Availability of Nutrients from Locally Available Low Cost Diet Mixtures to Nursing mothers

By

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LIST OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

Introduction

CHAPTER I

INTRODUCTION

"A mother is a mother still
The holiest thing alive" - Coleridge

"There is none in all this cold hollow world
No fountain of deep strong deathless love
Save that within a mother's Heart" - Hammad

"The bravest battle that ever was fought
shall I tell you where and when?
On the maps of the world you will find it not
For it was fought by the mothers of men"
- Joaquin Miller

Such are the sentiments accorded by poets to mothers and motherhood.

It has long been understood that, 'the hand that rocks the cradle is the hand that rules the world'. Thackerey has rightly said that "Mother" is the name of God in the lips and hearts of children.

As the famous economist - Cartoonist Piloo Modi says the development of any country can be adjudged by the status of women in that country. Mothers fight the bravest battle during pregnancy, parturition and nursing. It is therefore of utmost importance that they are provided with good nutrition especially during these occasions of increased physiological burden. Yet one of the most neglected subjects is that of the nutrition of women. Men as bread winners consume the lion's share of the family's food. The rest is shared by the children and only the last morsel reaches the woman of the house. When the mother has adequate nutrition, it means that adequate nutrition to the whole family and the country has been offered, since healthy mothers mean healthy children and healthy future citizens of the nation.

Of all the different stages in a woman's life, lactation makes a heavy demand on the nutrients supplied to the mother. Lactation is a process under the control of psychological, neurohormonal and nutritional factors. For the first nine months of independant life, the infant can be considered as an exterogestate or external foetus with the breast taking the place of placenta (Jellife and Jellife, 1979). Biological breast feeding under village circumstances is a 24 hour phenomena with many feeds given at night (Thompson and Black, 1979).

In a study of the Hill tribes of South India, Belavady and Coworkers (1971) found that the mothers continue to breast feed till atleast the end of the second year. Weaning was determined by the onset of the next pregnancy and not by any definite ideas or beliefs regarding the optimal time for weaning. Breast feeding itself was done on demand and not according to schedule.

Unlike in pregnancy, the nursing mother needs larger amounts of body building, protective and energy yielding foods to enable the secretion of milk (Sibert et al., 1980). Both in kind and amount, the food eaten by the nursing mothers in poor Indian communities does not differ from that consumed during pregnancy, or at any other time. (Shankar et al., 1982).

Diet surveys carried out in a series of poor Indian women in different stages of lactation have shown that the diets were grossly inadequate in several aspects. (Devadas et al., 1976 and Someswara Rao et al., 1982). Studies on the chemical composition of breast milk (Mayes and Hodwell, 1983) from women of poor Indian communities compared well with those obtained from well nourished mothers. It has hence been shown that Indian mothers keep up the quality of breast milk by withdrawing nutrients from their own blood, bones and muscles for the formation of milk, since their inadequate diet is by itself incapable of providing the nutrients for satisfactory milk production. Helsing and King (1984) have shown that milk production is maintained at the expense of the mother's reserves.

A lactating mother can use a variety of raw materials and make them into a highly specialised and complex liquid food with a wastage of less than 10 percent ie., about ninety percent of the extra food, the nursing mother ents is regained as breast milk (Thompson et al., 1984). The milk production in India amounts to 3.27 million tonnes. The value of human milk has been estimated to be 5.05 million rupees. This has been based on the assumption that breast feeding is carried out for one year by 30 percent of the mothers. Even this under estimate of available human milk in India would demonstrate what a great asset we have in this food. There is no suitable substitute that we can offer for this natural baby food in the immediate future. (Gopalan and Belavady, 1975). Diminished volume of milk is observed only in cases of severe malnutrition, anaemia, infections etc. which affect the maternal reflexes notably due to environmental and psychological stress. (Atalah et al., 1983)

India is a poor country with nearly 65 percent of her people living below the poverty line. Many a family in the poorer classes of society can hardly afford a bare square meal a day. (Masani, M. 1976). Yet the lactating mother of the lower socio economic group needs an adequate intake of the essential nutrients to help the infant to tide through the initial difficult period of life during which growth and development proceed at an accelerated pace. (Devadas, et al., 1982).

The inadequacy of food for the lactating mothers is further aggravated by food fads, customs, taboos and which affect their nutrition appreciably. Beliefs in nutritional demands during lactation, yet information regarding the precise nutritional demands is lacking. Only very scanty information regarding the availability of nutrients for the Indian nursing mother is available. Therefore, this study aimed at determining the retention of some of the essential nutrients and trace minerals in lactating women, fed on low cost locally available diet mixtures formulated accordingly to cater to their requirements as specified by the ICMR.

The study was conducted on six selected lactating women in the nearby village Govanur in Periamaickenpalayam block.

Review of Literature

CHAPTER II

REVIEW OF LITERATURE

The review of literature pertaining to the topic "Availability of nutrients from locally available low cost diet mixtures to lactating women", has been described under the following headings;

A. Maternal physiological adjustments during lactation

B. Nutritional requirements during lactation

C. Effect of maternal nutrition on lactation

D. Effect of dietary supplementation

E. Bioavailability of nutrients during lactation

A. Maternal physiological adjustments during lactation

The physiological developments for lactation begin during the later part of pregnancy (Higashi, 1982). Alterations occur in

i) General metabolism

The BMR is increased by about 12 percent during lactation. Hence the increase in resting oxygen requirement continues to be 10 percent above the non pregnant, non lactating women (Widdowson, 1977).

ii) Sugar metabolism

The sugar metabolism which is glucose centred in the non pregnant, non lactating women, becomes triglyceride centred during pregnancy and the onset of lactation. However with the production of mature milk the energy metabolism becomes glucose centred again (Steingrimsdottir, *et al.*, 1980)

iii) *Fat metabolism*

During normal pregnancy 2 kg of fat is deposited (Widdowson, 1979). These stores of lipids are an important buffer to ensure adequate fat resources during lactation when endocrine mechanisms favour fat transfer to the infant.

Blood lipid levels are elevated during the first months of lactation (Aurell and Cramer, 1979) and fatty acid synthesis rapidly declines (Hall, 1977). Essential fatty acid distribution within milk fat depends on the distribution within maternal tissues (Nichols and Nichols, 1981).

Fat stored during pregnancy makes a major contribution to the energy cost of lactation. Its mobilisation is under hormonal, rather than dietary control (Naismith, *et al.*, 1983).

iv) *Protein metabolism*

Plasma transferrin levels increase in the maternal organism during lactation. Its concentration parallels that of lactoferrin in human milk (Fowler, 1975).

