural grass collected from farmers' doorsteps during the survey work in different districts of Kerala are presented in Table 7.

5.5.1 Calcium

From the table, it can be seen that calcium content of natural grass varied from 0.22 to 0.58 per cent in different districts, the least value being recorded from Kasargod district while the highest value from Palakkad district. The results also reveal that levels of calcium in natural grass were above the critical limit of 0.3 per cent suggested by NRC (1989a), in all districts except Thiruvananthapuram, Kottayam, Idukki, Malappuram, Kozhikode and Kasargod. The values obtained in the present study for the different districts agree well with those reported by Mc Dowell (1992), while Lall *et al.* (1996) recorded a higher value of 0.64 per cent for local grasses in Hissar.

Statistical analysis of the results presented in Table 7.1 and its graphic representation in Fig.17 indicate significant differences ($P<0.01$) in the calcium content of natural grass collected from different districts.

5.5.2 Phosphorus

A perusal of the data presented in Table 7 on the phosphorus content of natural grass collected from various districts during the survey work indicates that the content varied from 0.19 to 0.32 per cent. The samples from Thiruvananthapuram had the lowest value while that from Wyanad had the highest value. It is, further, seen that the phosphorus levels in the fodder samples from all districts except Kollam, Alleppey, Kannur and Wyanad were lower than the critical limit of 0.25 per cent reported by NRC (1989a). The figures obtained for the phosphorus content of grass from all the districts in the present study are in keeping with those observed by Das *et al.* (1992) while they were much lower than those reported by Lall *et al.* (1996).

Statistical analysis of the results presented in Table 7.2 and represented in Fig.18 indicate that significant differences ($P<0.01$) exist in the phosphorus content of natural grass between the different districts.

5.5.3 Magnesium

Data presented in Table 7 on the magnesium content of natural grass reveal that the levels ranged from 0.17 per cent (Kozhikode district) to 0.27 per cent (Malappuram district). It can be, further, seen that except for the districts of Thiruvananthapuram, Kollam, Kozhikode and Kannur, the levels of magnesium in all other districts were above the critical limit of 0.20 per cent suggested by NRC (1989a). The magnesium levels obtained in the present study in regard to the natural grass from all the districts were also found to be in general agreement with those reported by Das *et al.* (1992).

Statistical analysis of the results presented in Table 7.3 and represented in Fig.19 indicate that significant differences ($P<0.01$) exist in the magnesium content of natural grass between the different districts.

5.5.4 Sodium

Sodium content of natural grass collected from the various districts presented in Table 7 and Fig.20 indicates that the levels ranged from 0.05 per cent to 0.11 per cent, the least value being observed in Kottayam district and the highest value in Pathanamthitta district. Information available on the sodium content of natural grasses is rather scanty in literature. However, the levels obtained for the various districts in the present study except Kottayam district are well above the critical limit of 0.06 per cent reported by NRC (1989a).

Statistical analysis of the results presented in Table 7.4 indicates non significant differences in the sodium content of natural grass between the different districts of Kerala.

5.5.5 Potassium

A perusal of the data presented in Table 7 on the potassium content of natural grass reveals that the levels ranged from 0.53 per cent (Thiruvananthapuram district) to 1.26 per cent (Kozhikode district). It can be, further, seen that but for the slightly lower levels in the districts of Thiruvananthapuram, Palakkad and Malappuram districts, in all other districts in the state the potassium levels were much above the critical level of 0.6 per cent reported by NRC (1989a).

The statistical analysis of the results presented in Table 7.5 and its graphic representation in Fig.21 indicate significant differences in the potassium content of natural grass of different districts.

5.5.6 Copper

A perusal of the copper content of natural grass presented in Table 7 reveals that the level ranged from 4.19 to 23.95 ppm, the lowest level being noticed in Kozhikode district and the highest in Idukki district. It can be further, seen that in all districts except Alleppey, Pathanamthitta, Idukki, Thrissur, Palakkad and Malappuram, the copper levels were below the critical limit of 10 ppm reported by NRC (1989a). The values obtained in the present study in this regard are much lower than those reported by Das *et al.* (1990) for local grasses and Lall *et al.* (1996) for *Cyanadon dactylon*. However, Patel (1966) reported copper levels ranging from 7 to 15 ppm in different types of grasses from Western India.

Statistical analysis of the results presented in Table 7.6 and its graphic representation in Fig.22 indicate significant differences (P<0.01) in the copper content of natural grass of different districts.

5.5.7 Zinc

Zinc content of natural grass from different districts collected during the survey work presented in Table 7 indicates that the levels ranged from 11.01 (Kozhikode district) to 81.70 ppm (Pathanamthitta district). The levels in all districts except Kozhikode were found to be above the critical limit of 30 ppm reported by NRC (1989a). The levels obtained in the present study except for Kozhikode district are almost in accordance with those reported by Das *et al.* (1990). The results in regard to Thiruvananthapuram, Kollam, Ernakulam and Palakkad are also in keeping with those observed by Lall *et al.* (1996) for local grasses in Hissar.

