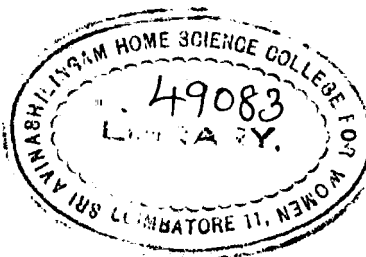


**AVAILABILITY OF CALCIUM FROM TREE LETTUCE ON SCHOOL  
CHILDREN**

**By**

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**A Thesis Submitted to the University of Madras  
in Partial Fulfilment of the requirements  
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## I INTRODUCTION

Man has progressed from food for survival to knowledge of nutrition for health. The maintenance of a high level of nutritional health requires the continuous availability of a wholesome, nourishing food supply that can provide all of the essential nutrients in amounts sufficient to meet human needs. Now, the immediate challenge facing the mankind is how to make available to all people every where enough food of the right kind, and how to educate all people to select and enjoy foods for nutritive value (Gopaldas, 1976 and Nagarajan, 1977).

Devadas et al (1976) emphasize that the nutrition of the preschool child and school child is of paramount importance since the foundation for lifetime health, strength and intellectual vitality is laid during that period. It is needless to mention that the children who are rapidly growing require more nutrients than the adults. It is the consensus of many nutritionists today that enough calcium must be provided to young children to ensure a well calcified skeleton when adulthood is attained.

However, it is disheartening to note that, of the 35 per cent of the child population, 75 per cent can be

classified as "not healthy" due to major and minor illnesses (Gopalan, 1975). Besides the main problems of shortage of calories and proteins, anaemia due to iron deficiency and blindness due to vitamin A deficiency are serious problems of Indian children (Devadas et al., 1969 and Easwaran et al., 1976).

Calcium deficiency is a crucial factor in the aetiology of skeletal retardation of young children. The skeletal retardation due to calcium deficiency seems to be much more prevalent than has been suspected. The retardation appears to be more evident in the post weaning period and to persist till the age of 10 years or more. Rajalakshmi (1976) puts forth that radiological appearance suggesting generalised osteoporosis is frequently seen in the bones of children suffering from protein-calorie malnutrition. The extensive diet surveys carried out by the National Institute of Nutrition (1975), Rajalakshmi (1976) and Devadas (1977) have revealed that the diets of the school children are deficient in nutrients such as calcium, iron, carotene and vitamin D. This is mainly due to the poor intake of milk, fruits, green leafy vegetables and other vegetables.

Now the immediate task of the nutritionists is not to beef up the existing dietary practices and introduce

drastic changes, but to improve the local dietaries with inexpensive local methods. It is appropriate to emphasize that the consumption of green leafy vegetables which are locally available foods can be enhanced to overcome the deficiency of minerals and vitamins (Devadas et al., 1973) and Kamalanathan et al., 1974). Nutritional benefits of green leafy vegetables has been proved by Devadas et al., (1965, 1971 and 1973) on children through school lunch feeding programmes.

Though in general all the green leafy vegetables are excellent source of minerals and vitamins, their contribution to the biological system differ from variety to variety because of various intervening factors. So far the beneficial effects of only a few leafy vegetables has been explored fully and there is a need to fulfil this lacuna. One of such unidentified sources is tree lettuce, botanically known as 'Pisonia alba'.

Tree lettuce is cultivated all over India and is grown in the form of a tree and hence the leaves will be available throughout the year especially during the winter seasons in excess amounts.

Aman (1969) in his book on "Medicinal secrets of your food" states that a glassful of fresh leaf juice of lettuce mixed with sugar or honey taken every night or in the morning is a medicine to cure stomatitis, sprue and anemia

due to iron deficiency. It prevents tuberculosis, asthma, bronchitis, jaundice, gall-bladder stones and corneal ulcers. Chewing leaves every day immediately after meals, prevents tooth decay, gingivitis, halitosis (bad breath), pyorrhoea, loss of excessive enamel of teeth and preserves the taste-detecting neurons of the tongue.

Above all, tree lettuce is found to be an excellent source of calcium having a content of 3204 mg/100 g. However its nutritional potentials has not been focussed by any previous studies so far. The present investigation is an attempt in that direction. It aims at studying the availability of calcium from tree lettuce on school children in comparison with that of amaranth tender (Amaranthus gangeticus). School lunch programme is one of the ameliorating measures in formulating and implementing the feeding trials on truly scientific lines. It was found necessary to use school children because large numbers could be used under reasonably controlled conditions. In this study, the tree lettuce was fed to children at two levels namely 5g and 25g/day and the effect on the nutritional status was studied over a period of three months.

## II REVIEW OF LITERATURE

The literature pertaining to this study entitled "Availability of calcium from tree lettuce on school children" is reviewed under the following headings:

- A. Prevalence of malnutrition among Indian children
- B. Nutritional contributions of green leafy vegetables in school lunch programme
- C. Factors influencing calcium absorption and retention and
- D. Studies on calcium metabolism.

### A. Prevalence of malnutrition among Indian children:

In India one third of the total population is comprised by children of the school age (4-15 years) (Nutrition, 1973 and Sen and Agarwal, 1975). Malnutrition in children is a global health problem. Most of the children are victimized by malnutrition due to dietary inadequacy, ignorance of basic dietary requirements and also due to gastro-enteritis and respiratory tract infections (Brown, 1975; Dutta et al., 1975 and Prasannappa et al., 1976).

Protein - Calorie malnutrition is the most important nutritional problem among preschool and school children of developing countries (Chandrasekhara, 1974 and Nutrition Reviews, 1974).

Gopalan. (1973, 1974) points out that in India today the incidence of severe forms of protein-calorie malnutrition

like kwashiorkor and marasmus, has been estimated to be around one to two per cent of all children between the ages of one and five years. This figure does not include the mild and moderate forms of malnutrition. Nearly 80 per cent of preschool children are suffering from I and II degree malnutrition. Apart from protein-calorie malnutrition, vitamin A deficiency is another major nutritional problem contributing to a considerable amount of preventable blindness. It is believed that in India alone, there may be over one million cases of blindness arising from vitamin A deficiency (Gopalan, 1975). Anemia due to iron deficiency ranks as the next nutritional deficiency.

Nutritional surveys carried out in various states by the ICMR revealed that the diet of the vulnerable groups is far from adequacy in calories and protective foods. A study conducted at Kanpur revealed that 30.2 per cent of children of one to three years had nutritional disorders, such as, anemia (18.3%), vitamin deficiency (9.9%) and protein-calorie malnutrition (1.9%). More than 80 per cent of nutritional disorders were in children of six months to four years of age. The morbidity pattern in the children included gastro-intestinal disorders (59.4%), respiratory diseases (29.2%), eruptive fevers (9.9%) and nutritional disorders (1.4%) (Mathur et al., 1974).

Gupta et al. (1973) surveyed local children in Delhi and observed that the mean values of weight, length, circumference of the chest, mid-arm - circumference and mid-leg girth were less in protein-calorie malnutrition and the head circumference was affected equally in rural groups of children suffering from chronic severe malnutrition.

The incidence of malnutrition among selected preschool children in Coimbatore city was studied by Easwaran et al. (1976) and it was found that nutritional disorders were considerably high in the morbidity pattern (49.16%). Among the nutritional disorders besides protein-calories malnutrition (39.71%), severe marasmus (35.93%), angular stomatitis (21.92%), bowlegs and knock knees (0.73%) were common.

#### B. Nutritional contributions of Greenleafy vegetables in school lunch programme

Children are our most valuable possessions, a trust and investment (Prokopec, 1964). The school going age is a dynamic period of physical growth and development when the child undergoes mental, emotional and social changes (Easwaran et al., 1975).

In fostering the children's physical, mental, social and emotional growth, and in helping them to attain maximum

stature, good nutrition is of great importance (Devadas and Kasipandya Devi, 1970). The free school meal programme in several parts of India is one of the important measures undertaken to overcome malnutrition among primary school children (Gopalan, 1970). UNICEF and CARE are augmenting the school lunch programme through the contributions of protective foods, such as salad oil, corn soya milk (CSM) and bulgar wheat. However food aid from foreign sources cannot be eternal.

Since green leafy vegetables are rich sources of calcium, iron and vitamins, they can be included regularly in the school lunch to overcome the common mineral and vitamin deficiencies.

Green leafy vegetables are essential for the maintenance of normal health and have been acclaimed as basic component of adequate diets all over the world, particularly for their vitamin and mineral content (Kamalanathan et al., 1974). Rajalakshmi and Ramakrishnan (1967) in their study furnished clear cut evidences that the leafy vegetables are plentifully available in India and these can provide the required amount of vitamin A, calcium and riboflavin. It has been shown by many workers that on a dry weight basis, some commonly consumed vegetables are superior to milk as gross sources of calcium (Oke, 1969). ICMR (1974) has reported that the calcium content of leafy vegetables vary from 20 mg/100 g in bamboo tender shoots to 3,095 mg/100 g in rape leaves.

While in temperate regions, leafy - vegetables are often considered as a prestige food which should appear daily in the menu, the opposite is observed in many tropical regions. According to Oomen (1967) green leaves are essentially cheap food sources and are rightly appreciated as a useful food in the temperate and industrialised countries.

The effect of supplementing the diet with iron from amaranthus in comparison with iron tonic was studied by Nirmala et al. (1968) and the results revealed that the haemoglobin and PCV values of the group fed amaranthus were higher than those of the group fed oral iron tonic.

Devadas et al. (1973) studied the availability of iron from green leafy vegetables compared to iron tablets and iron tonic for school children and proclaimed that the children fed amaranthus received considerable quantities of calcium and vitamin C than the other groups. The mean increase in height, weight and haemoglobin level of children of the group which received amaranthus was greater than the groups supplemented with iron supplements and the non school lunch children. The effect of supplementation of a rural school lunch programme with green leafy vegetables on the nutritional status of children was studied by Devadas et al. (1969) and the results revealed that the

Increases observed in the mean heights, weights and blood haemoglobin levels of children were significantly greater than the comparable controls.

By supplementing amaranthus cooked in iron utensils to school lunch programme, the blood haemoglobin levels of children were found to be greater than that of a group supplemented with greens cooked in aluminium utensils (Devadas et al 1973).

Thus green leafy vegetables can be regarded as an efficient supplement in feeding programmes for children. It has the additional advantages of being easily available at little or no cost.

#### C. Factors influencing calcium absorption and retention:

Studies have been carried out by several workers on the absorption and retention of calcium in human subjects. Absorption is an active process which depends on an adequate supply of oxygen and of glucose or other source of energy (Davidson et al, 1973). The absorption and retention of calcium will depend on (1) calcium intake (2) presence of interfering substances and (3) presence of vitamin D. On normal intake of calcium, the retention varies widely from 10 to 30 per cent depending on the diet and the age of the subjects (Swaminathan, 1974).

1. Substances assisting absorption:

a. Protein:

According to Hegsted (1971), in most studies with both calcium and protein, the finding has been that the larger the intake, the larger the amount retained.

Chu et al (1975) stated that the calcium and protein intakes had no effect on the calcium loss. They also proved that increase in urinary calcium is not likely to result solely from enhancement of intestinal calcium absorption and that increased glomerular filtration with possible inhibition of renal tubular reabsorption of calcium may be an additional mechanism responsible for the calciuretic effect during high protein intake.