Rat studies have revealed that lactation effected no loss on body proteins but 60 percent of the total body protein was mobilised into milk. Proteins supplemented were more efficiently used in lactating rats than by virgin controls (Naismith *et al.*, 1982)

Macrominerals - Sodium and Potassium

During early lactation colostral milk has increased sodium concentration which diminishes rapidly over a fortnight. This level reduced to 2 mEq/l and the potassium level to 4 mEq/l at 3-4 months of lactation. (Keenan, 1981).

The volume of milk produced is a function of the rate of synthesis of lactose in the alveolar cells. This trapping of osmolar forces in the human is thought to be responsible for the sodium potassium concentration in milk. The ratio of Sodium : Potassium is a reflection of the intracellular site in which lactose is synthesised (Peaker, 1976).

Calcium

During lactation 0.5 g/day of calcium is donated to the infant through breast milk (Pitkin, 1975) calcium and phosphorus levels decrease during pregnancy. Their concentrations increase to the non pregnant levels during lactation (Kirkland, 1981).

Donelson et al., (1982) have observed that frequent pregnancies with long copious lactation deplete the woman's body of calcium. According to Hansen *et al.*, (1983) sufficient reserves may be built up during pregnancy so that during lactation losses are not deletrious.

<u>Iron:</u>

Iron stores amount to 3500 mg in ~~a~~ normal women (Widdowson and Dickerson, 1963). During lactation 1.0 mg of iron is mobilised into milk (Picciano and Guthrie, 1976) Infant iron stores are independant of maternal stores (Dallman, *et al.*, 1980)

<u>Trace minerals - Zinc</u>

A women has 1.3 g of zinc in her body (Widdowson and Dickerson, 19 3). This increases to 1.7 g during pregnancy and lactation (Schraer and Calloway, 1983).

<u>Copper</u>

80 mg of copper are present in the adult woman (Vaughan, 1979). 0.2 mg of copper are secreted per day in breast milk (Weber and Kamberling, 1980). Following delivery the maternal serum copper levels decline over several months. This is due to the drain through breast milk (Samm, *et al.*, 1980)

Copper concentration in human milk decreases slightly with the production of mature milk but has no relation to maternal copper intake (Voori et al., 1980). Lower zinc and more copper has been reported in serum during lactation.

Fat Soluble Vitamins.

Vitamin D: The maternal serum levels of 25 hydroxy and 1, 25 dihydroxy vitamin D remain elevated during lactation. These levels parallel the serum concentration of prolactin. (Land and Selemes, 1979). Serum parathormone level was decreased with increased calcium and magnesium levels (Uneer, et al., 1982).

Vitamin A: Blood levels of vitamin A in lactating women receiving adequate intake of the vitamin are elevated 6 weeks after delivery (Gal and Parkinson, 1976).

Vitamin E. Serum levels of the vitamin are slightly raised and its level in colostrum parallels serum levels (Martin and Huxley, 1977).

Vitamin K. Metabolism has not been directly investigated in lactation.

Water Soluble Vitamins

Vitamin C. Maternal blood levels decreased to 50 percent of the normal during lactation (Mason and Rivers, 1977). No increase in concentration was noted after administration of C supplements (Thomas et al., 1979)

B Complex Metabolism

The concentration of riboflavin increases by 20 percent in maternal circulation. It decreases on prolonged lactation (Naismith, 1980).

The efficiency of conversion of tryptophan to niacin is increased during lactation (Thomas *et al.*, 1979).

Maternal serum concentration of pyridoxine are increased during early lactation. In mature milk the concentration is sixteen times greater than in maternal blood levels (Thomas *et al.*, 1979).

Changes in Body Weight and Composition

Indian women from rural communities gain between 5 and 7 kg in weight as accounted by the increased blood volume, development of mammary glands and deposition of body fat in the mother (Gopalan and Belavady, 1967).

Inspite of prolonged lactation Indian mothers showed no weight loss. Weight loss was masked by excessive hydration. The increases in body water parelled decline in body fat (Gopalan and Venkatachalam, 1967).

However Dalton and Allen, (1983) report that anthropometric measurements decreased at sites on the trunk but not on the limbs during lactation.

Butte *et al.*, (1984) have shown that nursing women of the developed countries lost 2 percent of body weight over 4 months of lactation.

B. Nutritional Requirements during Lactation

The additional requirements for lactation are computed from the volume of milk secreted. The estimated volume of milk secreted, is 400-600 ml/day by the mother belonging to the lower socio economic group in India (Rao, 1976).

Though breast milk is easily available from the mother, breast feeding imposes greater strain on her than pregnancy. In order to breast feed her infant without any undue strain on her own body, she must continue to eat more foods than the non pregnant, non lactating women (Guthrie, 1975; NIN, 1976; Robert, 1979). If these demands are not met the health of the mother is bound to suffer (Prema, 1980; Chatley, 1983). It is usually sufficient that additional amounts of the same types of food that she normally consumes with special attention to fluid intake and sources of calcium and ascorbic acid are provided (Worthington et al., 1977; Sims, 1978)

In the work of Shukers and Macy et al., it was found that, 'Lactation increases the food demands of the mother approximately 60 percent over and above that of pregnancy'.

Calories

On the basis of secretion of 850 ml of milk, and 80 percent efficiency of conversion of dietary energy into milk energy and taking into account the contribution of energy from fat stores built up during pregnancy it was recommended that additional energy allowance during lactation should be 500 K Cal/day for the first six months. Lactation upto one year calls for an extra allowance of 400 K Cal/day.

Proteins

The average protein content of breast milk of Indian women is 1.2 g/dl. The efficiency of conversion of dietary protein is not known and it is generally assumed that protein is used for milk protein synthesis as efficiently as for body protein synthesis. The protein allowance is given as 25 g/day for 0-6 months of lactation.

Fats

Breast milk secreted during a day, contains between 3 and 5 g of EFA. The efficiency of conversion of dietary EFA to milk EFA is not known. A level of 6 percent energy through EFA is recommended.

Iron

In addition to the basal losses, iron is lost through breast milk. The concentration of iron in breast milk is about 0.12 mg/dl. Because of lactational amenorrhoea 1 mg of iron which would have been otherwise lost, is saved and compensates for the iron loss through milk. Hence there appears to be no need for additional allowances during lactation.

Calcium

The calcium content of breast milk varies between 30 and 40 mg/dl, and the total calcium lost through milk is about 300 mg/day. The level of calcium which would result in such retention is not exactly known. An intake of about 1 g of calcium daily may be expected to cover the needs of pregnant and lactating women.

Vitamin A

The additional requirements are calculated on the basis of the vitamin A, secreted in milk. The vitamin A content of breast milk of Indian women is 21 mg/dl. 400 mg can be given for Indian women for 0-6 months of lactation.