Statistical analysis of the results presented in Table 7.7 and its graphic representation in Fig.23 indicate that significant difference ($P<0.01$) exists in the zinc content of natural grass of different districts.

5.5.8 Iron

Data presented in Table 7 on the iron content of natural grass collected from different districts of Kerala indicate that wide variations exist in the iron content, Thiruvanathapuram district registering the least value of 336.09 ppm while Kozhikode district, the highest value of 917.94 ppm. The data, further, reveal that the iron levels in all the districts are much above the critical limit of 30 ppm reported by NRC (1989a). Wide variations in the iron content of fodder have also been reported by Das *et al.* (1990) and Mc Dowell (1992) who observed variations to the extent of 10 to 2599 ppm in different types of pasture grasses.

Statistical analysis of the results presented in Table 7.8 and its graphic representation in Fig.24 indicate that significant differences ($P<0.01$) exist in the iron content of natural grass from different districts.

5.5.9 **Manganese**

Manganese levels in natural grass presented in Table 7 and Fig.25 indicate that the contents ranged from 9.71 (Wyanad) to 56.10 ppm (Kottayam district). Except for Kottayam district, the manganese levels in all other districts were found to be much below the critical limit of 30 ppm reported by NRC (1989a). However, the results obtained in this regard in samples from the districts of Palakkad, Malappuram and Kannur are almost similar to those reported by Lall *et al.* (1996) for local grasses in Hissar, while higher values ranging from 33.47 to 99.63 ppm have been reported for *Cyanodon dactylon* by Das *et al.* (1990).

Statistical analysis of the results presented in Table 7.9 reveals non significant differences between districts in the manganese content of natural grass.

From an overall assessment of the mineral levels in the local grass collected from different districts and their comparison with that of the critical limit for the same, it can be seen that the iron levels in all districts were much higher than the limit required while manganese levels were lower in all districts except Kottayam. Phosphorus deficiency was seen in 10 districts and was more wide spread followed by copper (eight districts), calcium (six districts), magnesium (four districts) and potassium (three districts), while sodium and zinc deficiency were noticed in one district. Thiruvananthapuram, Kottayam, Ernakulam, Calicut and Kasargod districts had low contents of phosphorus and copper and except for Ernakulam low level of calcium. The occurrence of deficiency of certain minerals was of scattered nature in that zinc deficiency was noticed only in Kozhikode district, sodium deficiency in Kottayam and potassium deficiency in Thiruvananthapuram, Palakkad and Malappuram districts.

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 condition.

5.6 Analysis of paddy straw

The data on the average mineral concentration of straw collected from farmers doorsteps during the survey work in different districts of Kerala are presented in Table 8.

5.6.1 Calcium

From the table it can be seen that calcium content of straw varied from 0.17 to 0.48 per cent in different districts, the least value being recorded from Palakkad district and the highest value from Pathanamthitta district. The values obtained in the present study for the different districts agree well with those reported by Morrison (1957) and Ensminger (1990) except for the districts of Pathanamthitta and Kollam which recorded a higher value of 0.48 and 0.36 per cent respectively. However, the results obtained in the present study are in agreement with those of Devasia *et al.* (1976) who reported calcium contents ranging from 0.26 to 0.67 per cent in different hybrid varieties of paddy straw.

5.6.2 Phosphorus

Data on the phosphorus content of straw reveal that the levels ranged from 0.06 (Idukki district) to 0.14 per cent (Ernakulam district), the levels in the straw from all the districts obtained in the present study being essentially in agreement with those reported by Morrison (1957) and Ensminger (1990). However, higher values ranging from 0.15 to 0.54 per cent have been reported by Devasia *et al.* (1976) for different hybrid varieties of paddy straw.

5.6.3 Magnesium and Potassium

A perusal of the data presented in Table 8 on the magnesium content of straw collected from various districts during the survey work indicates that the content varied from 0.15 to 0.27 per cent. The samples from Thrissur had the lowest value while that from Idukki the highest value. The values obtained in the present study are in keeping with those of Ensminger (1990).

The data set out in Table 8 further reveal that the potassium content of straw varied from 1.10 to 1.58 per cent, the observation in this regard being essentially in agreement with those of Morrison (1957) and Ensminger (1990) while at variance with those of Devasia *et al.* (1976) who reported a lower value ranging from 0.25 to 0.80 per cent for different hybrid varieties of paddy straw.

5.6.4 Sodium

Sodium content of straw collected from the various districts, presented in Table 8 indicates that the levels ranged from 0.19 to 0.29 per cent, the least value being observed in Kasargod district and the highest value in Kottayam district. The levels obtained for samples from various districts are found to be in general agreement with those observed by Devasia *et al.* (1976). However, higher values have been observed by Ensminger (1990) in this regard.