Anand and Linkswiler (1974) studied the effect of level of protein intake on urinary and faecal calcium and calcium balance on nine young adult human males and revealed the fact that the urinary calcium increased significantly with each increase in protein intake and faecal calcium was not significantly affected by the protein intake. Reports of earlier studies from the laboratory of Department of Nutritional Sciences, University of Wisconsin, Madison, indicate that an increase in protein intake from 47 g to 142 g daily has an adverse effect on calcium retention. This is in confirmity with the studies carried out by

Margen et al (1974) and Schewartz et al (1973). On the contrary, Adolph and Chen (1932), Kunnerth and Pittman(1939), Mccance et al (1942) and Hegsted et al (1952) showed that calcium retention was improved with higher protein intake. Bell et al (1975) explained that increased excretion of calcium in urine seen under conditions of high protein intake was due to a shift in the route of excretion of endogenous calcium from the faeces to the urine and to an increase in absorption of dietary calcium. He concluded that high protein diet had no effect on bone resorption when calcium and phosphorus intakes were adequate.

Johnson et al (1970) found that young adult males given 1400 mg calcium daily retained calcium at a protein intake of 47 g, but showed a negative calcium balance with a mean loss of 84 mg calcium at a protein intake of 142 g. Walker and Linkswiler (1972) reported that young men given 800 mg calcium retained on an average of 12 and 1 mg calcium respectively, when consuming 47 and 95 g protein, but lost 85 mg calcium when consuming 142 g proteins.

Results of these two studies and the study by Anand and Linkswiler (1974) showed that high protein intakes had a detrimental effect on calcium retention in young adult males.

b. Vitamin D:

Vitamin D improves the utilization of calcium for calcification and other purposes. There is convincing evidence that vitamin D promotes calcium absorption, there is also some evidence that it may act on the calcification process itself. The function of vitamin D appears to modilise the calcifying elements, so as to make possible their most efficient utilization even when the dietary supply is inadequate or disproportionate. It has been shown that even if calcium and phorphorus are fed in proper quantity and ratio, the absence of vitamin D, especially if prolonged, will result in poorer calcification of the bones than obtained under normal conditions (Oser, 1976).

The effect of vitamin D supplementation on calcium absorption in children was studied by Pereira and Reddy (1971) and they concluded that under the existing dietary and environmental conditions, supplementation of 200 I.U. of dietary vitamin D might be necessary to promote maximal calcium absorption and that raising the intake beyond that level did not have any additional benefit. It was however possible to achieve maximum calcium retention with amounts less than 200 I.U.daily. They also observed that when the level of vitamin D was raised to 400 I.U. there was no further increase in absorption.

The form of vitamin D<sub>3</sub> cholecalciferol, which may be most biologically active as concerns the transport and mobilization of calcium is increasingly documented to be the 1,25 dihydroxy metabolite. This compound results from hydroxylation in kidney of the 25 - hydroxy intermediate, which is the major circulating cholecalciferol metabolite formed in liver. More recent work has confirmed this involvement with intestinal calcium transport and additionally suggests that the 1,25 dihydroxy metabolite is responsible for bone calcium mobilization. (Nutrition Reviews, 1973).

## 2. Substances interfering with absorption:

Not all the calcium present in a foodstuff is available as there are substances which render calcium unavailable.

The chief, amongst these are

- a. Phytic acid
- b. Oxalic acid
- c. Fiber (cellulose) and
- d. Fats and fatty acids

### a. Phytic acid:

Phytic acid is inositol hexaphosphate; it is the most common substance present in the edible plants which interferes with the calcium and phosphorus metabolism. It reduces the absorption of minerals from the intestinal tract. The per cent of total phosphorus occurring as phytate-phosphorus

varies considerably in different varieties and strains of edible plants (Nutrition Reviews, 1955 and Phadnis and Schonle, 1974).

Numerous short-term experiments in man and in animals have demonstrated that the administration of phytic acid or materials high in phytic acid, may adversely affect calcium absorption (Harris, 1955).

Consumption of large amounts of high extraction flour has been shown to reduce calcium absorption in human volunteers (Nutrition Reviews, 1973 and Reinhold et al., 1975).

Many workers have demonstrated and studied the antinutritional effect of phytic acid. According to them phytic acid lowers the availability of calcium and phosphorus in the diet and deficiency of calcium and phosphorus has been reported to result in changes in the structure of bones (Gaster et al., 1967 and Phadnis and Schonle, 1974).

These findings have been demonstrated in populations consuming large amounts of whole grain or largely milled cereals and other vegetable products, the phytic acid of which theoretically should precipitate all dietary calcium. In almost all such populations a habitually low calcium intake is the rule. Although exceedingly large amounts of phytic acid which have been used theoretically to inhibit

calcium absorption may effectively do so for a time, there is little reason to believe that calcium requirements are influenced by the amount of this acid commonly encountered in human diets (FAO/WHO, 1962).

Dikshit and Ranganathan (1958) Devadas et al (1964) and Gaster et al (1967) Gupta and Appanna (1967) and Sumners et al (1967). have reported similar findings with diets either low in calcium and phosphorus or with low amounts of available calcium and phosphorus due to the presence of phytic acid in the diet. The role of phytate as a possible casual agent in the development of rickets and osteomalacia in populations that consume large amounts of whole-grain cereals, as in India, Pakistan and the Middle East is not yet clear (Nutrition Reviews, 1973).

Thus the available evidence indicates that (1) phytic acid or soluble salts of phytic acid interfere with the absorption of calcium and iron from the intestinal tract of man. (2) the phytate compounds in foods interfere with calcium and iron absorption to lesser extents and (3) the effects of food phytates upon calcium absorption can be masked, partially or completely by the presence of an abundance of (a) calcium or (b) vitamin D in the diet, or (c) by adjustment of the calcium: phosphorus ratio of the diet.

(b) Oxalic acids

It has been shown by many workers that on a dry weight basis some commonly consumed vegetables are superior

to milk as gross sources of calcium (Sur and Subrahmanyam, 1949 and Oke, 1969). The acid which is studied most as a criterion for ascertaining the quality of vegetables is oxalic acid. (Oke, 1969). This is due to the discovery that oxalic acid forms an insoluble salt with calcium which is of great importance in our diet, thereby lowering the nutritive value by making the calcium unavailable. Experimental studies in animals have shown that oxalates in larger amounts may interfere with calcium absorption (FAO/WHO, 1962; Oke, 1969 and Pilac et al., 1971).

When a mixture of food is usually undergoing digestion at any time the total oxalate in relation to the total calcium must be considered. Vegetables containing a calcium to oxalate ratio below 2 should not be considered advisable as sources of calcium in the diet (Pilac et al., 1971).

Thomas (1965) reported that the commonly consumed greens in Tamil Nadu like Kuppakeerai, Mukkarettai Keerai, Kuppamani Keerai, Punnakku Keerai, Nerringi Keeri and Vellakeerai contain larger amounts of oxalates.

Thomas (1965) estimated the oxalic acid and calcium content of seven edible greens and the availability of calcium on albino rats. On raising the calcium content of the diet to about 350 mg, he found that Mukkarettai Keerai could be suggested as a good source of calcium when compared to

Kuppakeeral inspite of similar amounts of calcium and oxalate in the two greens.

Leafy greens belonging to the "goose foot" family (Chenopodiaceae) like spinach, swiss chard or sea kale beet, are good sources of calcium; however, they contain oxalic acid (Kohman 1931).

Feeding experiments conducted by pilac et al (1971) on rats gave some revealing and interesting aspects. When a certain plant (Amaranthus gangeticus) was included in the diet of rats, there was failure of growth, decalcification and death of creatures, but when rice was given as supplement in the diet, good growth and survival was followed. Calcium was apparently rendered available atleast in part by the addition of rice. The incidence of oxaluria has also been closely associated with the ingestion of oxalate-rich foods.

### (C) Fiber:

Fiber (cellulose) in addition to phytic acid exerts influence on the absorption of calcium by the intestine. Several workers have studied the effect of dietary fiber on calcium absorption. The excess of cellulose in the diet seems to inhibit the absorption of calcium, perhaps as a result of retention of calcium by their fibers (Phadnis and Sohoni, 1974).

Bloom (1930) and Adolph et al (1938) observed that the addition of 8.0 per cent of fiber to a diet of normal calcium content had no effect upon calcium retention in rats. Ascham (1931) stated that bulk might increase faecal calcium loss in dogs. Duckworth and Godden (1941) observed that increasing the fiber content of the diet of rats to a level as high as 30 per cent had no influence on calcium retention but reduced the nitrogen balance. Morgan (1934) studying adult human subjects consuming coarsely ground cellulose added to a standard diet found that calcium balance tended to become negative during the higher fiber period.

All these observations clearly indicate that factors like phytic acid and fiber accompanying dietary constituents such as carbohydrates and minerals exert influence on the calcium and phosphorus metabolism of the body and on the structure of bones (Phadnis and Sohoni, 1974).

(d) Fats and fatty acids:

The problem of the influence of dietary fat on calcium utilisation has received considerable attention with some what conflicting results (Basu and Nath, 1946).

Yacowitz (1962) and Yacowitz et al (1967) furnished clearcut evidence that moderate levels of fat in the diet favoured the utilization of calcium.

Now the view has changed that the presence of moderate levels of fat in the diet interferes with calcium absorption. Fatty acids form insoluble soaps with calcium. Thus fatty acids, and particularly those that are saturated, may carry into the faeces significant amounts of calcium. They may also carry with them fat soluble vitamin D. Hence it is understandable how patients with chronic intestinal disorders leading to increased fat in faeces may develop osteomalacia after a time (Davidson et al.1973 and Swaminathan, 1974).

#### Calcium: Phosphorus ratio in the diet:

Diets having distorted Calcium: Phosphorus ratios have been used to produce experimental rickets in animals. Numerous studies, particularly in vitamin D deficient animals, have shown the Ca/p ratio to be one of the determinants in assessing calcium requirements. The diets of man especially those consisting largely of vegetable products, almost invariably contain much more phosphorus than calcium (FAO/WHO 1962). Further more there is a convincing evidence, obtained with human subjects, which demonstrated that the addition of a rather large amount of phosphate to

the diet had almost no effect on calcium absorption (Malm, 1958). Hence, the FAO/WHO Group (1962) felt that variations in the Ca/p ratio in habitual diets are of no practical significance in human nutrition.

Observations on several species have indicated that during rapid growth and calcification, the diet should have a calcium:phosphorus ratio 1:1 (Swaminathan, 1974).

#### D. Studies on calcium metabolism:

The normal adult body contains some 1200 g calcium, 99 per cent of which is present in the skeleton and this constitutes 1.5 to 2 per cent of the body weight (Best and Taylor, 1967 and Cuthbertson, 1973).

The ileum responds to dietary calcium; high levels induce an increase in movement from lumen to blood producing net absorption (Nutrition Reviews, 1975).

In a study with four apparently healthy men on calcium lactate and calcium sulphate supplementation, Nageswararao and Narasingarao (1974) concluded that excretion of calcium through faeces and urine varied widely in the same subject on different days. This finding is in confirmity with the report of other Indian workers (Basu et al. 1939 and Shenolikar, 1969).