Vitamin D

The requirements for vitamin D during lactation is higher since calcium metabolism is under physiological stress, 400 IU of vitamin D has been recommended.

Vitamin C

The additional needs during lactation are calculated on the basis of vitamin C secreted in milk. Studies have shown that 2.6 mg/dl of vitamin C are secreted in breast milk. The ICMR had recommended 15 mg of vitamin C per day during lactation. The present committee has recommended 40 mg/day. Additional needs are based on the amount of ascorbic acid needed to maintain concentrations of the vitamin in leucocytes.

Thiamine

In breast milk is below 15 μg /dl. The maximum concentration was 20 μg/dl. Thiamine allowance is calculated on basis of energy allowance of 0.5 mg /1000 calories.

Riboflavin

Breast milk contains 17 μg of riboflavin per 100 ml. The requirements can be computed for normal subjects on the basis of 0.6 mg/1000 K calories.

Niacin

The nicotinic acid content of breast milk in Indian women ranges from 100-150 μg /dl. Dietary allowances for niacin have been fixed at 6.6 mg niacin equivalents per 1000 K Cals during lactation.

Pyridoxine

Studies have shown that more than 4 mg of vitamin B are required to maintain the plasma levels of pyridoxal phosphate.

C. Effect of Maternal Nutrition of Lactation

Studies have shown that poor dietary intake and nutritional status of nursing mothers were not reflected in the concentration of nutrients and other constituents of breast milk (Reddy et al., 1977)

Women of poor communities are in a state of continuous lactation, throughout the child bearing period of their lives. Malnutrition affects the quantity of breast milk though the quality compares well with the breast milk of well nourished women (Gopalan and Belavady, 1960). Volume of milk output is also governed by the stage of lactation (Belavady et al., 1970)

Severe degrees of malnutrition remarkably diminish the milk out put (Parischa, 1957). Mothers belonging to the poor communities secrete between 450 and 600 g of milk in twenty four hours (Phalsankar and Patwardhan 1965).

The concentrations of fat and vitamins A, B and C are lower in milk samples of malnourished mothers than those in the breast milk of their well nourished counter parts (Ghosh, 1981)

Food fads and beliefs regarding hot and cold foods and galactogogues also contribute to malnutrition which has an impact on lactation among women of the lower socio economic group (Worman, 1976).

Apart from malnutrition, anaemia, infections and factors affecting the maternal reflexes notably, environmental and psychological stress also produced a reduction in breast milk output (Mad et al., 1977). Anxiety, uncertainity and lack of interest interfere with the letdown reflex and failure of lactation ensures (Jellife and Jellief, 1978).

Inadequacy of milk, breast problems, refusal of the infant to be fed, illness, work, study or holiday of the mothers may pose problems during lactation. Transitional lactational crisis may occur due to emotions or fatigue, menstruation and for no clear reason (Verenen, 1979).

Lactation is also governed by hormonal factors which are stimulated by the suckling reflex, and the neuro hormonal mechanisms (Best and Taylor, 1967).

D. Effect of Dietary Supplementation on Lactation

Though the composition of breast milk does not vary by alterations in maternal nutrition, yet the output of lactation varies with the maternal nutritional status.

Studies have shown that women who lactated the most had the highest energy intake. They lost the smallest amount of weight (Dalton and Allen, 1982).

Addition of more amounts of cholesterol to the maternal diet does not change the cholesterol level in breast milk (Mellies et al., 1978). However the production of myelin in the infant which requires saturated fatty acids can be modified if the quantity of fatty acid is altered in the maternal diet (Hansen et al., 1970)

Maternal protein inadequacy is associated with decreased milk production. Feeding of protein supplements increased milk volume which is sustained for the period of supplementation. No alteration was observed in the concentration of protein in breast milk (Edozain et al., 1976)

Concentration of fat and some of the vitamins especially the water soluble ones increased in breast milk with supplementation of the respective nutrients in the diet. The levels of minerals remain unaltered (Rajalakshmi et al., 1975)

Studies on the effect of dietary supplementation on the composition of breast milk (Belavady and Gopalan 1960) showed that supplementation of the maternal diet with vitamin A had no effect on the concentration of this vitamin in milk. Thiamine and ascorbic acid supplements brought about an increase of the same in milk. Calcium supplementation for shorter periods has no effect while longer periods of supplementation reduced the calcium concentration of milk. Roger and white head (1984) have observed a thirty five week shortening of post pastum amenorrhoea in lactating Gambian women following a substantial increase in food consumption.

Studies conducted on lactating Indian women also show a progressive decrease in the postponement of menstruation (NIN, 1977).

Lunn and Colleagues (1982) have suggested that there is a real risk of an increase in birth rate following maternal supplementation.

Poor nutrition increases prolactin levels by inhibiting the release of gonadotrophins thereby suppressing resumption of ovulation.

E. <u>Bioavailability of nutrients</u>

Bioavailability of nutrients according to Cuthbertson (1973) is defined as the percentage of nutrients supplied by the food which can be used to make good the endogenous loss or promote storage for growth, reproduction or lactation. The bioavailability of nutrients differ from individual to individual (Cuthberton, 1973).

Nitrogen balance studies on young Indian women on marginal intake of mixed proteins at three different levels showed an average retention of 2.71 g/sq. metre/day. At marginal nitrogen intakes nitrogen balance in Indian women belonging to the poor socio economic group are similar to that of well nourished women (Parischa, et al., 1965)

The value for minimum protein for maintaining balance was increased in lactating women. An intake of 100g of or above of protein per day have been shown to discharge the tissue protein deficit of lactating women belonging to the low socio economic group (Gopalan and Belavady, 1967). Nitrogen retention was found to be between 0.2 and 1.26 g at 9.81 g of intake in nursing mothers (Belavady and Venkatachalam, 1969).

During lactation 0.3 g/day of calcium are secreted in the breast milk (Lie et al., 1970). Increased intakes of calcium caused an increase of calcium in fecal excretion. This shows that factors inhibiting retention were operating in the body of the nursing mother (Iriven, 1973).

Garry and Stevens, (1973) observe that positive balance for calcium is maintained when the mothers are provided with good mixed diets supplying not less than four times the milk calcium needed for positive balance.

Studies on the absorption of iron have been done using extrinsic tag techniques. 30 mg of Iron have been recommended by the ICMR to maintain balance in nursing mothers. During lactation there is an increased intestinal uptake of iron. The mechanism is unknown (Cuthberton, 1973). Absorption and retention of trace elements in adults are given as percentages of dietary intakes. On an intake of 1.73 mg and 4.1 mg of copper and manganese respectively, balances of these elements were observed. The mean retention values were found to be 18 percent and 14 percent respectively. Zinc was retained at the level of 16 percent (Nageswara Rao *et al.*, 1980)

Studies on breast milk of Indian women showed that 1.2 g of zinc and 0.17 g of copper were present in 1 ml of breast milk. Concentrations of copper, zinc and manganese were not related to their dietary intakes of the elements (Rajalakshmi and Srikantia, 1980).