5.6.5 Copper

A perusal of the copper content of samples of straw presented in Table 8 reveals that the level ranged from 4.39 to 23.43 ppm, the lowest level being noticed in Kannur district and the highest level in Pathanamthitta district. The values obtained are almost in agreement with those reported by Ranjhan (1994). The values obtained also agree well with those reported by Bedi and Khan (1989) except for the districts of Ernakulam and Kannur which recorded a lower value.

5.6.6 Zinc and Iron

Figures presented on the zinc content of straw indicate that the levels ranged from 39.71 (Thrissur district) to

66.11 ppm (Kollam district). The levels in all districts were found to be higher than those reported by Patel *et al.* (1966) and Bedi and Khan (1989).

Data set out in the Table 8 indicate that the iron contents of straw showed very wide variations from 344.37 (Palakkad district) to 2003.05 ppm (Pathanamthitta district). The levels seen in all districts are much higher than the values reported by Patel *et al.* (1966) and Bedi and Khan (1989).

5.6.7 Manganese

Manganese levels in straw presented in Table 8 indicate that the contents ranged from 40.20 (Kannur district) to 107.90 ppm (Thrissur district). The values obtained in the present study are found to be in agreement with those reported by Patel *et al.* (1966) and Bedi and Khan (1989) except for the districts of Kannur, Wyanad and Kasargod which recorded very low values.

Statistical analysis of the results presented in Table 8.1 to 8.9 and their graphic representation in figure 26 to 34 indicate that significant differences ($P<0.01$) exist in the mineral contents (both macro and micro) of straw from different districts, the variations being attributable to the differences in the variety of straws available for feeding in various areas and the differences in the soil/region from which the straw was harvested.

5.7 Analysis of serum

The summarised data on the average concentration of calcium, phosphorus, magnesium, sodium, potassium, copper, zinc, iron and manganese in serum collected from lactating cattle maintained in different districts are set out in Table 9. The results are discussed under the following subheads.

5.7.1 Calcium

The data presented in Table 9 on the average serum calcium content of lactating cows in different districts reveal that the calcium content varied from 7.06 to 10.19 mg per 100 ml, the lowest value being recorded from Kottayam district and the highest value from Thiruvananthapuram district. The data further reveal that the serum from cattle maintained in Kottayam, Wyanad and Kasargod districts had less calcium concentration than the normal range of 8-11 mg per 100 ml reported by Underwood (1981), the normal level of serum calcium required for effective reproductive process in cattle as per Maynard *et al.* (1979) being 8-12 mg/100 ml.

Statistical analysis of the results presented in Table 9.1 and its graphic representation in Fig.35 indicate significant differences ($P<0.01$) in the calcium content of serum in cattle from different districts.

5.7.2 Phosphorus

A perusal of the data on average phosphorus concentration in serum indicates that the average level ranged from 4.12 mg/100 ml (Kannur district) to 5.88 mg/100 ml (Idukki district). According to Maynard *et al.* (1979) the normal level of serum inorganic phosphorus ranges from 4 to 9 mg/100 ml whereas a serum level of less than 4 mg/100 ml was reported to be indicative of phosphorus deficiency in cattle (Pillai, 1980). In cattle of Haryana which had a serum phosphorus level of 1.02 to 5.24 mg/100 ml, Singhal and Lohan (1988) opined mineral deficiency as a probable contributing factor to infertility. However, the values obtained for cattle in Thiruvananthapuram and Kannur were found to be slightly lower than the normal range of serum phosphorus of 4.5 to 7 mg/100 ml reported by Underwood (1981).

Statistical analysis of the results presented in Table 9.2 and its graphic representation in Fig.36 indicate significant differences ($P<0.01$) in the phosphorus content of serum of cattle from different districts.

5.7.3 Magnesium

Serum magnesium concentration of lactating cattle maintained in different districts set out in Table 9 indicates that cattle in Pathanamthitta district recorded the least value of 1.75 mg/100 ml whereas those of Kollam district recorded the highest value of 2.96 mg/100 ml. It can be further observed that the animals in all districts maintained a normal serum magnesium level when compared to the normal range of 1.8 to 3.2 mg/100 ml reported for the same by Underwood (1981). However, the normal concentration of serum magnesium in cattle reported by Kaneko (1989) ranged from 2 to 5 mg/100 ml. Whitaker (1982) reported clinical hypomagnesaemia in one per cent dairy cows in England and subclinical hypomagnesaemia in seven per cent milking cows and 15 per cent of dry cows with serum magnesium levels of less than 1.9 mg/dl.

Statistical analysis of the results presented in Table 9.3 and its graphic representation in Fig.37 indicate significant differences (P<0.01) between the magnesium content of serum of cattle from different districts.