Favourable effects of flouride, such as alleviation of bone pain, increase in bone density and improvement of the calcium balance have been reported by Spencer et al (1969). Prolonged administration of large amounts of flouride has been reported to lead to increased retention of calcium as stated by Rich and Ensinn (1961), Bernstein et al (1963), Rich et al (1964) and Bernstein et al (1969). In other investigations, however, this effect could not be demonstrated after either short-time (Higgins et al.1965) or long-term administration of large amounts of sodium flouride (Rose, 1965).

Walker et al (1975) suggested, that of the calcium ingested, some is absorbed and some is excreted in the faeces. Some of the calcium absorbed is retained for utilization, some is secreted into the bowel (endogenous loss) and some is excreted in the urine. Observations by McCance and Widdowson (1942) and Knapp (1974) demonstrated that an increase in calcium intake is followed by an increase in the amount excreted in the urine.

Studies carried out by Rajalakshmi et al (1973) on the effects of supplements varying in carotene and calcium content on the physical, biochemical and skeletal status of preschool children furnished clear cut evidence that there were increments in height, weight and skeletal status as

judged by bone age and cortical thickness of the second metacarpel bone and femur, and biochemical status as judged by the composition of blood (haemoglobin), serum (protein, albumin and vitamin A) and urine (creatinine, nitrogen, thiamine, riboflavin and vitamin C).

Keith et al (1974) in their study on increased urinary oxalate, calcium and iron in rats fed high dietary levels of vitamin C and iron revealed that vitamin C (20 mg/kg) and iron (250 mg/kg) reduced serum calcium concentration slightly and did not increase kidney calcium concentration significantly inspite of increased urinary oxalate concentration.

While the role of the parathyroid hormone in regulating blood calcium levels has been known for a relatively long time, the possible role of other hormonal factors in calcium metabolism has remained largely unknown. A publication by Dallemagne (1950) dealing with the influence of estrone on the calcium metabolism of the pigeon indicated that female sex hormones have a determining effect.

Braithwaite (1974) observed that animals receiving an adequate calcium intake absorbed sufficient calcium to supply their maintenance requirements only; a change in intake resulted in a corresponding change in the rate of

absorption and disturbed this balance. The new rate of absorption appeared to be determined by the calcium concentration of the new diet and the efficiency of absorption of calcium from the previous diet. When a lack of available calcium in the diet made it impossible for them to meet their maintenance requirements, they slowly reduced faecal endogenous excretion of calcium. The results indicated that calcium resorption from bone is the major process involved in calcium homeostasis and that calcium absorption is responsible for the long term control of calcium metabolism and in particular for maintaining body calcium reserves.

In a calcium balance study conducted by Begum and Pereira (1969) on preschool children, the results showed that mean dietary calcium intake was 204.0 mg per child per day with average absorption being 103.0 mg, the faecal excretion as 101.4 mg, the loss in the urine-26.2 mg with mean retention of 76.6 mg or 38.5 per cent of intake.

Venkatachalam (1971) in his study proclaimed that the calcium supplementation had not provided the children with any benefit with respect to growth because the calories and protein intakes were low. Calcium balance studies conducted by Malm (1958) had shown that as a general rule, larger amounts of calcium are retained on high calcium intakes within limits. According to Goto and Sawamura (1970)

in youngstage, excess supply of calcium lactate caused a fall in food intake and weight gain.

Excess calcium in the sheep decreased the absorption of fats with an extremely high excretion of combined fatty acid. When the dietary calcium to phosphorus ratio is high, excretion of combined fatty acid was increased in both young and adult rats (Goto and Sugai, 1975).

Fleischmen et al (1966) reported that the excess calcium in diet depresses the absorption of fat in mature rats and the disparity of amounts of faecal liquid between young and adult rats might be due to the aging of animals.

High calcium intake has been reported to cause serum cholesterol lowering both in animals and in humans (Vitale et al, 1959, and Iacono et al, 1960). Fleishman et al (1966) in matched groups of rats fed beef tallow, observed that an increase of calcium in the diet caused a decrease of serum and concluded that the effect was mediated in part by increased excretion of bile acids and lipids in the faeces.

Calcium was hypolipemic with either corn oil or cocoa butter, but the effects were more pronounced in the presence of saturated fat (Yacowitz et al, 1967).

In a study by Iacono (1974) and Thornton (1974) it was found that plasma cholesterol and phospholipid were

elevated in the group fed the calcium deficient diets, whereas plasma triglycerides appeared to be unaffected by the level of calcium fed. When the rabbits were fed the high calcium diet, heart, skeletal muscle and adrenal gland showed significant decreases in free cholesterol, but only skeletal muscle showed a decrease in total phospholipids with high calcium supplementation. Increase in the levels of triglycerides of kidney, skeletal muscle and adrenal glands were observed with increasing increments of dietary calcium.

#### Calcium requirements:

The FAO/WHO Expert group on calcium requirements (1962) reveal that the volume and total content of calcium is determined genetically, but is influenced by nutrition and by physical activity. However, one can postulate that additional calcium over and above the actual requirement will not lead to significant further bone formation. There is a good agreement between the recommended allowances of calcium by FAO/WHO Expert Group (1962) and the ICMR Nutrition Expert Group (1968). The ICMR Nutrition Expert (1968) had recommended the following allowances for Indians.

Children 1-12 years	- 0.4-05 g.
Adolescents 13-15 years	- 0.6-07 g.
16-18 years	- 0.5-0.6 g.
Adult man and woman	-0.4-05 g
Pregnancy and lactation	- 1.0 g.

Thus in the absence of precise information on calcium requirement of different groups a range of allowance has been suggested (Swaminathan, 1974).

### III. EXPERIMENTAL PROCEDURE

The experimental procedure for the present investigation on "Availability of calcium from tree lettuce on school children" consisted of the following steps:

- A. Selection and analysis of the leaves
- B. Selection of the children
- C. Feeding the children
- D. Assessment of the nutritional status of children and
- E. Calcium balance study

#### A. Selection and analysis of the leaves:

The leaves selected for the experiment were Tree lettuce which is botanically known as 'Pisonia alba'. These leaves are loose and do not form heads (Figures 1 and 2). It is a rich source of minerals especially calcium and vitamins and consumed when young and tender. The school garden supplied adequate quantities of these leaves and the same leaves were used throughout the experimental period. Since amaranath tender (Amaranthus gangeticus) is being used continuously in the school meals, the same was selected for comparison against tree lettuce. Studies by Devadas et al (1969) have shown that amaranthus can be supplemented to the diets of children for minerals and vitamins such as calcium, iron and vitamin A. The required quantities of amaranthus were obtained from the school garden itself.



FIGURE-1  
TREE LETTUCE - 'Pisonia alba'



FIGURE-2  
TREE LETTUCE - A GROWING TREE

As a first step in this study both tree lettuce and amaranthus leaves were analysed for the following nutrients.

1. Protein
2. Calcium
3. Iron
4. Phosphorus
5. Ascorbic acid and
6.  $\beta$ -carotene.

All these nutrients were analysed according to the procedures developed by the National Institute of Nutrition (NIN, 1971).

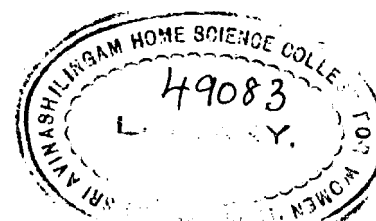
Analysing a vegetable for calcium includes determination of other factors which ascertain the quality of vegetables (Oke, 1969). Hence oxalic acid and phytic acid, the factors which interfere calcium absorption were also analysed for their contents.

The nutrient content, oxalic acid and phytic acid contents of the tree lettuce and amaranthus as analysed are given in Table. I.

**TABLE. I**  
**PERCENTAGE NUTRIENT, OXALIC ACID AND PHYTIC ACID CONTENTS**  
**OF TREE LETTUCE AND AMARANTHUS.**

S.No.	Factor analysed	Quantity present	
		Tree lettuce	Amaranthus
1.	Protein (g)	4.4	3.9
2.	Calcium (mg)	3204.0	597.0
3.	Iron (mg)	17.5	25.4
4.	Phosphorus (mg)	59.8	86.8
5.	$\beta$ -Carotene(g)	1250.0	5480.0
6.	Ascorbic acid (mg)	76.4	90.6
7.	Oxalic acid (mg)	213.8	120.0
8.	Phytic acid (mg)	40.0	10.0

Both the leaves were found to be very rich in minerals and vitamins. The calcium content of tree lettuce was 3204 mg/100g whereas the calcium content of amaranthus was only 597 mg/100g. Though amaranthus had lesser quantity of calcium it was found to contain greater quantities of iron, phosphorus,  $\beta$ -Carotene and ascorbic acid. In spite of a remarkable calcium content, the tree lettuce was found to contain only 213.8 mg. of oxalic



acid and 40 mg of phytic acid. However these values are greater than those of amaranthus.

#### B. Selection of the children:

It was found convenient to use elementary school children for the study because large numbers could be used under reasonably controlled conditions. Moreover, large numbers were needed because of the known wide range of individual metabolic response to calcium (Walker et al 1975).

For carrying out the feeding trial on children, Sri. Avinashilingam Basic school was selected. Since a well organised school lunch feeding programme is being carried out in this school, it facilitated the feeding of the leafy vegetables for a longer period of time to study the impact on children.

Among the 105 children of five to eleven years old, who were participating in the feeding programme, 75 children of below ten years were selected and initially height, weight and blood haemoglobin levels of all the children were recorded. Based on their mean initial age, height, weight, blood haemoglobin level and socio economic status, they were divided into three comparable groups of

25 children each. They were designated as groups A, B and C, and a comparable group of children who were not participating in the school lunch programme were also selected to serve as controls and they were designated as group D.

The mean initial height, weight and blood haemoglobin levels of the selected groups is presented in Table II.

TABLE II  
MEAN INITIAL HEIGHT, WEIGHT AND BLOOD HAEMOGLOBIN LEVELS  
OF THE SELECTED GROUPS OF CHILDREN

S.No.	Groups	Mean height in cm	Mean Weight in kg	Mean blood haemoglobin level g/ 100 ml
1.	A	111.06 $\pm$ 6.38	16.59 $\pm$ 2.19	9.12 $\pm$ 0.75
2.	B	110.85 $\pm$ 7.26	16.52 $\pm$ 2.93	8.93 $\pm$ 0.69
3.	C	111.20 $\pm$ 5.75	16.57 $\pm$ 2.08	8.79 $\pm$ 0.63
4.	D	111.20 $\pm$ 7.06	16.62 $\pm$ 3.19	8.99 $\pm$ 0.75

The children in group A were fed with the normal school lunch. The normal school lunch provided 25 g of amaranthus in the form of a kootu, which is a preparation

of dhal and greens. Twenty five grams of amaranthus supplied 150 mg of calcium per child per day apart from 81.1 mg of calcium supplied from other ingredients of the school menu.

The tree lettuce contains 3,204 mg of calcium per 100 g. In order to supply 150 mg of calcium through tree lettuce to children in group B, they were fed with 5 g of the leaves in the form of kootu. In group C, a greater quantity of the tree lettuce, namely 25 g was fed daily per child. Twenty five grams of the tree lettuce supplied 801 mg of calcium. In this group, the utilisation of calcium was tested at higher levels of feeding as done by Anand and Linkswiler (1974). The control group children were not fed with any supplementation.

### C. Feeding the children:

The feeding trial carried out for children is discussed under the following heads:

1. Testing the acceptability of the greens preparation
2. Planning the school lunch menu
3. Nutritive value and cost of the foods included in the menu and
4. Conducting the programme.