A minimum of 10 mg of Zinc per day with an absorption of 20 percent have to be provided in an average Indian diet to achieve a positive balance of this element. A retention of 1 mg/day account for losses in sweat also (Narasinga Rao et al., 1980)

Manganese balance was observed at a level of intake of 4.15 mg/day. The retention of 18 percent of copper from regional diets is lower than the mean value of 30 percent reported by Cartwright and Wintrobe (1964) for American diets.

Results of balance studies done by ICMR research workers (1977) on lactating women showed that 20-30 percent of magnesium and 10-35 percent of copper, zinc and manganese were absorbed.

Availability of zinc from protein rich foods is greater than that from energy rich sources (Underwood, 1978).

Stanislowski et al., (1980) have shown that the greater availability of zinc from breast milk was due to its binding to a Low Molecular Weight, Zinc Binding Ligand (LMW/ZBL). This ZBL is found to be zinc citrate.

In normal adults the intake of zinc 14 mg and the output is 14 mg (Schroeder, 1973).

Experimental Procedure

CHAPTER III

EXPERIMENTAL PROCEDURE

The methodology involved in the conduct of this study in the "Availability of nutrients from low cost locally available foods for lactating women" is discussed under the following heads;

A. Selection of village and Lactating Women

B. Orienting the subjects regarding the study

C. Formulation of the diets

   i. Basal

   ii. Experimental I

   iii. Experimental II

D. Conducting the study

A. <u>Selection of village and Lactating women</u>

A nearby village, Gogumar in the Periamaicken-palayam block was selected for the study since the people were co-operative. The village had all the facilities for conducting the balance study. The previous longitudinal growth studies on humans were conducted by Devadas and coworkers (1975-81) in this village and hence the necessary co-operation was forthcoming and orientation had already been effected. Six lactating women who were in the phase of 0-6 months lactation were selected for the study with the help of the village leader.

2. Orienting the subjects regarding the study

The selected lactating women were informed about the aim and the procedure involved in the actual conduct of the study. They were advised to volunteer for the study if they were in a position to adhere to all the specifications mentioned and be under the strict control of the investigator. Thus the initial rapport was established and co-operation ensured for the controlled conditions necessary for the conduct of balance studies. The age, height and weight of the six lactating women thus selected are given in Table. I

TABLE I

AGE, HEIGHT AND WEIGHT OF THE SUBJECTS

Sl.No.	AGE Yrs	HEIGHT Cms.	WEIGHT Kg
1.	21	149.0	34.0
2.	20	150.0	40.0
3.	20	151.0	38.0
4.	21	156.5	39.0
5.	22	151.5	38.0
6.	23	155.0	42.5

C. Formulation of the Diet

i) Basal Diet

Based on the results of the diet survey conducted in the beginning of this study to elicit the local dietary and eating habits, the basal diet was formulated. The food items commonly consumed included Ragi, Semolina (Wheat rava), Rice, Brinjal, Potato, Greens and dhal. With these food items as the basis, the basal meal pattern was planned taking care that the recipes were not often repeated. In planning the menu, the meal pattern of the women in their homes, the kinds of foods consumed in their homes and their usual food habits and timings of meals were also borne in mind (Isaksson and Sjogren, 1967). The basal meal pattern thus formulated is given in Table II

TABLE II

MEAL PATTERN

NAME OF THE MEAL	TIME	NAME OF THE PREPARATION
Break fast	8.00 A.M.	Ragi pittu/Wheat uppuma/Wheat dosai/ragi dosai/Ragi uppuma
Lunch	1.30 P.M.	Ragi kali/Rice/Ragi dosai/Potato brinjal Sambar Cabbage sambar/Keerai pongal
Supper	8.00 P.M.	Rice/Ragi roti Brinjal/Potato brinjal poriyal

ii) Experimental Diets I and II

The lactating women were to be fed so as to meet their daily food requirements through the experimental diets. The diets chosen were the same as the rice and ragi based diets formulated by Devadas and coworkers (1975-81). The percentage composition of these diets and the ICMR allowances formed the basis for calculating the quantities of each food item to be fed daily. The quantities thus formulated was distributed in four meals and suitable meal patterns planned, for both rice and ragi based diets. Menus were thus planned for two weeks (15 days) using various food ingredients for both the diet combinations. The quantities had to be standardised. In planning these menus, the local dietary habits were given prime consideration. As far as possible the recipes used and their distribution in the four meals of the day were in accordance with the local dietaries.

Though the recipes included in the meal pattern were customarily used in the local villages, they had to be standardised to accommodate in each recipe the quantities of food in the two suggested rice and ragi diet composition. The recipes were standardised using the normal procedure outlined by Amerine et al.,

(1965) for quantity of ingredients, procedure, reproducibility and feasibility of using them in the feeding trial and portion control for each serving. Table.III shows formulated composition of rice and ragi based diets to meet the recommended food allowances based on ICMR (1982) food allowances for lactating women doing sedantary work. Table. IV gives the menu pattern followed during the two experimental period

B. Conducting the study

The procedure involved in conducting this aspect of, the study included;

1. Designing the experiment
2. Preparation for the metabolic study
3. Collection and preservation of the samples
4. Analysis of the samples

1. Designing the experiment

The experimental period of 21 days consisted of 3 phases.

Phase 1 : Basal diet to include a four day adaptation period and a three day collection period.

Phase 2 : Ragi based diet to include a four day adaptation period and a three day collection period.

Phase 3 : Rice based diet to include a four day adaptation period and a three day collection period.