5.7.4 Sodium

A perusal of the data presented in Table 9 and Fig.38 on sodium content of serum of lactating cattle reveals that those maintained in Alleppey district showed the least sodium concentration (126.81 meq/litre) in serum while those in Palakkad recorded the highest value of 152.69 meq/litre. It is further observed that the values obtained for animals in Thiruvananthapuram, Pathanamthitta, Kottayam, Idukki, Palakkad, Kannur and Wyanad district were all within the normal range of 130 to 150 meq/litre) reported by Underwood (1981) in this regard. A level of 132 to 152 meq/litre of serum sodium has been suggested as normal for cattle by Kaneko (1989).

Statistical analysis of the same, the data of which are presented in Table 9.4, indicate non significant differences between the various districts in regard to the sodium content of serum.

5.7.5 Potassium

Levels of serum potassium in lactating cattle maintained in different districts presented in Table 9 indicate that animals in Pathanamthitta district showed the least potassium level of 3.87 meq/litre as against those in Kottayam district with 5.53 meq/litre. The results further reveal that animals in Alleppey, Pathanamthitta, Idukki and Kannur districts showed a slightly lower serum potassium level when compared to the normal values of 4.7 meq/litre reported by Underwood (1981). However, the levels obtained in the present study are in keeping with those of Kaneko (1989) who reported a normal value ranging from 3.90 to 5.80 meq/litre.

Statistical analysis of the results presented in Table 9.5 and its graphic representation in Fig.39 indicate significant differences (P<0.01) between the potassium content of serum in cattle from different districts.

5.7.6 Copper

The data presented in Table 9 on the serum copper level of lactating cattle indicate that the content ranged from 0.7 ppm to 1.41 ppm in different districts, the lowest level being recorded from animals in Kozhikode district and the highest from Alleppey district. The results further reveal that the animals in all districts maintained a normal serum copper level in as much as the values obtained were within the normal range of 0.6 to 1.5 ppm reported by Underwood (1981). However, Maynard *et al*. (1979) reported that a level of 1 ppm serum copper is necessary for normal reproductive process in cattle while Prasad *et al*. (1989) reported a level of 70 to 115 μg/100 ml of serum copper in normally cycling cattle.

Statistical analysis of the results presented in Table 9.6 and represented in Fig.40 indicate that significant differences (P<0.01) exist in the copper content of serum of cattle between the different districts.

5.7.7 Zinc

From Table 9 on the zinc levels in the serum of lactating cattle from different districts, it can be noted that the levels were in the range of 0.93 (Kozhikode district) to 1.92 ppm (Wyanad district). It can be further seen that the serum zinc levels in animals from Pathanamthitta, Idukki, Ernakulam and Kozhikode districts were lower than the normal range of 1.2 to 1.8 ppm (Underwood, 1981). However, Wegner (1973) reported that the normal zinc serum level in cattle varies from 0.85 to 1.75 ppm with a mean of 1.17 ± 0.039 ppm. Serum zinc levels of less than 0.9 ppm had been reported as a contributing factor to infertility in cattle in Haryana by Singhal and Lohan (1988), while Nickerk *et al.* (1990) grouped cattle showing a plasma zinc level below 80 μg/dl as zinc deficient.

Statistical analysis of the results presented in Table 9.7 and its graphic representation in Fig.41 indicate that significant differences ($P<0.01$) exist in the zinc content of serum of cattle between the different districts.

5.7.8 Iron

Results of analysis of serum collected from lactating cattle for iron levels, set out in Table 9 indicate that the least value for iron of 1.05 ppm was noticed in animals from

Pathanamthitta district and the highest value of 1.87 ppm from Malappuram district. The data further reveal that the iron levels in animals from all the districts were within the normal physiological range reported for lactating cattle by Underwood (1981).

Statistical analysis of the results presented in Table 9.8 and its graphic representation in Fig.42 indicate significant differences (P<0.01) in the iron content of serum of cattle between the different districts.

5.7.9 **Manganese**

From the data presented in Table 9 and Fig.43 on the serum manganese concentration of cattle maintained in different districts, it can be seen that the values ranged from 0.02 to 0.05 ppm, indicating that the animals in all districts have manganese levels within the normal physiological range of 0.02 to 0.1 ppm reported for cattle by Hansard (1983). Serum manganese level of below 0.02 ppm has been reported to be associated with anoestrus condition in heifers (Simeonov *et al.*, 1989).

Statistical analysis of the results presented in Table 9.9 indicates non significant difference in regard to the manganese content of serum between the cattle of different districts.

From an overall evaluation of the results obtained on analysis of blood serum from cattle maintained in different districts it can be seen that animals in all the districts maintained a normal mineral status in regard to all the minerals (phosphorus, magnesium, sodium, potassium, copper, zinc, iron and manganese) except calcium for which slightly lower levels were observed in cattle from Kottayam, Wyanad and Kasargod districts. The mild deficiency noticed in these districts may be due to the comparatively lesser dietary intake of the element possibly due to the differences in the feed ingredients used for feeding in these districts coupled with the presence of incriminating factors such as oxalate which reduce the availability of the elements and the high percentage of magnesium and iron in the ration.