#### 1. Testing the acceptability of the greens preparation:

Before introducing the tree lettuce preparation in the school lunch, the acceptability of the greens was tested on

children in the form<sup>of</sup> the usual school lunch preparation namely kootu (a preparation of dhal and greens). Recipes were prepared using amaranthus as a standard. Two variations were prepared without altering the quantities of other ingredients used for amaranthus kootu, one with 25 g of leaves and the other with 5 g of leaves per serving and were tested on children for their acceptability. Both the preparations were found to be equally acceptable, when compared with the preparation of amaranthus kootu.

## 2. Planning the school lunch menu

The school lunch is served for six days a week. The normal school lunch menu was followed during the experimental period. The weekly school lunch menu planned for the children is presented in Table III.

TABLE III  
WEEKLY SCHOOL LUNCH MENU

Days	Menu
Monday Wednesday and Friday	Bulgar wheat Uppuma, Greens Kootu, Tomato/Papaya, CSM Payasam.
Tuesday	Tamarind rice, Greens Kootu, Tomato/Papaya, CSM Payasam.
Thursday	Dhal rice, Greens Kootu, Tomato/Papaya, CSM Payasam.
Saturday	Lime rice, Greens Kootu, Tomato/Papaya, CSM Payasam.

Enough variation was introduced in school lunch menu to avoid monotony. As the table indicates, on alternate days bulgar wheat uppuma was fed to children as the cereal preparation. Corn Soya Milk (CSM) beverage in the form of a sweet drink was served to children on all the days. Both CSM and bulgar wheat are free food supplies from CARE.

3. Nutritive value and cost of the foods included in the menu:

The nutritive value of the school lunch menu in comparison with one third recommended daily allowance of the Indian Council of Medical Research is given in Table IV.

TABLE IV

ENERGY AND NUTRIENT CONTRIBUTION OF THE  
SCHOOL LUNCH MENUS

S.No	Groups	Calories (g)	Protein (g)	Calcium (mg)	Iron (mg)	$\beta$ -Carotene ( $\mu$ g)	Thiamine (mg)	Ribe- fla- C(mg)	Vitamin C(mg)
1.	A	633	16.51	231.1	13.93	1478	0.694	0.282	33.7
2.	B	642	15.73	241.1	8.41	161	0.687	0.212	12.5
3.	C	664	16.61	881.1	11.90	411	0.694	0.234	27.8
4.	One third RDA	600	9.2	133	5	467	0.283	0.300	10
				167	6.67				16.7

RDA. Recommended Daily Allowance of ICMR (1968)

Though it was planned to provide one third of the recommended dietary allowances through school lunch programme, all the three groups were supplied with the nutrients greater than the recommended daily allowances of the ICMR (1974).

The Table V presents the quantity of food stuffs used in the lunch along with the cost of the meal per day.

TABLE V  
COST AND QUANTITY OF FOODSTUFFS USED PER  
CHILD PER DAY

S.No.	Food item (g)	Quantity	Cost Per meal (Paise)
1.	Rice or Bulgar wheat	100	17.4 (8.7)* Free from CARE
2.	Redgram dhal	10	2.2
3.	Greens	25	Free from GARDEN
4.	CSM	10	Free from CARE
5.	Jaggery	10	2.7
6.	Papaya or Tomato	20	Free from garden 1.4
7.	Oil	8	Free from CARE
Total			15.0

\* Rice was included only on alternate days.

The cost was calculated according to the price levels in Coimbatore Super Market during January 1977. The cost of foods included in school menu was 15.0 paise per day per child.

#### 4. Conducting the programme:

For all the recipes included in the school lunch, the raw ingredients used and the cooked preparations were weighed and standardised in terms of volumes at the beginning of the experiment. These measurements were followed strictly throughout the experimental period. The individual servings were also standardised in terms of spoons and cups to facilitate the serving.

The three experimental groups were seated separately for the lunch. For those, who needed more food, the cereal preparation alone was served in the second and subsequent servings. Extra servings, plate waste and the daily attendance were also recorded regularly. The study was carried out for the period of three months.

#### D. Assessment of the nutritional status of children:

The need for any active nutrition programmes and their efficacy can only be determined by periodic assessment of the nutritional status of the children and people

(Davidson et al 1973). Hence in this investigation nutritional status of children was assessed using:

1. Anthropometric measurements
2. Biochemical assessment and
3. Clinical examination.

1. Anthropometric measurements:

As the physical dimensions of the body are much influenced by nutrition, particularly in rapidly growing period of childhood (Jelliffe, 1966), selected body measurements such as height and weight were used in this study to obtain valuable information on the nutritional status of children.

a. Height:

The height of all the children were recorded monthly using a vertical measuring rod fixed with a scale to the nearest 0.1 cm, following all the precautions strictly as listed by Jelliffe (1966).

b. Weight:

The weights of the children were also recorded monthly using a beam balance, to the nearest 0.05 kg. following precautions as given by Jelliffe(1966).

## 2. Biochemical assessment:

### a. Blood haemoglobin levels:

Blood was collected by the finger prick method and analysed for haemoglobin by the cyanmethaemoglobin method (Varley, 1975). The values were recorded for all the children every month.

### b. Urinary calcium:

According to Walker et al (1975), urinary calcium expressed as percentage of calcium intake varies inversely with calcium intake per kg body weight and is an important test in measuring the calcium absorption. Accordingly it was thought that in a group of persons under standard conditions, the mean excretion of calcium in the urine over a period of say, six hours after the consumption of a given intake of leaves might conceivably serve as a valuable index of the amount of calcium absorbed within that period.

Hence in this investigation, urine was collected immediately after the consumption of leaves. Five children in the age group of five to seven years from all the three experimental and the control groups were selected randomly. Endeavours were made to carryout all studies at the same time of the day in view of the diurnal rhythm of urinary calcium excretion. The selected children in all the groups were asked to empty the bladders immediately before

the experiment and the collections were made exactly two, four and six hours after feeding as per the procedure followed by Rajalakshmi et al (1973) and Walker et al (1975). Care was taken to keep pupils under constant surveillance to avoid loss of any portion of urine sample. The combined volume of the three two hourly samples for each individual was measured, preserved with toluene and stored in a refrigerator. One ml. of the urine was analysed in duplicate for its calcium content using the procedure of Hooper (1956).

### 3. Clinical examination:

Skeletal maturity is a measure of how far the bones of an area have progressed towards maturity, not in size, but in shape and their relative positions one to another and could be assessed in calcium supplementation studies (Rajalakshmi et al 1973). Since a study by Devadas et al (1977) has revealed that. The radiological studies are of no effect in short-term feeding trials, clinical examination alone was carried out for all the children before and after the feeding programme using the ICMR clinical assessment schedule with the help of a physician. This was mainly carried out to ensure that all the children under study were normal during the experimental period.

### E. Calcium balance study:

Begum and Pereira (1969) stated that the amount of calcium needed to attain calcium equilibrium or a positive calcium balance could be determined by balance studies. Hence a three day balance study was also carried out to determine the utilisation of calcium from leaves on children. The pertinent procedure for carrying out the balance study consisted of

1. Selection of subjects
2. Collection and analysis of food samples and
3. Collection and analysis of urine and faeces samples.

#### 1. Selection of subjects:

All the children selected for the urinary calcium analysis were selected for the calcium balance study. The investigator explained the purpose of the study to children and created a rapport with family members of all the children in order to get good co-operation for the study.

#### 2. Collection and analysis of food samples:

A food weightment survey was carried out for all the selected children in order to find out their nutrient consumption through home diets. A three day food weightment survey was carried out as it is reported to be as accurate as the commonly followed seven day weightment surveys (Tasker et al 1967). All the raw ingredients used by the families, the cooked food preparations and the foods consumed by the individual were weighed accurately on all the three days. ~~On each of the three days.~~ On each of the three days, one tenth of food

identical to that consumed by each child was collected for 24 hours, homogenized and analysed for calcium, phosphorus and total protein. Calcium content was estimated by permanganate titration of the ashed food. Phosphorus and total protein content were estimated according to the procedure of NIN (1971). The samples were analysed in duplicate for all the three days separately.

### 3. Collection and analysis of urine and faeces samples:

Urine and faeces samples were collected separately on all the three days for all the selected 20 children and preserved by the methods described by Murthy et al (1954).

Stools were homogenised in a waring blender and portions were weighed out and ashed. The ash was dissolved in concentrated hydrochloric acid. The calcium content of the extract was determined by McCruden's (1912) permanganate titration method and urinary calcium was determined by Hooper's (1956) micro method as given by Varley (1975).

Apparent absorption of calcium for all the subjects in the four regimen was calculated using the formula

$$\text{Per cent apparent absorption} = \frac{\text{Intake} - \text{Faecal excretion}}{\text{Intake}} \times 100$$

The calcium balance was arrived at using the following formula as given by Nageswararao and Narasingarao (1974).

$$\text{Calcium balance} = \text{Calcium intake} - \text{Urinary calcium} + \text{faecal calcium.}$$

#### IV RESULTS AND DISCUSSION

An attempt was made in the present investigation to study the availability of calcium from tree lettuce on school children. The availability of the mineral from tree lettuce was studied in comparison with that of amaranthus. School lunch programme was used as a medium to carry out this investigation as large numbers could be fed under controlled conditions for a longer period of time. The results obtained after three months of feeding are discussed under the following heads:

A. Food and nutrient intake of children

B. Changes in the nutritional status of children

1. Anthropometric measurements

2. Biochemical measurements

3. Clinical picture

and C. Absorption of calcium and calcium balance

##### A. Food and nutrient intake of children:

The three day weight survey conducted on selected five children from all the three experimental groups and the control group threw more light on the types and quantities of foods consumed by the children and the nutrients derived.

Table VI presents the quantities of different foods consumed by the four groups of children.

TABLE VI

MEAN DAILY FOOD INTAKE OF THE SELECTED CHILDREN

Groups	Food intake (g)							
	Cereals	Pulses	Green leafy vegetables	Other Vege- tables and roots and tubers	Fruits	Milk	Fats and oils	Sugar and Jaggery
A	250.8	33.2	34.2	38.2	39.4	197.2	11.2	33.6
B	247.0	32.0	19.8	40.8	38.4	178.6	15.2	32.2
C	272.6	36.2	25.0	46.4	55.6	161.4	16.2	50.8
D	196.2	19.2	11.4	33.2	21.6	158.6	12.2	26.0
ICMR (1968) Recommendations.	225.0	65.0	75.0	50.0	50.0	250.0	27.5	45.0

The children in all the three experimental groups received adequate quantities of cereals whereas the intake by the control group children was inadequate. When compared with the IC'R recommended allowances, the intake of pulses, green leafy vegetables, other vegetables, milk and fats and oils was deficient in all the four groups of children. It was noted that during the three days of weighment survey, the children in group C did not receive any green leafy vegetables except that given in the school lunch. The children in other groups received some amount of green leafy vegetables mainly as cabbage through home diets apart from the leafy vegetable provided through the school lunch.

The mean energy and nutrient intake of the children is given in Table VII. The individual analysed values are given in Appendix.E.