TABLE XII

FORMULATED COMPOSITION OF THE RICE AND RAGI BASED DIETS TO MEET THE RECOMMENDED DAILY ALLOWANCES

FOODS	PERCENTAGE COMPOSITION OF RICE BASED DIETS	DAILY REQUIREMENTS COMPUTED FROM THE ICMR RECOMMENDED ALLOWANCES (g.)	PERCENTAGE COMPOSITION OF RAGI BASED DIETS	DAILY REQUIREMENTS COMPUTED FROM THE ICMR RECOMMENDED ALLOWANCES (g.)
Rice (Parboiled & Milled) / Ragi	35.89	409.5733	38.84	444.0
Sweet potato	4.50	6.00	5.00	57.1067
Horsegram	13.50	18.00	11.00	125.64
Sesame	5.0	6.667	5.00	57.1067
Amaranthus	5.5	7.33	4.00	45.64
Groundnut	4.5	6.00	5.00	57.1067
Other ingredients				
Redgram dhal	7.64	9.9467	7.46	85.5
Drumstick leaves	3.09	4.12	3.09	35.28
Potato	4.22	5.6267	4.22	48.1867
Brinjal	4.87	6.4933	4.87	55.6267
Banana	1.52	2.0267	1.52	17.36
Milk	7.08	9.44	7.88	90
Jaggery	1.29	1.72	1.29	14.5733
Groundnut oil	0.83	1.1067	0.83	9.4667

TABLE IV

MENU PATTERN OF THE LACTATING WOMEN DURING THE EXPERIMENTAL PERIOD

DAYS	NAME OF MEAL AND TIME		RAGI BASED DIET	RICE BASED DIET
1 and 4	Breakfast	9.00 A.M.	Ragi kali, Horsegram and Brinjal thokku, Sesame Chutney, Banana	Rice Uppuma, Horsegram and Brinjal Kottu, Horsegram podi, banana
	Lunch	1.30 P.M.	Ragi+Horsegram+Redgram dhal, dosai, Greens+Dhal koottu, Sweet potato and potato poriyal and butter milk	Dhal+Greens rice, sweet potato+potato poriyal, Horsegram thokku
	Tea	4.00 P.M.	Horsegram sundal, roasted peanuts, jaggery	Sesame groundnut balls
	Supper	8.00 P.M.	Ragi, horsegram, redgram dhal dosai, greens+dhal kootu, Sweet potato and potato poriyal	Dhal+Greens rice, sweet potato+potato poriyal Horsegram thokku
2 and 5	Breakfast	9.00 A.M.	Ragi uppuma, Horsegram+ Redgram dhal + Brinjal Kootu, Sesame chutney, banana	Rice adai, horsegram thokku sesame chutney (sweet) banana
	Lunch	1.30 P.M.	Ragi kali, redgram dhal+ greens kootu, sweet potato, potato poriyal, horsegram thokku, butter milk	Rice, horsegram+redgram+ Greens sambar, sweet potato+ potato+brinjal poriyal, butter milk
	Tea	4.00 P.M.	Horsegram sundal, roasted peanuts, jaggery	Horsegram sundal, roasted groundnuts.

Contd....

TABLE. IV (Contd..)

DAYS	NAME OF MEAL AND TIME		RAGI BASED DIET	RICE BASED DIET
	Dinner	8.00 P.M.	Ragi kali, redgram dhal+ greens kootu, Sweet potato poriyal, horsegram thokku.	
5 and 6	Breakfast	9.00 A.M.	Ragi + horsegram+redgram dhal dosai, Greens+Redgram dhal, marriyal, Horsegram padi, banana.	Rice pittu, groundnut+ jaggery+sesame chutney banana.
	Lunch	1.30 P.M.	Ragi kali, Horsegram thokku Sesame+brinjal sambar, sweet potato+potato poriyal, buttermilk.	Brinjal rice, sweet potato+potato poriyal, redgram dhal+greens masiyal, horsegram thokku, buttermilk.
	Tea	4.00 P.M	Horsegram sundal, Roasted peanut, jaggery.	Horsegram sundal.
	Dinner	8.00 P.M.	Ragi kali, horsegram thokku, sesame + brinjal sambar, sweet potato + potato poriyal.	
7	Breakfast	9.00 A.M.	Ragi+Horsegram+Redgram dhal+greens marriyal, groundnut jaggery chutney, banana.	Brinjal rice, greens marriyal, sesame sweet chutney, banana.

Contd....

TABLE. IV (Contd...)

DAYS	NAME OF THE MEAL TIME	RAGI BASED DIET	RICE BASED DIET
	Lunch 1.30 P.M.	Ragi pittu, brinjal+Sweet potato+potato poriyal, Sesame chutney, buttermilk	Rice, thick dhal, horsegram thokku, sweet potato, potato poriyal, buttermilk
	Tea 4.00 P.M.	Horsegram sundal	Horsegram sundal, roasted groundnuts.
	Dinner 8.00 P.M.	Ragi pittu, Brinjal + Sweet potato+potato poriyal, Sesame chutney	

BREAKFAST

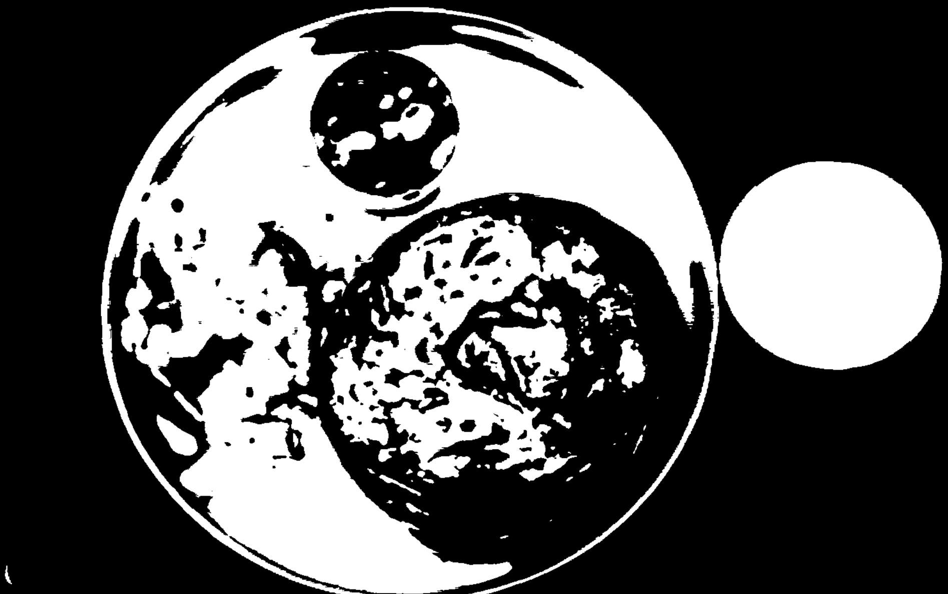
RAGI KALI, HORSE GRAM + BRINJAL THOKKU

SESAME CHUTNEY, BANANA.

BREAK-FAST

RAGI KALI, HORSE GRAM + BRINJAL THOKKU

SESAME CHUTNEY, BANANA.



LUNCH

RAGI + REDGRAM DHAL + HORSE GRAM DOSAI,

GREENS + DHAL KOOTU, POTATO + SWEET POTATO

PORIYAL, BUTTERMILK.

TEA

ROASTED PEANUTS, JAGGERY

HORSE GRAM SUNDAL

SUPPER.