5.8 Recorded cases on nutritional deficiency/ metabolic disorders/reproductive disorders

The data presented in Table 10 on the cases recorded in the veterinary institution in the areas surveyed, for a previous period of six months indicate that the incidence of metabolic diseases ranged from 2.64 to 3.76 per cent, not much variation being seen between the districts. The percentage incidence of deficiency diseases recorded ranged from 1.27 to 2.81. The percentage incidence of reproductive disorders other than abortion and dystocia was found to be from 8.34 to

13.16 per cent which was more than the incidence of either nutritional deficiency or metabolic diseases.

In as much as information on the nature of the actual nutrient (minerals, vitamins or other nutrients) involved in the different conditions recorded in the various institutions is lacking, it is rather difficult to predict the actual involvement of a mineral deficiency in the various conditions observed in the surveyed areas. However, a small proportion of the various conditions recorded is likely to be the result of a marginal deficiency of a mineral element/elements which might have gone undetected or due to reduced utilisation of the element as a result of the interaction of different minerals themselves or minerals and other organic fractions in the diet.

5.9 Dietary intake of minerals

Data on the average dietary intake of minerals by lactating cows in the surveyed areas, calculated from the total quantity of feeds consumed and their corresponding mineral concentration are presented in Table 11. From a comparison of the dietary intake of different minerals by animals maintained in different districts with that of their minimum requirement set by NRC (1989a), it can be seen that the intake of calcium was satisfactory only in

Thiruvananthapuram, Kollam, Alleppey, Ernakulam and Kozhikode districts, slightly lower in Thrissur, Palakkadu and Wyanad districts and grossly inadequate in Pathanamthitta, Idukki, Kottayam, Malappuram, Kannur and Kasargod districts. The lower dietary intake of calcium in these areas is attributable to the differences in the type of feeds and quality of mineral mixtures provided to animals in these areas. A perusal of the serum calcium levels of animals maintained in different districts (Table 9) indicate that only animals maintained in Kottayam, Wyanad and Kasargod districts exhibited slightly lower level of mineral in the blood whereas even animals maintained in some districts with a lesser dietary intake of the mineral showed a normal concentration for the same in the blood. The reason for a normal serum calcium concentration in animals maintained in districts with a lesser calcium intake is that a low calcium intake especially for a short period need not result in a low serum calcium level because of calcium homeostasis in the animal. However, the discrepancy obtained in this regard might also be due to the variations in the requirement of these animals in that the actual requirement of the animal would have been lesser because of the lesser milk yield at the time of survey with a consequent reduction in the feed provided, as against a higher estimated requirement which was based on the average milk yield of the cow during the entire lactation period. It may also be due to the fact that the animals would have received some quantity of fodder as a result of grazing during the rainy season which was not taken into account in calculating the dietary intake. An underestimation of the feed intake and thereby the 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.

The data presented in Table 11 also reveal that the dietary intake of animals in regard to phosphorus, magnesium, copper, zinc, iron and manganese in different districts was not only satisfactory but much higher when compared to the requirement set by NRC (1989a) for the above minerals, except in Kasargod district in which the intake of phosphorus was only just adequate to meet the requirement of the animals.

5.10 Relationship of mineral concentration of soils and plants with that of animals

On a critical evaluation of the levels of various minerals in soils and their relationship to the concentration of the same in plants and in the animals in each area, the following observations were made.

5.10.1 Calcium

The concentration of calcium in soil (Table 3) was found to be low in all districts except Kasargod, Wyanad district having the least concentration of the element. The local grass samples collected from the various districts (Table 7) were also found to be lower in the element except Kollam, Alleppey, Pathanamthitta, Ernakulam, Thrissur, Palakkad, Kannur and Wyanad. However, the least concentration of calcium was observed in fodder samples collected from Kasargod district in spite of the highest concentration of the element in soil. The probable reason for the low content of calcium in samples of fodder from Kasargod district may be due to the fact that concentration of mineral elements in plants are dependant on the interaction of a number of factors especially the nature and extent of fertilization of soil and its pH regulation (Mc Dowell, 1992). pH of soil has been considered as a major factor in influencing the calcium absorption from soil by Beeson (1978). A depression of calcium concentration of herbage may be due to the greater use of potassium fertilizer as stated by Kemp (1971). A greatly reduced uptake of calcium has also been reported by Wilcos and Hoff (1974) due to ammonium absorption by the plant. Season has also been attributed as a factor influencing the calcium content of fodders by Metson and Saunders (1978).