TABLE VII

MEAN ENERGY AND NUTRIENT INTAKE OF THE CHILDREN

Groups	Details	Calories	Protein* (g)	Calcium* (mg)	Phosphorus* (mg)	Iron (mg)	β-Carotene (μg)	Thiamine (mg)	Riboflavin (mg)	Vitamin C (mg)
A	H.D	869	19.7	290	297	8.6	359	0.56	0.42	20
	S.L	637	16.2	232	220	14.0	1478	0.70	0.28	34
	Total	1506	35.9	522	517	22.6	1837	1.26	0.70	54
B	H.D	799	17.7	289	351	10.0	443	0.43	0.36	12
	S.L	648	15.4	240	230	8.4	161	0.69	0.21	13
	Total	1447	33.1	529	581	18.4	604	1.12	0.57	25
C	H.D	930	20.0	316	392	10.1	900	0.53	0.45	15
	S.L	676	17.1	883	320	11.9	464	0.73	0.24	28
	Total	1626	37.1	1199	712	22.0	1371	1.26	0.69	43
D	H.D	945	19.9	273	324	14.4	735	0.61	0.50	28
	S.L	-	-	-	-	-	-	-	-	-
	Total	945	19.9	273	324	14.4	735	0.61	0.50	28
ICMR Recommendations		1650	27.5	400-500	-	15-20	1400	0.85	0.90	30-50

H.D : Home Diet

S.L: School Lunch

\*Analysed values

### Energy:

It is evident that the diets of all the children except those in group C were deficient in calories. Though the school lunch was planned to provide one third of the day's calorie requirements, it was found that the children in groups A, B and C received 42, 45 and 42 percent respectively, of their total calorie intakes through school lunch alone. This finding is in confirmity with the reports of Devadas et al (1975) on school children.

### Protein:

The analysed values for protein show that the diets of the children in the three experimental groups were adequate in protein content whereas it was deficient in the dietaries of the control group children. This is mainly because of the lowest consumption of cereals, pulses and milk by the control group children when compared with the other three groups.

### Minerals:

Since the school lunch provided considerable quantities of calcium, none of the experimental children showed deficiency in the intake of calcium whereas the children of group D consumed only 273 mg of calcium as against the

recommended allowance of 400 to 500 mg. Of all the four groups, children belonged to group C consumed the highest quantity of calcium which was 1,199 mg/day.

As Swaminathan (1974) pointed out the optimal Ca:P ratio for infants and children is 1:1 and NRC, U.S.A (1968) has recommended an allowance for phosphorus equal to that of calcium for all the age groups excepting infants. Based on these reports, it was evaluated that except the children in group D all the others received adequate quantities of phosphorus through their home and school diets.

The major source of iron for all the children was green leafy vegetables. The iron content of amaranthus was found to be 25.4 mg/100 g whereas that of tree lettuce was 17.4 mg/100g. Since the quantities of greens fed to the children through school lunch were controlled on the basis of their calcium supply, the iron content of the school lunch diets were 14.0, 8.4 and 11.9 mg respectively for groups A, B and C. However none of the children were deficient in their iron consumption and even the children of control group derived 14.4 mg of iron/day.

#### Vitamins:

Children in the group A received the highest quantities of  $\beta$ -carotene which fulfilled their daily requirement. The children in the other three groups received inadequate

quantities of B-carotene namely 604, 1,317 and 735 mg respectively for groups B, C and D. Except the control group children, all the others received required quantities of thiamine, where as all the diets were deficient in riboflavin. Vitamin C requirement was met by only two groups namely, A and C.

**B. Changes in the nutritional status of children:**

**1. Anthropometric measurements:**

**a. Heights:**

The mean increments in heights of children recorded in the four groups over a period of three months is presented in Table VIII with the details of the individual heights in Appendix. A.

TABLE VIII

MEAN INCREASE IN HEIGHTS OF CHILDREN OVER A PERIOD OF THREE MONTHS.

Groups	Heights in cm.			Groups compared	't' value
	Initial	Final	Increase in height		
A	111.06 $\pm$ 6.38	112.82 $\pm$ 7.20	1.76 $\pm$ 0.24	A Vs B A Vs C A Vs D	1.404 0.079 4.333 **
B	110.85 $\pm$ 7.26	111.38 $\pm$ 10.56	1.53 $\pm$ 0.277	B Vs C B Vs D	1.861 2.148
C	111.20 $\pm$ 5.75	112.98 $\pm$ 5.55	1.78 $\pm$ 0.333	C Vs D	6.79 **
D	111.20 $\pm$ 7.06	112.4 $\pm$ 6.87	1.24 $\pm$ 0.12		

\*\* Significant at one per cent level.

It was observed that the children in all the four groups evinced an increase in body heights over a period of three months. The height increments observed in the present investigation are in accordance with the values reported by ICMR (1972) and Devadas et al (1975). The height increments of children varied from 1.78 cm in group C receiving 25 g tree lettuce to 1.24 cm in group D which was the control. The difference between these two groups was significant at one per cent level. Among the two groups fed tree lettuce, children receiving 25 g tree lettuce recorded higher increase in height when compared with the group receiving 5 g tree lettuce. It can be correlated that the intake of all the nutrients were greater in group C, resulting in higher increments in height when compared with the group B. The difference in the height increments of groups A and D was also significant at one per cent level. The other comparisons between the groups were not statistically significant.

b. Weights:

The mean increments in weights of children recorded over a period of three months is presented in Table IX with the details of the individual weights in Appendix.B.

TABLE IX

MEAN INCREASE IN WEIGHTS OF CHILDREN OVER A PERIOD OF THREE MONTHS

Groups	Weights in kg		Increase in weight	Groups compared	't' value
	Initial	Final			
A	16.59 $\pm$ 2.19	17.56 $\pm$ 2.25	0.97 $\pm$ 0.11	A Vs B A Vs C A Vs D	1.359 1.153 8.42 **
B	16.52 $\pm$ 2.93	17.39 $\pm$ 2.99	0.87 $\pm$ 0.13	B Vs C B Vs D	1.42 6.04 **
C	16.57 $\pm$ 2.08	17.53 $\pm$ 1.90	0.96 $\pm$ 0.06	C Vs D	13.1 **
D	16.62 $\pm$ 3.19	17.09 $\pm$ 3.15	0.47 $\pm$ 0.06		

\*\* Significant at one per cent level.

The results showed that the children in all the four groups had registered increments in body weights. The rate of increase in body weights is similar to the values reported by Devadas *et al* (1970, 1971, 1973 and 1975). The increments recorded ranged from 0.96 kg for the children in group C to 0.47 kg for the children in Group D. The weights recorded by the control group children was significantly lower than the groups A, B, and C at one per cent level. Similar trends have been reported by Chandrasekhar and Amirthaveni (1976).

Similar to the observations in heights, the weight increments were also very close between the groups A and C.

## 2. Biochemical measurements:

### a. Blood haemoglobin levels:

Table X presents the <sup>mean</sup> initial and final blood haemoglobin levels of the children participated in the study. The individual values are presented in Appendix.C.

**Table X**  
MEAN INCREASE IN BLOOD HAEMOGLOBIN LEVEL OF CHILDREN OVER  
A PERIOD OF THREE MONTHS

Groups	Blood haemoglobin level g/100 ml.		Increase in level	Groups compared	't' value
	Initial	Final			
A	9.12 <sub>±</sub> 0.73	10.02 <sub>±</sub> 0.74	0.90 <sub>±</sub> 0.067	A Vs B A Vs C A Vs D	2.34 0.47 6.11**
B	8.93 <sub>±</sub> 0.69	9.55 <sub>±</sub> 0.78	0.62 <sub>±</sub> 0.259	B Vs C B Vs D	1.13 0.85
C	8.79 <sub>±</sub> 0.63	9.62 <sub>±</sub> 0.61	0.83 <sub>±</sub> 0.323	C Vs D	2.65*
D	8.99 <sub>±</sub> 0.75	9.50 <sub>±</sub> 0.98	0.51 <sub>±</sub> 0.126		

\* Significant at five per cent level

\*\* Significant at one per cent level.

The iron content of amaranthus and tree lettuce were 25.4 mg and 17.5 mg/100 g respectively. Since different quantities of greens were fed to children, group A received 6.35 mg of iron from amaranthus, group B received 0.88 mg from tree lettuce and group C received 4.38 mg iron of from tree lettuce. The groups were ranked in the same order even when their whole day's intake was considered. The effect of consuming varying quantities of iron is reflected in their blood haemoglobin values.

The mean increase in haemoglobin values registered were 0.90, 0.62 and 0.83 g/100 ml blood respectively for groups A, B and C. Children in the control group registered the lowest increase in haemoglobin level namely 0.51 g/100 ml which was significantly lower than that of group A at one per cent level and group C at five per cent level. Similar results were reported by Devadas et al (1971) who studied the effect of supplementation of rural school lunch programme with green leafy vegetables on the nutritional status of children.

b. Urinary excretion of calcium:

The six hours urine samples of selected children from the four groups were analysed for calcium content and the results are presented in Table XI along with the statistical appraisal.

TABLE XI  
URINARY EXCRETION OF CALCIUM(SIX HOURS COLLECTION)

Groups	Subjects	Urinary calcium excretion(mg)	Groups compared	't' value
A	1	36	A Vs B	0.1528
	2	40	A Vs C	8.162 **
	3	47	A Vs D	5.181 **
	4	45		
	5	58		
Mean		45.1±8.59		
B	1	43	B Vs C	8.037 **
	2	37	B Vs D	4.563 **
	3	54		
	4	53		
	5	35		
Mean		44.4±9.87		
C	1	89	C Vs D	13.77 **
	2	93		
	3	107		
	4	128		
	5	92		
Mean		103.8±11.54		
D	1	18		
	2	16		
	3	22		
	4	24		
	5	25		
Mean		21.0±3.46		

\*\* Significant at one per cent level.

The urinary calcium excretion varied from 21.0 mg for the control group to 103.8 mg for group receiving increased levels of calcium through tree lettuce. As Walker et al (1976) pointed out, there was considerable individual variations in calcium excretion in every single group of children. It was noted that the excretion of calcium through urine was closely associated with calcium intake. The group C which consumed 883 mg of calcium through school lunch excreted the highest quantity of calcium within six hours after consumption and the control group D which consumed the lowest quantity of calcium excreted the lowest quantity of the mineral through urine. The results are supporting the views of Hegsted et al (1952) who had reported that the urinary calcium excretion is a linear function of calcium intake. It is notable that the groups A and B receiving an almost similar quantity of calcium supply through their dietaries had recorded very close values being 45.0 and 44.4 mg of calcium respectively.

The urinary calcium excretion of children in groups A, B and C were significantly greater than that of children in group D at one per cent level and at the same time the values registered by the groups A and B were significantly lower than that of group C at one per cent level. The other factors which are suggested by Walker(1969)

to affect urinary calcium excretion are plasma calcium concentration, glomerular filtration rate, parathyroid hormone and metabolic acidosis.

### 3. Clinical picture:

The changes identified in the clinical picture of the children participated in the study after a period of three months is presented in Table XII.

TABLE XII  
INITIAL AND FINAL CLINICAL PICTURE OF THE CHILDREN  
(in percentage)

Symptoms	Experimental groups		Control group	
	Initial	Final	Initial	Final
Angular stomatitis	15.3	5.9	20.0	14.0
Bleeding gums	9.4	4.0	8.6	6.2
Dull and dry hair	6.9	-	7.3	6.0
Dry and rough skin	7.3	1.4	10.0	8.1
Dental caries	12.8	7.3	20.1	16.7

The common clinical symptoms observed initially in children were angular stomatitis, bleeding gums, dull and dry hair, dry and rough skin and dental caries. All the experimental groups put together there were 31 children below six year seven months and they were either new to the

school lunch programme or had experienced the programme for a shorter period of time. Hence initially deficiency symptoms were in several children. Towards the end of the study, the presence of deficiency symptoms was greatly reduced in the children who participated in the school lunch programme, where as the improvement was little in the control group children. Similar findings have also been reported by Devadas et al (1973,1975).