RAGI + REDGRAM DHAL + HORSE GRAM DOSAI, POTATO + SWEET POTATO PORIYAL, DRUMSTICK LEAVES + DHAL KOOTU.

2. Preparation for the Metabolic study

For the metabolic study to be conducted, a separate house with two rooms and a kitchen was obtained in the village and the lactating women housed there. The kitchen served as the cooking and washing area. The subjects were once again oriented about the procedures involved in the conduct of the study and what was required of them. Each of the nursing mothers were provided with containers to urinate and defecate. They were instructed to collect the whole day's urine and feces.

Before the study commenced, a list of all the ingredients needed for the diets were made and those which were required for one week were purchased in bulk. Perishable items like greens, banana and milk were bought every day.

All the raw foods used for the preparation of the meals were weighed out accurately. The cooked products were weighed and given according to the need of the individual subject in the case of the basal diet, whereas for the experimental phases two and three the cooked food was quantified and served equally to all the women. One twentieth of the individual consumption for each diet phase was weighed and preserved for analysis. A daily food intake record for each individual was also maintained.

3. Collection and Preservation of Samples

a) Food

One-twentieth aliquot portions of all the cooked feeds served to the individual per day, was preserved in 6 N Hcl for nitrogen analysis. Another one-twentieth portion was sun dried and preserved for analysis of trace elements.

b) Faeces

[illegible] tablets which served as a marker facilitated the collection of feces which was done in widemouthed flat plastic containers. The whole days feces was weighed, homogenised and two one-twentieth aliquot portions were taken, one preserved under 9 N Hcl for nitrogen analysis and the other sun dried for trace mineral analysis.

c) Urine

A whole day's urine was collected in large bottles containing toluene as preservative, measured and one twentieth aliquots preserved for analysis.

d) Breast milk

Samples of breast milk were collected in injection vials and transported immediately to the laboratory for analysis.

4. <u>Analysis of the Samples</u>

The samples of food, breast milk, feces and urine were analysed for their nitrogen, calcium, iron, potassium and copper, zinc and manganese contents. The balance of retention for each nutrient was then calculated.

Nitrogen in the food samples and feces were analysed by the macrokjeldahl method (Hawk et al., 1961). The urine samples were analysed by the microkjeldahl method (Hawk *et al.*, 1961)

Calcium in food, feces and urine were analysed by the versenate titration method (Jackson, 1957).

Iron and the trace elements such as copper, zinc, and manganese were estimated by the after the wet ashing procedure of Gerasch using 3:2:1 mixture (Triple acid) in the atomic absorption spectro photometer (Varian Techtron 1000) (Appendix I). Potassium was estimated using the flame photometer.

<u>Breast milk</u>

Breast milk was analysed by standard procedures for the different nutrients and trace minerals.

Results and Discussion

CHAPTER IV

RESULTS AND DISCUSSION

The results of this investigation on "Availability of nutrients from local diet mixtures to lactating women" are discussed under the following headings;

A. Nitrogen retention by Lactating women

B. Calcium retention from the diets

C. Iron retention from the diets

D. Retention of some trace elements by lactating women.

A. Nitrogen retention by lactating women

The mean daily nitrogen intake urinary and fecal excretion of nitrogen, breast milk output and the apparent nitrogen retention by the six selected lactating women studied in this investigation during the basal and the two experimental periods are given in Table.V. The details of statistical analysis are presented in Appendix II.

While two women were on negative nitrogen balance during the basal period all the six women and positive nitrogen balance during the two phases of the experiment. The negative nitrogen balance evinced by the lactating women during the basal period may be due to their body reserve depletion during lactation

TABLE V

MEAN DAILY INTAKE EXCRETION AND RETENTION OF NITROGEN BY NURSING MOTHERS ON BASAL AND EXPERIMENTAL DIETS

Subjects	Description of diet	Nitrogen intake g/day	EXCRETION OF NITROGEN g/day				Apparent Nitrogen retention or balance	Mean difference in average nitrogen retention	t value
			Urinary	Fecal	Breast milk	Total			
1	Basal	5.17	1.29	0.71	0.96	2.96	2.21		
	Ragi	11.25	0.14	0.09		1.19	10.06		
	Rice	12.00	1.08	0.22		2.20	9.80		
2	Basal	4.68	1.38	0.76	1.08	3.16	1.52		Basal Vs Ragi = 16.71**
	Ragi	11.25	1.20	0.06		2.24	9.01		
	Rice	12.0	1.12	0.41		2.61	9.39	$\bar{X}$ = 0.370 (Basal)	
3	Basal	4.87	5.23	0.2	1.14	6.57	-1.70		Basal Vs Rice = 13.83
	Ragi	11.25	1.02	0.07		2.23	9.02	$\bar{X}_1$ = 9.26 (Ragi)	
	Rice	12.00	2.09	0.13		3.36	8.64		
4	Basal	5.06	3.26	0.4	1.2	4.86	0.2		Ragi Vs Rice = 1.90
	Ragi	11.25	0.02	0.05		1.27	9.98	$\bar{X}_2$ = 8.84 (Rice)	
	Rice	12.0	1.27	0.9		3.37	8.65		
5	Basal	4.09	2.12	0.31	1.44	3.87	0.22		
	Ragi	11.25	0.54	0.22		2.20	9.05		
	Rice	12.00	2.04	0.37		3.85	8.15		
6	Basal	4.97	3.74	0.18	1.32	5.24	-0.27		
	Ragi	11.25	1.04	0.43		2.79	8.46		
	Rice	12.00	2.12	0.11		3.55	8.45		

** Significant at one percent level

since they were continuously on the diets which are both quantitatively and qualitatively deficient in all the nutrients.

It is vividly observed that both the ragi based and rice based experimental diets fed during lactation were capable of overcoming the short comings observed during basal phase and raising the level of retention appreciably, presumably facilitating the maternal body reserves, and providing provision for the successful lactation.

When analysed statistically the difference in nitrogen retention between the basal phase and the two experimental phases were significant at one percent level. Whereas, there was no significant different between the two experimental phases. Both the experimental diets were based on local dietary pattern but enhanced quantitatively and qualitatively using low cost local foods judiciously, keeping in mind cost and local dietary pattern. Such enhancement accounts for the higher nitrogen retention at practically little cost. Devadoss _et al_., (1982) have reported that both the ragi based and rice based diets were comparable in maintaining the nutritional status of the lactating women and helping them to produce enough breast milk and thus inturn resulting in better growth of infants. The observation made in this investigation further substantiates the above observation and brings out the beneficial impact of providing either rice based or ragi based local diets to lactating women.

B. <u>Calcium Retention from the diets</u>

The mean daily calcium intake, excretion, breast milk output and apparent retention by the six selected lactating women during the three phases of the study along with the statistical analysis are presented in Table VI. The details of statistical analysis are presented in Appendix II.