A correlation between calcium content in plants with that of the same in serum of animals (Table 9) maintained in the various districts reveal that only animals maintained in Kottayam, Wyanad and Kasargod districts showed slightly lower levels of the element in blood. The reason for the normal concentration of the element in blood of the animals in other districts is that the animals also received dry forage and concentrate feed ingredients, including mineral mixtures in addition to grass which contributed a substantial quantity of the mineral element to satisfy the mineral requirement of the animals. The slightly lower concentrations of calcium in the serum of animals from Kottayam, Wyanad and Kasargod district is attributable to the comparatively lesser dietary intake of the element possibly due to the differences in the feed ingredients used for feeding in these districts.

5.10.2 Phosphorus

A perusal of the data given in Table 3 on the mineral content of soil reveal that except for Kottayam district, which recorded a slightly low value, all other districts had levels above the critical level (Jackson, 1967). The figures on the phosphorus content of natural grass (Table 7) collected from different districts indicated that the levels were above the critical level in Kollam, Alleppey, Kannur and Wyanad, all other districts having levels lower than the critical level, the least level being recorded from Thiruvananthapuram district. This observation is in keeping with that of Das *et al.* (1992) who also reported deficiency of phosphorus in most of the grazing forage plants in the Midnapore district of West Bengal eventhough the phosphorus content of soil was above the critical level. The low content of phosphorus in fodder from Thiruvananthapuram district in spite of an adequate level in the soil is attributable to the factors such as fertilization and pH regulation (Mc Dowell, 1992), soil temperature (Nye and Tinker, 1977) and stage of maturity of the plant (Fleming, 1965).

A comparison of the phosphorus level in plants with that of the concentration of the same in blood serum of animals maintained in various districts (Table 9) reveal that the animals from various districts including those in Thiruvananthapuram district where the fodder was low in the element, had a normal blood level of the element, due to the adequate intake of other feed ingredients including mineral mixture along with local grass to meet the total requirement of the animal in respect of phosphorus.

5.10.3 Magnesium

The data presented in Table 3 on the magnesium content of soil indicate that all districts had a satisfactory magnesium level in the soil. A perusal of the concentration of the element in the plants (Table 7) grown in the different areas reveal that the fodder from all districts except Thiruvananthapuram, Kollam, Kozhikode and Kannur had levels above the critical level for the element, Kozhikode district registering the least value for plant magnesium. Higher fertilization with potassium (Kemp, 1971; Mc Dowell, 1992) and nitrogen which reduce the magnesium content in grasses may be the reason for the low content of magnesium in fodder collected from Thiruvananthapuram, Kollam, Kannur and Kozhikode where the soil level was adequate.

5.10.4 Copper

A perusal of the data set out in Table 3 on the copper content of the soil indicate wide spread deficiency of copper in soils throughout the state. The data on copper content of local grass presented in Table 7 also indicate deficiency of the element in all districts of the state.

5.10.5 Zinc

A comparison of the zinc levels in soils presented in Table 3 with that of the levels in natural grass (Table 7) reveal that while the soils from all districts had an adequate zinc level, all districts except Kozhikode also registered an adequate level of the element in the natural grass.

5.10.6 Iron

A perusal of the data presented in Table 3 on the iron content of the soils and a comparison of its content in the fodder grown in the same areas (Table 7) reveals a very high content of iron in both the soil and in the fodder collected from different districts of the state.

5.10.7 **Manganese**

Manganese content of the soil presented in Table 3 indicate a low concentration of the element in the soil throughout the state. A perusal of the concentration of the element in natural grass collected from different districts (Table 7) also reveal a low concentration of the element in the fodder in all districts except Kottayam.

The data presented in Table 9 on the levels of phosphorus, magnesium, sodium, potassium, copper, zinc, iron and manganese in the serum of cattle collected from the different districts reveal that the animals in all the districts maintained a normal level of the various elements in spite of the fact that the local grass collected from some of the districts had a low concentration of some of the above minerals. An adequate intake of other feeds such as dry fodder and concentrate feed ingredients and a wide spread use of mineral mixture for feeding the animals are attributable for a satisfactory mineral status of animals in the areas surveyed.

From a critical evaluation of the overall results obtained in the present study it can be inferred that the animals in the surveyed area maintained a satisfactory mineral status as evidenced by a normal blood concentration of phosphorus, magnesium, sodium, potassium, copper, zinc, iron and manganese in spite of a generalised deficiency of copper and manganese and a scattered deficiency of calcium, phosphorus and magnesium in soils and local grass. However, the slightly lower blood calcium values were recorded in animals from Kottayam, Wyanad and Kasargod districts. The lower dietary intake of the minerals in these areas is attributable to the differences in the type of feeds and the quality of mineral mixture provided to these animals. The higher incidence of reproductive disorders reported from the Veterinary Institutions from the surveyed areas may be due to either marginal deficiencies of minerals which may go undetected, their lower utilisation due to interactions or imbalances or mainly deficiencies of major nutrients particularly energy.