C. Absorption of calcium and calcium balance:

Table XIII presents the mean absorption of calcium in the four groups of children and the results of calcium balance study. The individual values are presented in Appendix.D.

TABLE XIII

PERCENTAGE CALCIUM ABSORPTION AND CALCIUM BALANCE REGISTERED BY THE CHILDREN

Groups	Subjects	Calcium in- take (mg)	Urine	Faeces	Calcium excretion in mg Balance	'Percentage' absorption	'Groups' compared	't' value for percent age absor- ption.
A	1	408	61	289	+58	29.17	A Vs B	2.124
	2	446	135	323	-12	27.58		
	3	544	130	326	+88	40.08	A Vs C	1.790
	4	610	129	358	+123	41.31	A Vs D	0.474
	5	501	137	339	+25	32.34		
	Mean	502	118	327	+56	34.10± 5.59		
B	1	585	164	327	+94	44.10	B Vs C	0.491
	2	492	138	262	+92	46.75	B Vs D	0.980
	3	607	166	390	+51	35.75		
	4	594	151	368	+75	38.05		
	5	514	137	292	+85	42.41		
	Mean	558	151	328	+79	41.41± 4.02		

contd.....

Groups	Subjects	Calcium intake (mg)	Urine	Calcium excretion in mg	Balance	Percentage absorption	Groups compared	Value for percentage absorption
C	1	1215	346	711	+158	41.48	C Vs D	0.720
	2	1116	332	596	+188	46.59		
	3	1216	319	777	+120	35.86		
	4	1190	330	731	+129	38.57		
	5	1178	323	732	+123	37.86		
	Mean	1183	330	709	+144	40.08± 3.60		
D	1	243	68	178	- 3	26.75		
	2	297	69	195	+33	34.34		
	3	185	71	131	-17	29.19		
	4	326	79	158	+89	51.53		
	5	318	78	187	+53	41.19		
	Mean	274	73	170	+31	36.60± 8.95		

The apparent calcium absorption per cent varied from individual to individual. The mean apparent calcium absorption per cent ranged from 34.10 to 41.41 and these observations are in agreement with the values reported by Malm (1958) and Nageswararao and Narasingarao(1974).

The group fed 25 g of amaranthus registered an absorption of 34.10 per cent while the group receiving the same quantity of calcium through 5 g of tree lettuce registered an absorption level of 41.41 per cent. It is notable that the children in group B though received the same quantity of calcium through a different green leafy vegetable, their mean total calcium consumption was greater because of the home food intake and at the same time, the intake of oxalates and phytates was lesser (Table XIV) with the individual values in (Appendix.E)

TABLE XIV  
MEAN OXALATE AND PHYTATE CONTENT OF THE DIETS OF CHILDREN

Groups	Oxalate (mg)	Phytate (mg)
A	271	313
B	180	281
C	217	328
D	169	273

The mean consumption of oxalates and phytates for group A were 271 and 313 mg respectively and for group B were 180 and 281 mg respectively. Higher concentration of these hindering factors might have lessened the absorption of calcium in group A pointed out by Patton, (1955) and Draper et al (1972).

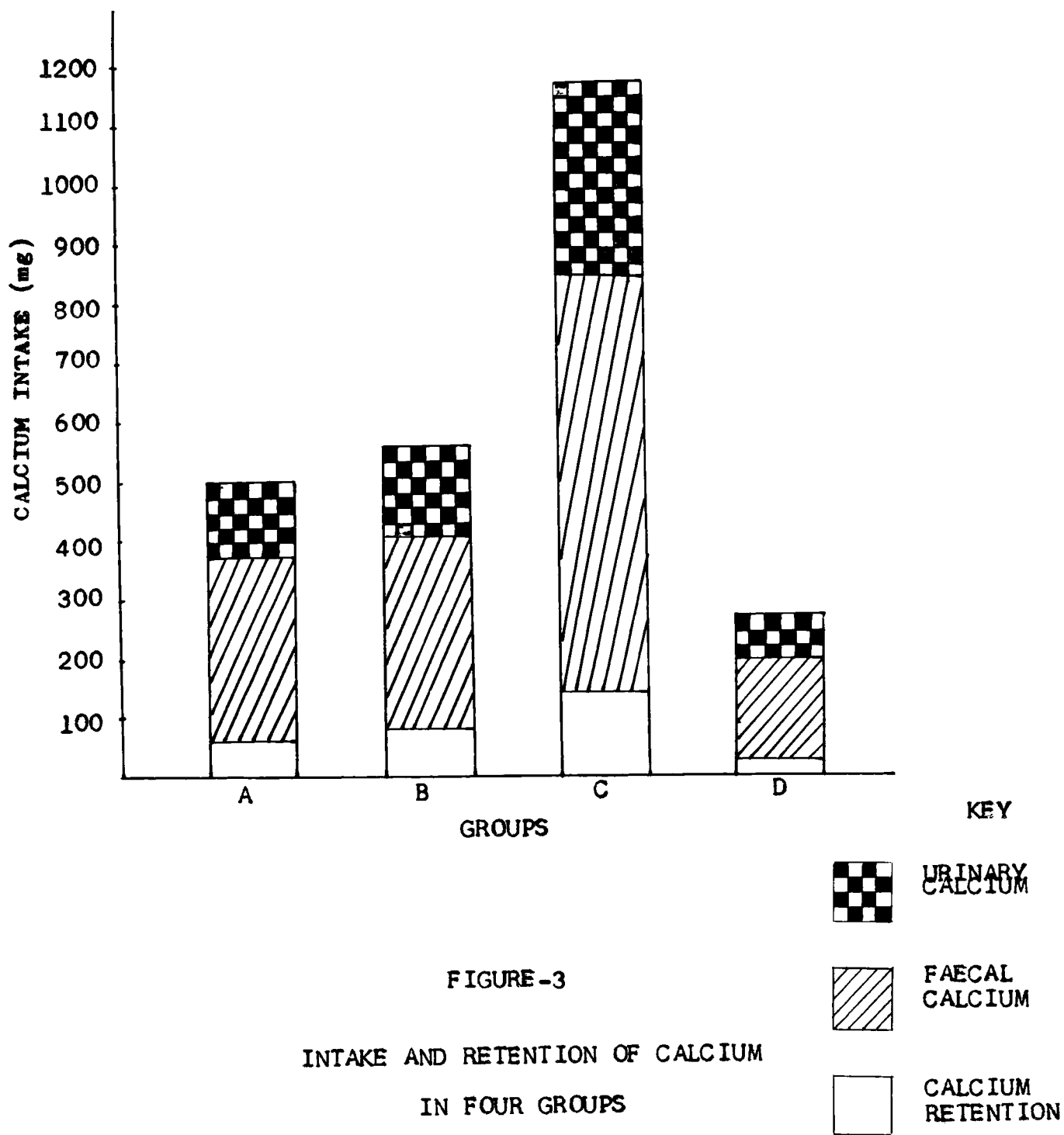
Though the children in group C received very high quantities of calcium, the percentage absorption did not increase very much. Swaminathan (1974) reported similar findings that when calcium intake is high, the percentage absorption is low and when the intake is low, the percentage absorption is high. Moreover the phosphorus and phytate content of the diets were also greater in this group when compared with those of group B.

The percentage absorption of calcium in group D was 36.60. The children in this group though consumed the lowest quantity of calcium, their absorption ranked higher than that of amaranthus group. These observations are in confirmity with the reports of Hegsted et al (1952) and Malm (1958) who explained that in the course of lowered calcium intake, the percentage calcium absorption increases, that is the faecal calcium falls and after some time the negative balance changes to a positive one or to a state of equilibrium and this adaptive mechanism acts independently

of the plasma calcium concentration. Another contributing factor is that because of the lowest consumption of leafy vegetables and cereals by the children in group D, the oxalate and phytate contents of their diets were very low when compared with the other groups. However the statistical comparison of the percentage absorption of calcium between the groups did not show any significance between the groups. Similar type of results were obtained by Devadas et al (1977).

The calcium balance observed in the study varied from individual to individual (Fig.3). The large variation in the day to day excretion of calcium resulted in irregular balances during the three days of collection in the individual subjects. It was observed that some of the subjects were either in negative or positive balances on one or more days in each collection period. This type of variations were also observed by Nageswararao and Narasingarao (1974). In the two groups given tree lettuce namely B and C, no one evinced negative calcium balance whereas in the group A fed with amaranthus, and in group D, negative calcium balances were noticed in some children.

Margen et al (1974) observed that at various levels of calcium intake or at each level of calcium intake one subject markedly different from the others can significantly influence the mean and thus in this present investigation it



was observed that in the groups A and D though some subjects were in negative balance, the mean retentions registered were +56.0 mg and +31.0 mg respectively.

Thus from the various parameters tested, it can be concluded that the tree lettuce could be used as a good source of calcium in human dietaries without any ill effects. Though 5 g of tree lettuce could supply the calcium present in 25 g of amaranthus, to obtain proper quantities of all the other nutrients needed for the overall improvement of the body, consumption of tree lettuce may be kept at a reasonable level.

## V SUMMARY AND CONCLUSION

In the present investigation, the availability of calcium from tree lettuce (Pisonia alba) on school children was studied in comparison with that of amaranthus (Amaranthus gangeticus). School lunch programme at Sri Avinashilingam Basic school was used as a medium for introducing the leafy vegetable preparations to children over a period of three months. A group of 75 children of the age group of five to ten years were selected and divided into three comparable groups (A, B and C) of 25 children each based on their mean initial age, height, weight and blood haemoglobin levels. A comparable group of children not participating in the school lunch served as controls (Group D).

Children in group A were fed with the normal school lunch menu which provided 25 g of amaranthus daily in the form of a kootu. Twentyfive grams of amaranthus supplied 150 mg calcium. In order to supply the same 150 mg. of calcium through tree lettuce, the group B was fed with 5 g of the leaves in the form of kootu for it contains 3,204 mg calcium per 100 g of leaves. The effect of feeding higher level of calcium through tree lettuce was tested in group C by feeding the children with 25 g of tree lettuce per day. Twenty five grams of tree lettuce supplied 801 mg of calcium.

The regular school lunch programme supplied one third of the day's requirement for nutrients. Home food analysis, anthropometric measurements namely monthly heights and weights, biochemical parameter namely six hours urinary calcium excretion, calcium balance and clinical picture were used as the criteria to test the availability of calcium from tree lettuce. The utilization of iron from the leaves was also tested in this study through changes in the blood haemoglobin levels of children. The results revealed the following:

1. The children in all the three experimental groups received adequate quantities of cereals whereas the intake of pulses, green leafy vegetables, other vegetables, milk and fats and oils was deficient in all the four groups of children.