TABLE VI

MEAN DAILY INTAKE, EXCRETION AND RETENTION OF CALCIUM BY NURSING MOTHERS ON BASAL AND

EXPERIMENTAL DIETS

Subjects	Description of diets	Calcium intake g/day	EXCRETION OF CALCIUM g/day				Apparent calcium retention or Balance	Mean Difference in Average Calcium Retention	t value
			Urinary	Fecal	Breast milk	Total			
1	Basal	0.68	0.09	1.27	0.32	1.68	-1.0		
	Ragi	1.93	0.13	1.02		1.47	0.46		
	Rice	1.65	0.15	0.58		1.05	0.60		Basal Vs Ragi
2	Basal	0.55	0.10	1.64	0.32	2.06	-1.51	$\bar{X}$ = -0.82 (Basal)	= 6.33**
	Ragi	1.93	0.12	1.06		1.50	0.43		
	Rice	1.65	0.11	0.65		1.08	0.57		
3	Basal	0.72	0.16	0.34	0.28	0.78	-0.06	$\bar{X}_1$ = 0.54 (Ragi)	Basal Vs Rice
	Ragi	1.93	0.06	1.01		1.35	0.58		= 6.95**
	Rice	1.65	0.04	0.70		1.02	0.63		
4	Basal	0.66	0.09	0.77	0.30	1.16	-0.50	$\bar{X}_2$ = 0.69 (Rice)	Ragi Vs
	Ragi	1.93	0.12	0.98		1.40	0.53		Rice
	Rice	1.65	0.08	0.62		1.00	0.65		= 2.46
5	Basal	0.58	0.06	1.12	0.33	1.50	-0.92		
	Ragi	1.93	0.24	0.67		1.25	0.68		
	Rice	1.65	0.15	0.30		0.78	0.87		
6	Basal	0.51	0.10	1.07	0.27	1.44	-0.93		
	Ragi	1.93	0.26	0.86		1.39	0.54		
	Rice	1.65	0.30	0.30		0.87	0.78		

**Significant at one percent level

with calcium all the six women were on negative balance during the basal period and the retention was significantly better with both the rice and the ragi diet (P 0.01). However, there was no significant difference between the retention of calcium when both the experimental diets were considered.

Observation in calcium retention are similar to that of nitrogen retention and is on par with the observation on albino rats by Devadas and co-workers (1973-76). They had observed that retention from ragi diets containing composition similar to that studied here was the highest.

C. Iron retention from the diets

The mean daily iron intake, excretion and retention by the selected nursing mothers along with the statistical data is present in Table VII. Details of statistical analysis given in Appendix II.

TABLE VII

MEAN DAILY EXCRETION AND RETENTION OF IRON BY NURSING MOTHERS ON BASAL AND EXPERIMENTAL DIETS

Subjects	Description of Diets	Iron Intake mg/day	EXCRETION OF IRON mg/day				Apparent retention or balance mg	Mean Difference in average iron retention (mg)	't' value
			Urinary	Fecal	Breast milk	Total			
1	Basal	31.27	1.7	14.22	0.68	16.6	+14.67		
	Ragi	38.73	0.90	13.75	0.68	15.33	+23.40		
	Rice	36.11	1.2	12.62	0.68	14.5	+21.61		
2	Basal	32.14	0.54	16.91	1.12	18.57	+13.57		
	Ragi	38.73	0.49	16.22	1.12	17.83	+20.9		
	Rice	36.11	0.35	12.60	1.12	14.07	+22.04		Basal Vs Ragi = 3.77**
3	Basal	29.19	0.95	10.12	0.72	11.79	+17.4	$\bar{X}_B$ = 16.975 (Basal)	
	Ragi	38.73	0.81	16.02	0.72	17.55	+21.18		Basal Vs Rice = 1.97
	Rice	36.11	0.92	9.94	0.72	11.58	+24.53		
4	Basal	30.96	0.66	7.57	0.65	8.88	+22.08	$\bar{X}_R$ = 26.445 (Ragi)	
	Ragi	38.73	0.51	6.70	0.65	7.86	+30.87		Ragi Vs Rice = 1.716
	Rice	36.11	0.72	17.25	0.65	18.62	+17.49		
5	Basal	29.77	1.24	13.16	0.74	15.14	+14.63	$\bar{X}_R$ = 22.88166 (Rice)	
	Ragi	38.73	0.82	7.24	0.74	8.80	+29.93		
	Rice	36.11	1.17	11.97	0.74	13.88	+22.23		
6	Basal	30.52	0.86	9.52	0.69	11.07	+19.45		
	Ragi	38.73	0.60	5.05	0.69	6.34	+32.39		
	Rice	36.11	0.89	8.74	0.69	10.32	+25.79		

** Significant at one percent level

It is seen that the intake of iron even during the basal period by the mothers ranged from 29 to 31 mg of iron per day. This may be attributed to the fact that these women who belonged to the lower economic Strata of the society in that village at ragi as the basal cereal regularly included any kind of jungle greens in their diet. This might account for the higher intake of iron and better retention over prolonged intake. Observations also indicate that retention of iron during the basal period was positive, both ragi and rice diets gave higher retention ther basal. Cuthberton (1973) has observed that there is increased absorption of iron during lactation. The mechanism is unknown. Increased absorption of iron was noted in the present study also. Statistically the retention between basal and ragi and basal and rice was significant at one percent level whereas there was no significant difference between ragi and rice.

D. <u>Retention of some trace lelements by nursing mothers</u>

<u>Potassium</u> The mean daily intake, excretion and retention of potassima by the nursing mothers fed basal and the two experimental diets along with statistical analysis is presented in Table VIII. Details of statistical analysis are given in Appendix II