Summary

SUMMARY

With the objective of assessing the present feeding condition as well as the mineral status of cattle in Kerala, a survey work was conducted covering all the districts under the different agro-climatic regions in the state. From each district, 50 per cent of the taluks and from each taluk two villages were selected for the survey work. From each village nine samples of blood were collected from cattle maintained by three categories of farmers (large, medium and marginal), divided as per socio-economic conditions. Blood samples as well as representative samples of soil and feeds and fodders fed to lactating cattle were collected from farmers households and also from organised and private farms in the different regions surveyed, for the estimation of calcium, phosphorus, magnesium, sodium, potassium, copper, zinc, iron and manganese, the estimations being done by Atomic Absorption Spectrophotometry except for phosphorus for which standard colorimetric method was used. Data on nutritional status of animals were collected using a proforma supplied to each farmer. Incidence of nutritional deficiency conditions in animals in the particular region was assessed from information gathered from the clinical cases recorded in various veterinary institutions in the concerned districts. From the information gathered during the survey work on the quantities of feeds and fodders fed and from the results on the mineral

analysis of samples of feeds and fodder collected, data on dietary intakes of minerals by lactating cattle were calculated to ascertain the mineral status of the animals in the respective areas.

The results on the nutritional survey indicated that majority of the farmers maintained crossbred cows with an average milk yield ranging from 6.0 to 8.0 kg. A small proportion of the farmers in all districts practised fodder cultivation for feeding their animals. Majority of the animals in all the districts received both straw and grass as roughage. The farmers, particularly in southern districts used some of the unconventional feeds also for feeding their animals. The majority of farmers used a mixture of compounded feeds and feed ingredients. Feeding of separate mineral mixture was practised in all the districts, the percentage of such households ranging from 17 to 58 per cent.

Study on the soil characteristics of different districts in Kerala revealed that texture of surface layers of soil in Kerala covers a wide range of sandy to clay, about 82 per cent of the area having moderately or well drained soils.

Results of analysis of minerals in soils from different districts when compared with their critical limits, indicated that while the level of iron in soils from all the districts was much higher and those of magnesium and zinc just adequate, there was a general deficiency of copper and manganese throughout the state. Further, the soils from all the districts except Kasargod were found to be lower in calcium, while phosphorus deficiency was noticed only in Kottayam district.

From a comparison of the levels of various minerals in the concentrate mixtures collected from different districts with their corresponding dietary requirements, it was seen that the levels of iron were much higher, those of phosphorus, magnesium and copper adequate, calcium adequate in all districts except Idukki and Kasargod, zinc adequate except in Palakkad and manganese adequate except in Alleppey, Kozhikode and Kasargod. However, the levels of sodium and potassium were found to be lower in all the districts.

The mineral contents in various concentrate feed ingredients collected from different districts were found to be within the normal range reported for the same.

A perusal of data on the mineral concentration in the different mineral mixtures collected during the present study revealed that none of the mineral mixtures analysed, was found to conform fully to the BIS standard, the contents of most of the minerals being either higher or lower, an observation which warrants strict regulations of quality control of all mineral mixtures marketed in the country.

From the results of mineral analysis of the local grasses collected from different districts and a comparison of the same with that of the critical limit for each element, it was observed that the levels of iron were much higher in all districts, while manganese levels were lower throughout except Kottayam district. Deficiency of phosphorus and copper were more wide spread followed by calcium, deficiency of zinc, sodium and potassium being scattered in nature.

Wide variations were observed in the mineral contents of paddy straw collected from different districts, the variations being attributable mainly to the differences in the variety of straws available for feeding in various areas.

Results of analysis of blood serum from lactating cattle maintained in different districts revealed that animals in all the districts maintained a normal mineral status in regard to all the minerals except calcium for which slightly lower levels were observed in animals from Kottayam, Wyanad and Kasargod districts.

The percentage incidence of reproductive disorders, other than abortion and dystocia, recorded in the veterinary institutions in the areas surveyed, was found to be more when compared to either nutritional deficiency or metabolic diseases.

From a comparison of the dietary intake of minerals by lactating cattle of different districts with their corresponding minimum requirements, it was seen that the intake of phosphorus, magnesium, copper, zinc, iron and manganese by animals in all districts was not only satisfactory but was much higher except in Kasargod district where the intake of phosphorus was just adequate to meet the requirements of the animals. However, the intake of calcium was grossly inadequate in the districts of Pathanamthitta, Kottayam, Idukki, Malappuram, Kannur and Kasargod districts.