2. Diets of all the children except those in group C were deficient in calories. The children in the control group had the deficiency of calories as well as protein. Since the school lunch provided considerable quantities of calcium, none of the experimental children showed the deficiency in the intake of calcium whereas the children in Group D consumed only 273 mg calcium as against the requirements of 400 to 500 mg. None of the diets were deficient in iron. Children consuming amaranthus alone were meeting the requirements for  $\beta$ -carotene. Except the control

group children, all the others received required quantities of thiamine, whereas all the diets were deficient in riboflavin. Vitamin C requirement was met by only two groups namely A and C.

3. Over a period of three months, the children in all the four groups evinced increases in heights, weights and blood haemoglobin levels.

4. The height increments varied from 1.78 cm in group C to 1.24 cm in group D. The differences between the groups C and D and A and D were significant at one per cent level. Among the two groups fed tree lettuce, children receiving 25 g tree lettuce recorded higher increase in body length than the group receiving 5 g tree lettuce.

5. The mean increments recorded for body weights ranged from 0.97 kg for the children in group A to 0.47 kg for the children in group D. The weights recorded by control group children was significantly lower than groups A, B and C at one per cent level.

6. The mean increase in blood haemoglobin levels registered were 0.90, 0.62, 0.83 and 0.51 g/100 ml respectively for groups A, B, C and D. The value of group D was significantly lower than that of group A at one per cent level and group C at five per cent level.

7. The six hours urinary calcium excretion varied from 21.0 mg for the control group to 103.8 mg for group C. As the intake of calcium increased, the excretion of calcium through urine also increased. The groups A and B receiving an almost similar quantity of calcium supply through their dietaries had very close values of calcium excretion namely 45.0 and 44.4 mg respectively.

8. The urinary calcium excretion of children in groups A, B and C were significantly greater than that of children in group D at one per cent level and at the same time the values registered by the groups A and B were significantly lower than that of group C at one per cent level.

9. The clinical picture of all the experimental children was greatly improved towards the end of the study when compared with the non school lunch children.

10. The apparent calcium absorption per cent varied from individual to individual. The apparent calcium absorption per cent for groups A, B C and D were 34.10, 41.41, 40.08 and 36.60 respectively. However, the statistical comparison between the groups did not show any significant difference.

11. In the two groups given tree lettuce namely B and C, no one evinced negative calcium balance whereas in the

group A fed with amaranthus, and in the control group D negative calcium balances were noticed in some children. However the mean calcium balance observed in groups A,B,C and D were +56, +79, +144 and +31 mg respectively.

Based on all the parameters tested, it can be concluded that tree lettuce can be used as a cheap and excellent source of calcium though its iron content is not as good as that of amaranthus. Though 5 g of tree lettuce could supply the calcium present in 25 g of amaranthus, to obtain proper quantities of all the other nutrients needed for the overall health of the body, 20 to 26 g of leaves should be recommended for providing through school lunch. Longterm feeding trials and radiological studies should be continued to see the effect of tree lettuce on bone formation. Further exploration to establish the medicinal values of this leafy vegetable would provide a wealth of information. Though in general leafy vegetables are inexpensive source of nutrients, because of inadequate facilities mainly shortage of water, the schools do not cultivate and include it in the school meal programme. If every school aims at having one or two of these trees, it would be possible to have a perennial supply of a nutritious leafy vegetable throughout the year.

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**APPENDICES**

## APPENDIX A

## INDIVIDUAL HEIGHTS OF THE CHILDREN OVER A PERIOD OF THREE MONTHS.

-----				
Group A				
Subject No.	Age in Yrs-months	First month	Second month	Third month
-----				
1.	5-6	94.7	95.3	96.4
2.	5-7	107.3	108.0	108.9
3.	5-8	106.2	107.0	108.0
4.	5-10	100.0	101.3	102.4
5.	5-10	111.7	112.6	113.4
6.	6-3	104.5	105.4	106.3
7.	6-6	111.1	111.9	112.8
8.	6-7	110.3	111.4	112.5
9.	6-7	107.3	108.3	109.1
10.	6-7	106.4	107.1	108.1
11.	6-7	106.3	107.3	108.0
12.	6-8	113.2	114.1	115.0
13.	6-9	112.4	113.2	114.1
14.	7-2	117.8	118.7	119.6
15.	7-2	111.6	112.5	113.3
16.	7-5	112.0	112.8	113.7
17.	7-7	112.0	112.9	113.6
18.	7-8	114.0	115.0	115.7
19.	7-10	112.0	112.9	113.8

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contd....

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Group A

Subject No.	Age in Yrs-months	First month	Second month	Third month
20.	7-11	118.7	119.4	120.4
21.	7-11	118.0	118.9	119.7
22.	8-6	109.4	110.1	111.1
23.	8-6	120.7	121.5	122.4
24.	8-7	122.0	122.9	123.7
25.	8-7	117.0	117.9	118.8

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## APPENDIX A

## INDIVIDUAL HEIGHTS OF THE CHILDREN OVER A PERIOD OF THREE MONTHS.

-----				
Group B				
Subject No.	Age in yrs-month	----- First month	----- Second month	----- Third month
-----				
1.	5-6	94.7	95.1	95.8
2.	5-7	103.6	104.2	105.0
3.	5-8	104.4	105.3	106.0
4.	5-10	101.1	102.1	102.8
5.	5-10	99.0	99.8	100.6
6.	6-2	113.0	113.9	114.7
7.	6-6	107.7	108.5	109.5
8.	6-6	101.5	101.9	102.8
9.	6-7	103.6	104.4	105.3
10.	6-7	114.8	115.8	116.6
11.	6-8	120.0	120.7	121.4
12.	6-8	123.1	123.9	124.9
13.	6-10	115.2	115.9	116.9
14.	7-0	106.8	107.4	108.2
15.	7-2	114.4	115.4	116.0
16.	7-3	106.6	107.5	108.4
17.	7-6	118.3	119.1	119.8
18.	7-7	119.0	119.8	120.4
19.	7-8	112.3	112.9	113.7
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contd....

Subject No.	Age in yrs-month	Group B		
		First month	Second month	Third month
20.	7-11	120.8	121.6	121.8
21.	8-0	117.4	117.6	118.5
22.	8-6	114.6	115.6	116.4
23.	8-6	110.7	111.6	112.3
24.	8-6	113.3	114.1	115.0
25.	8-7	115.3	116.1	117.0

Subject No.	Age in Yrs-month	Group C		
		First month	Second month	Third month
1.	5-6	105.1	106.4	107.5
2.	5-7	99.2	99.9	101.0
3.	5-9	104.3	105.4	106.0
4.	5-10	96.8	97.2	99.6
5.	6-0	105.8	106.6	107.4
6.	6-6	105.6	106.4	107.4
7.	6-6	110.2	111.7	112.3
8.	6-7	111.1	111.5	111.8
9.	6-7	114.4	115.3	116.3
10.	6-8	110.0	110.9	111.8
11.	6-8	109.6	110.8	111.6
12.	6-10	109.3	110.2	110.9
13.	7-0	112.9	113.8	114.8
14.	7-2	114.4	115.4	116.3
15.	7-5	119.4	120.2	121.0
16.	7-6	108.7	109.7	110.6
17.	7-6	113.5	114.4	115.4
18.	7-8	109.4	110.2	110.0
19.	7-9	118.2	119.1	120.0

contd.....

Subject No.	Age in yrs-month	Group C		
		First month	Second month	Third month
20.	8-0	107.3	108.1	109.0
21.	8-1	118.8	119.5	120.4
22.	8-5	121.4	121.8	122.3
23.	8-6	120.6	121.3	122.4
24.	8-7	116.0	116.9	117.9
25.	8-7	117.9	118.9	119.8

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Group D				
Subject No.	Age in Yrs-month	First month	Second month	Third month
-----				
1.	5-6	105.1	106.4	107.5
2.	5-7	99.2	99.9	101.0
3.	5-9	104.3	105.4	106.0
4.	5-10	96.8	97.2	99.6
5.	6-10	105.8	106.6	107.4
6.	6-6	105.6	106.4	107.4
7.	6-6	110.2	111.7	112.3
8.	6-7	111.1	111.5	111.8
9.	6-7	114.4	115.3	116.3
10.	6-8	110.0	110.9	111.8
11.	6-8	109.6	110.8	111.6
12.	6-10	109.3	110.2	110.9
13.	7-0	112.9	113.8	114.8
14.	7-2	114.4	115.4	116.3
15.	7-5	119.4	120.2	121.0
16.	7-6	108.7	109.7	110.6
17.	7-6	113.5	114.4	115.4
18.	7-8	109.4	110.2	111.0
19.	7-9	118.2	119.1	120.0
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Subject No.	Age in yrs-month	Group D		
		First month	Second month	Third month
20.	7-9	120.8	121.4	121.9
21.	8-0	118.6	119.2	119.6
22.	8-2	117.6	118.3	119.0
23.	8-4	120.4	120.8	121.7
24.	8-6	124.6	125.4	125.9
25.	8-7	120.6	120.9	121.5

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## APPENDIX B

## INDIVIDUAL WEIGHTS (IN KG) OF THE CHILDREN OVER A PERIOD OF THREE MONTHS.

Subject No.	Group A		
	First month	Second month	Third month
1.	15.600	16.000	16.550
2.	14.550	15.000	15.450
3.	15.450	16.050	16.450
4.	12.700	13.250	13.650
5.	15.900	16.500	17.400
6.	16.400	16.850	17.300
7.	16.450	16.950	17.450
8.	17.000	17.550	17.950
9.	14.800	15.300	15.700
10.	15.050	15.450	16.000
11.	15.750	16.150	16.650
12.	15.950	16.550	16.950
13.	15.300	15.700	16.200
14.	16.150	16.750	17.150
15.	21.450	21.950	22.400
16.	15.300	15.800	16.200
17.	17.950	18.450	18.950
18.	18.150	18.500	19.050
19.	20.800	21.200	21.800

contd.....

Subject No.	Group A		
	First month	Second month	Third month
20.	14.000	14.450	14.950
21.	18.900	19.600	19.800
22.	18.350	18.850	19.300
23.	19.500	20.550	20.500
24.	15.250	15.800	16.200
25.	18.100	18.500	19.050

Subject No.	Group B		
	First month	Second month	Third month
1.	12.600	12.950	13.450
2.	15.600	16.050	16.600
3.	14.450	13.850	14.300
4.	13.700	14.700	15.150
5.	14.400	14.700	15.150
6.	15.850	16.500	16.750
7.	16.000	16.500	17.050
8.	14.250	14.650	15.050
9.	14.350	14.750	15.300
10.	17.800	18.100	18.600
11.	22.250	24.650	23.800
12.	24.250	24.650	25.000
13.	15.850	16.250	16.750
14.	15.250	15.750	16.150
15.	17.100	17.400	17.750
16.	14.550	14.950	15.400
17.	18.400	18.850	19.300
18.	19.000	19.300	19.750
19.	15.400	15.750	16.350

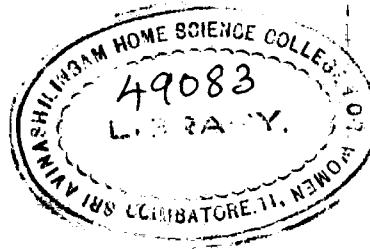
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Subject No.	Group B		
	First month	Second month	Third month
20.	19.100	19.500	20.000
21.	18.850	19.300	19.700
22.	15.850	16.250	16.650
23.	15.900	16.300	16.650
24.	16.350	16.850	17.250
25.	17.000	17.400	17.850

Subject No.	Group C		
	First month	Second month	Third month
1.	14.850	15.300	15.900
2.	14.950	14.350	15.900
3.	15.450	16.900	17.350
4.	13.250	13.700	14.250
5.	16.850	17.300	17.800
6.	16.800	17.750	18.150
7.	16.350	16.750	17.300
8.	17.200	17.750	18.150
9.	14.450	14.950	15.350
10.	16.850	17.250	17.700
11.	15.200	15.800	16.150
12.	16.600	17.050	17.500
13.	19.250	19.750	20.250
14.	20.750	21.200	21.650
15.	18.150	18.650	19.250
16.	17.650	18.050	18.600
17.	15.750	16.300	16.700
18.	16.400	17.000	17.400
19.	17.950	18.250	18.900

contd.....

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Group C			
Subject No.	First month	Second month	Third month
-----			
20.	13.100	13.500	14.200
21.	16.850	17.150	17.750
22.	12.750	13.250	13.750
23.	18.500	18.850	19.400
24.	19.950	20.350	20.900
25.	18.000	18.500	18.900
-----			



Subject No.	Group D		
	First month	Second month	Third month
1.	14.400	14.600	14.850
2.	16.400	16.550	16.800
3.	14.950	15.150	15.500
4.	15.300	15.550	15.800
5.	13.600	13.700	14.100
6.	16.400	16.650	16.850
7.	13.300	13.650	13.750
8.	15.550	15.800	16.050
9.	18.350	18.500	18.750
10.	14.050	14.250	14.500
11.	15.500	15.800	16.050
12.	14.600	14.900	15.100
13.	15.800	16.000	16.200
14.	14.200	14.600	14.800
15.	15.450	15.700	15.950
16.	20.900	21.150	21.350
17.	18.150	18.350	18.600
18.	16.300	16.500	16.850
19.	17.150	17.450	17.650

contd.....

Subject No.	Group D		
	First month	Second month	Third month
20.	20.250	20.450	20.700
21.	16.600	16.800	17.000
22.	17.850	18.050	18.250
23.	21.150	21.350	21.600
24.	20.450	20.700	20.950
25.	18.800	19.100	19.350

## APPENDIX C

INDIVIDUAL BLOOD HAEMOGLOBIN LEVELS OF THE CHILDREN OVER  
A PERIOD OF THREE MONTH.

Subject No.	Group A		
	First month	Second month	Third month
1.	8.46	8.90	9.37
2.	8.39	8.99	9.39
3.	8.45	8.87	9.34
4.	8.43	8.88	9.36
5.	8.57	9.07	9.52
6.	8.59	8.79	9.56
7.	8.60	9.04	9.44
8.	8.65	9.10	9.64
9.	8.68	9.02	9.58
10.	8.72	9.17	9.63
11.	8.89	9.37	9.75
12.	8.92	9.22	9.85
13.	8.90	9.37	9.82
14.	8.91	9.34	9.70
15.	8.95	9.38	9.86
16.	9.20	9.55	10.00
17.	9.25	9.69	10.16
18.	9.29	9.70	10.16
19.	9.75	10.41	10.60

contd.....

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Group A

Subject No.	First month	Second month	Third month
20.	9.56	10.08	10.52
21.	9.77	10.11	10.65
22.	10.11	10.41	11.02
23.	10.28	10.68	11.18
24.	10.17	10.67	10.99
25.	10.52	10.92	11.42

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Subject No.	Group B		
	First month	Second month	Third month
1.	7.95	8.39	8.56
2.	7.99	8.27	8.61
3.	7.21	7.51	7.81
4.	8.41	8.74	9.06
5.	8.39	8.70	8.99
6.	8.56	8.89	9.11
7.	8.70	8.95	9.35
8.	8.70	9.02	9.36
9.	8.75	9.09	9.39
10.	8.80	9.04	9.42
11.	8.80	9.11	9.41
12.	8.81	9.21	9.46
13.	8.89	9.38	9.49
14.	8.91	9.11	9.50
15.	9.10	9.32	9.75
16.	9.00	9.50	9.69
17.	9.20	9.50	9.81
18.	9.49	9.73	10.02
19.	9.37	9.67	10.05

contd.....

Subject No.	Group B		
	First month	Second month	Third month
20.	9.90	10.30	10.52
21.	9.80	10.12	10.48
22.	9.77	10.09	10.37
23.	9.13	9.53	9.76
24.	9.25	9.61	9.91
25.	10.45	10.70	11.05

Subject No.	Group C		
	First month	Second month	Third month
1.	7.81	8.42	8.66
2.	7.80	8.43	8.70
3.	8.17	8.62	9.04
4.	8.25	8.69	9.18
5.	8.27	8.67	9.17
6.	8.67	9.08	9.51
7.	8.49	8.90	9.33
8.	8.49	8.91	9.33
9.	8.59	8.96	9.54
10.	8.61	9.05	9.47
11.	8.60	9.01	9.35
12.	8.70	9.10	9.55
13.	8.75	8.84	9.62
14.	8.77	9.18	9.65
15.	8.80	9.10	9.67
16.	8.81	9.28	9.72
17.	8.89	9.28	9.78
18.	8.90	9.36	9.79
19.	8.90	9.27	9.70

contd.....

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Subject No.	Group C		
	First month	Second month	Third month
20.	9.20	9.41	9.72
21.	9.30	9.69	10.10
22.	9.42	9.83	10.22
23.	9.67	9.96	10.32
24.	9.57	10.07	10.60
25.	10.21	10.61	11.21

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Subject No.	Group D		
	First month	Second month	Third month
1.	8.45	8.66	8.95
2.	8.30	8.54	8.85
3.	8.30	8.50	8.81
4.	8.41	8.61	8.93
5.	8.42	8.64	8.93
6.	7.41	7.61	7.94
7.	8.50	8.75	9.06
8.	8.60	8.85	9.13
9.	8.52	8.93	9.09
10.	8.62	8.93	9.29
11.	8.64	8.86	9.15
12.	8.75	8.96	9.26
13.	8.75	8.96	9.25
14.	8.80	9.01	9.32
15.	8.82	9.09	9.27
16.	8.84	9.10	9.28
17.	9.45	9.71	10.00
18.	8.95	9.11	9.51
19.	9.40	9.61	9.91

contd.....

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Subject No.	Group D		
	First month	Second month	Third month
20.	10.45	10.70	11.04
21.	9.67	9.92	10.22
22.	9.75	9.75	9.75
23.	9.89	10.10	10.41
24.	10.50	10.60	10.99
25.	10.50	10.74	11.00

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## APPENDIX D

CALCIUM INTAKE AND EXCRETION OF THE SELECTED CHILDREN  
DURING THE THREE DAY BALANCE STUDY.

Groups	Subject No.	Day	Calcium intake in mg.	Calcium Excretion in mg	
				Urino	Faeces.
A	1	I	492	68	310
		II	340	52	230
		III	392	63	329
	2	I	416	102	301
		II	470	170	320
		III	452	133	348
	3	I	509	90	360
		II	503	140	420
		III	620	160	198
	4.	I	610	120	380
		II	542	109	331
		III	538	158	403
	5.	I	498	106	339
		II	470	140	300
		III	535	165	378
B	1	I	515	164	309
		II	480	110	316
		III	760	218	356

contd....

Groups	Subject	Day	Calcium intake in mg.	Calcium excretion in mg.	
				Urine	Faeces
	2	I	481	131	276
		II	440	141	230
		III	555	142	280
	3	I	640	129	380
		II	500	140	350
		III	681	229	440
	4	I	572	160	370
		II	610	120	334
		III	600	173	400
	5	I	500	105	300
		II	580	160	292
		III	462	146	284
C	1	I	1230	362	730
		II	1104	317	620
		III	1311	359	783
	2	I	1109	340	605
		II	999	250	490
		III	1240	406	693
	3	I	1367	337	841
		II	1065	320	740
		III	1216	300	750

contd.....

Groups	Subject No.	Day	Calcium intake in mg.	Calcium Excretion in mg.	
				Urine	Faeces.
	4	I	1126	300	740
		II	1124	290	703
		III	1320	400	750
	5	I	1350	379	848
		II	1290	350	718
		III	894	240	630
D	1	I	192	62	162
		II	230	64	182
		III	307	78	190
	2	I	250	60	140
		II	310	72	210
		III	331	75	235
	3	I	190	72	143
		II	152	65	140
		III	213	76	110
	4	I	410	79	158
		II	230	74	120
		III	338	84	196
	5	I	405	84	231
		II	309	80	190
		III	240	70	140

## APPENDIX E

CONSUMPTION OF PROTEIN, PHOSPHORUS, OXALATES AND PHYTATES  
 BY THE SELECTED CHILDREN DURING THE THREE DAY BALANCE  
 STUDY,

Groups	Subject No.	Day	Protein in g.	Phosphorus in mg.	Oxalates in mg.	Phytates in mg.
A	1	I	36.42	470.0	285.0	304
		II	37.69	350.0	310	310
		III	37.22	440.0	299	301
	2	I	45.17	450.0	309	369
		II	34.56	485.0	272	380
		III	43.63	475.3	274	367
	3	I	33.79	515.6	219	301
		II	41.10	520.1	250	290
		III	30.89	648.5	257	294
	4	I	30.59	630.1	245	299
		II	28.92	503.0	210	305
		III	34.00	710.1	297	308
	5	I	35.12	510.2	282	285
		II	37.69	490.4	249	291
		III	31.17	560.0	296	294
B	1	I	32.78	524.5	152	185
		II	36.19	512.5	164	199
		III	30.42	733.0	161	219

contd.....

Groups	Subject No	Day	Protein in g.	Phosphorus in mg.	Oxalates in mg.	Phytates in mg.
	2	I	34.52	495.2	166	201
		II	29.17	460.1	159	214
		III	32.01	590.3	170	209
	3	I	29.00	616.9	178	302
		II	32.45	510.2	190	320
		III	30.29	664.1	181	314
	4	I	35.14	580.0	149	281
		II	33.67	611.0	182	289
		III	36.52	669.0	170	300
	5	I	35.45	535.0	165	252
		II	30.09	520.0	209	280
		III	37.33	595.0	205	295
C	1	I	34.75	720.0	222	321
		II	31.25	715.0	240	319
		III	44.25	875.0	195	314
	2	I	40.76	672.4	219	280
		II	35.49	600.7	260	308
		III	38.08	769.6	211	297
	3	I	37.89	688.5	189	300
		II	38.67	709.1	219	315
		III	41.25	739.0	195	309

contd....

Groups	Subject No	Day	Protein in g.	Phosphorus in mg.	Oxalates in mg.	Phytates in mg.
	4	I	40.70	725.9	204	320
		II	32.24	670.4	240	340
		III	41.54	692.9	192	327
	5	I	30.45	610.0	223	340
		II	36.91	751.5	198	351
		III	32.45	740.0	245	326
D	1	I	16.84	280.9	135	241
		II	16.49	210.4	147	254
		III	20.38	394.9	144	282
	2	I	19.75	315.0	160	234
		II	22.16	340.0	190	241
		III	16.71	305.6	181	230
	3	I	17.91	215.2	151	325
		II	18.15	170.0	265	340
		III	23.37	249.0	214	331
	4	I	19.49	492.2	182	303
		II	21.00	291.1	169	320
		III	21.82	482.1	219	331
	5	I	19.81	440.0	192	240
		II	22.10	401.0	181	325
		III	22.95	329.0	188	295