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 blood concentrations of phosphorus, magnesium, sodium, potassium, copper, zinc, iron and manganese, in spite of a generalised deficiency of copper and manganese and a scattered deficiency of calcium, phosphorus and magnesium in soils and local grasses. However, slightly lower blood calcium values were recorded in animals from Kottayam, Wyanad and Kasargod districts. The lower dietary intake of the minerals in these areas is attributable to the differences in the type of feeds and the quality of mineral mixture provided to these animals. The higher incidence of reproductive disorders reported from the veterinary institutions from the surveyed areas may be due to either marginal deficiencies of minerals which may go undetected, their lower utilisation due to various interactions or imbalances or deficiencies of major nutrients particularly energy.

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ASSESSMENT OF MINERAL STATUS OF CATTLE IN KERALA

By
KURUVILLA VARGHESE

ABSTRACT OF A THESIS

Submitted in partial fulfilment of the requirement for the degree of

Master of Veterinary Science

Faculty of Veterinary and Animal Sciences
Kerala Agricultural University

Department of Animal Nutrition
COLLEGE OF VETERINARY AND ANIMAL SCIENCES
MANNUTHY, THRISSUR - 680651
KERALA

1998

ABSTRACT

To assess the present feeding conditions as well as the mineral status of cattle in Kerala, a survey work was conducted covering all the districts under the different agro-climatic regions in the state. From each district, 50 per cent of the taluks and from each taluk, two villages were selected for the survey work. From each village, nine samples of blood were collected from lactating cattle maintained by three categories of farmers (large, medium and marginal) based on socio-economic conditions. Samples of soil and feeds and fodders fed to cattle were also collected from different regions for the estimation of major as well as trace elements. Nutritional status of animals and incidence of nutritional deficiency conditions were assessed by using a proforma supplied to each farmer and also from the clinical cases recorded in various veterinary institutions in the concerned districts. Dietary intake of minerals by lactating cattle was calculated from the information gathered during the survey work on the quantities of feeds and fodders fed and from the results on the mineral analysis of samples of feeds and fodders collected.

The results on the nutritional survey indicated that majority of farmers maintained crossbred cows and a small proportion in all districts practised fodder cultivation for

feeding their animals. The animals in all districts received both straw and grass as roughage. As concentrate feeds, majority of farmers used a mixture of compounded feed and concentrate feed ingredients. Feeding of separate mineral mixture was practised in all the districts.

From the results of analysis of soil, it was seen that while the level of iron in soil from all the districts was much higher and level of magnesium and zinc adequate, there was a general deficiency of copper and manganese. Phosphorus deficiency was noticed only in Kottayam district, but levels of calcium were low throughout the state except in Kasargod district.

The results of analysis of concentrate mixtures revealed that the levels of iron in all the districts were much higher, phosphorus, magnesium and copper adequate, calcium adequate except in Idukki and Kasargod, zinc adequate except in Palakkad and manganese adequate except in Alleppey, Kozhikode and Kasargod. But the levels of sodium and potassium were found to be lower in all the districts. The mineral levels in the various concentrate feed ingredients collected from the different districts were found to be within the normal range.

The mineral concentration in the different mineral mixtures collected during the present study revealed that none of the mineral mixtures analysed, was found to conform fully to the BIS Standard, the contents of most of the minerals being either higher or lower, an observation which warrants strict regulations of quality control of all mineral mixtures marketed in the country.

Analysis of local grasses collected during the survey work revealed that manganese levels were lower in all districts except Kottayam. Deficiency of phosphorus and copper were more wide spread, followed by calcium and deficiency of zinc, sodium and potassium scattered in nature, while the iron levels in all districts were much higher. Wide variations were observed in the mineral concentration of paddy straw collected from different districts, the variations being mainly attributable to the differences in the variety of straw fed to the animals.

Analysis of blood serum collected from lactating cattle from different districts revealed a normal mineral status in regard to all the minerals except calcium for which slightly lower levels were observed in animals from Kottayam, Wyanad and Kasargod districts.

More cases of reproductive disorders other than abortion and dystocia were recorded in the areas surveyed than either metabolic or nutritional deficiency.

The dietary intake of minerals by lactating cattle in regard to all major and minor elements was not only satisfactory but was much higher in all districts except for calcium, the intake of which was relatively inadequate in Pathanamthitta, Kottayam, Idukki, Malappuram, Kannur and Kasargod districts.

From an overall evaluation of the results obtained in the present study, it can be inferred that the animals in all districts maintained a satisfactory mineral status for all minerals except for calcium, in spite of a generalised deficiency of copper and manganese and a scattered deficiency of calcium, phosphorus and magnesium in soils and local grasses. Slightly lower blood calcium values were recorded from Kottayam, Wyanad and Kasargod districts. The lower dietary intake of the element in these areas, probably is due to the differences in the type of feeds and quality of mineral mixture provided to them. However, marginal deficiencies of minerals which may go undetected, lower utilisation of minerals due to their interactions or imbalances or deficiencies of major nutrients particularly energy, might also be probable contributory factors for the higher incidence of reproductive disorders reported from veterinary institutions in the surveyed areas.