TABLE VIII

MEAN DAILY INTAKE, EXCRETION AND RETENTION OF POTASSIUM BY LACTATING WOMEN ON BASAL AND EXPERIMENTAL DIETS

Subjects	Description of diets	Potassium intake mg/day	EXCRETION OF POTASSIUM mg/day				Apparent potassium retention or balance mg	Mean difference in average potassium retention mg	't' value
			Urinary	Fecal	Breast milk	Total			
1	Basal	7.7	1.11	6.74	0.20	8.05	-0.35		
	Ragi	19.42	0.82	2.05		3.07	16.35		
	Rice	19.70	0.19	2.97		3.56	16.34		
2	Basal	6.88	0.80	2.11	0.27	3.18	3.64	$\bar{x}$ = 2.115	Basal Vs Ragi = 15.86 **
	Ragi	19.42	0.14	2.78		3.13	16.29		
	Rice	19.70	0.91	1.97		3.15	16.55		
3	Basal	7.4	1.27	5.08	0.26	6.55	0.85	$\bar{x}_1$ = 16.50	Basal Vs Rice = 14.13 **
	Ragi	19.42	0.24	2.64		3.84	15.58		
	Rice	19.70	1.24	3.64		5.14	14.56		
4	Basal	7.01	0.17	1.98	0.16	2.31	4.70	$\bar{x}_2$ = 16.12	Ragi Vs Rice = 1.09
	Ragi	19.42	0.32	2.06		3.04	16.38		
	Rice	19.70	0.06	1.97		2.19	17.51		
5	Basal	6.9	0.72	2.15	0.24	3.11	3.79		
	Ragi	19.42	0.14	1.12		1.50	17.92		
	Rice	19.70	0.65	3.66		4.55	15.15		
6	Basal	7.24	0.76	6.24	0.18	7.18	0.06		
	Ragi	19.42	0.84	1.92		2.94	16.48		
	Rice	19.70	0.64	2.30		3.12	16.58		

** Significant at one percent level

The mean retention for potassium was similar to that observed for nitrogen and calcium. Basal diet resulted in negative retention for three of the subjects. Which was statistically lowered (P 0.01) which in themselves did not show any difference statistically.

Studies by Holbrook *et al.*, (1984) on potassium retention have shown that sodium and potassium are absorbed to the extent of 85 percent. The present observation shows an absorption of 84 percent in the case of potassium. This difference can be attributed to the secretion of potassium in breast milk.

<u>Copper</u>: Data pertaining to the intake of copper, excretion and apparent retention from the basal and the rice based and ragi based diets by the selected lactating women is presented in Table IX. Statistical analysis is approved (Appendix II)

TABLE IX

MEAN DAILY INTAKE EXCRETION AND RETENTION OF COPPER BY NURSING MOTHERS ON BASAL AND EXPERIMENTAL DIETS

Subjects	Description of diets	Copper intake mg/day	EXCRETION OF COPPER mg/day				Apparent retention or balance mg	Mean Difference in average copper retention mg	't' value
			Urinary	Fecal	Breast milk	Total			
1	Basal	1.38	0.00	0.10	0.16	0.26	1.12		
	Ragi	2.90	0.01	0.17		0.34	2.56		
	Rice	2.11	0.05	0.04		0.25	1.86	$\bar{X}$ = 0.9933 (Basal)	Basal Vs Ragi = 9.0423**
2	Basal	1.36	0.02	0.09	0.21	0.32	1.04		
	Ragi	2.90	0.07	0.22		0.50	2.40		
	Rice	2.11	0.04	0.02		0.27	1.84	$\bar{X}_1$ = 2.489 (Ragi)	Basal Vs Rice** = 7.1410
3	Basal	1.45	0.00	0.24	0.14	0.38	1.07		
	Ragi	2.90	0.07	0.25		0.46	2.44		Ragi Vs Rice = 0.537
	Rice	2.11	0.03	0.03		0.20	1.91	$\bar{X}_2$ = 1.82 (rice)	
4	Basal	1.31	0.07	0.01	0.17	0.25	1.06		
	Ragi	2.90	0.02	0.21		0.40	2.50		
	Rice	2.11	0.00	0.14		0.31	1.80		
5	Basal	1.52	0.07	0.12	0.12	0.31	1.21		
	Ragi	2.90	0.01	0.138		0.268	2.635		
	Rice	2.11	0.09	0.18		0.39	1.72		
6	Basal	1.30	0.03	0.54	0.29	0.86	0.44		
	Ragi	2.90	0.019	0.19		0.499	2.041		
	Rice	2.11	0.00	0.05		0.34	1.77		

** Significant at one percent level

Observations on copper retention is similar to that of iron in that retention during the basal period is positive. The retention with ragi diet is significantly higher than ($P > 0.01$) basal rice diet.

Copper retention is related to that of iron. Studies by Cuthbertson (1978) have shown that there is an increased intestinal absorption of copper during lactation. It follows the same trend as that of iron. Results of the present study also show an increased absorption of copper though determination of the exact site of increased absorption is not within the scope of the study.

Zinc: Results on the mean daily intake excretion and retention by the lactating women on basal and experimental diets along with the statistical analysis are presented in Table X. Information on statistical data is appended (Appendix II)

TABLE X

MEAN DAILY INTAKE, EXCRETION AND RETENTION FOR NURSING [illegible] ON BASAL AND [illegible] DIETS

$\bar{X}$ = 14.23 (Basal)

Subjects	Description of diets	Zinc intake mg/day	EXCRETION OF ZINC mg/day				Apparent zinc retention or balance mg	Mean difference in average zinc retention mg	't' value
			Urinary	Fecal	Breast milk	Total			
1	Basal	14.05	0.20	1.0	1.72	2.92	11.33		
	Ragi	16.23	0.08	1.05		2.85	13.38		
	Rice	15.84	0.22	3.22		5.16	10.68		
2	Basal	14.22	0.18	0.97	1.67	2.82	11.20	D = [illegible]	Basal Vs Ragi** = 6.?041
	Ragi	16.23	0.22	0.80		3.17	13.06		
	Rice	15.84	0.64	1.81		4.12	11.72		Basal Vs Rice = 0.72459
3	Basal	13.97	0.11	0.30	2.70	3.11	10.86	$\bar{X}_1$ = 13.86 (Ragi)	
	Ragi	16.23	0.06	0.95		3.71	12.52		
	Rice	15.84	1.18	0.97		4.79	11.05		Ragi Vs Rice = 2.5377
4	Basal	14.16	0.17	1.02	1.94	3.13	11.03		
	Ragi	16.23	0.12	0.92		2.98	13.25	$\bar{X}_2$ = 11.72 (Rice)	
	Rice	15.84	0.15	1.01		3.10	12.74		
5	Basal	14.35	0.00	0.66	2.92	3.58	10.77		
	Ragi	16.23	0.08	0.27		3.27	12.96		
	Rice	15.84	1.36	1.26		5.54	10.30		
6	Basal	13.81	0.16	1.04	0.99	2.19	11.62		
	Ragi	15.23	0.12	0072		1.83	14.40		
	Rice	15.84	0.15	0.36		2.00	13.84		

**Significant at one percent level

Information on Zinc retention indicates that ragi based diet was significantly ($P > 0.01$) superior to that of basal and rice based diets and the retention between the basal and rice diet was not significant. As these are trace elements required in minute quantities, intake and retention from normal diets is not inadequate. Since the experimental diets especially ragi diet is an improved local diet commonly used by the low income strata of the community it is encouraging to note that these diets are capable of maintaining higher trace element retention.

Studies on Zinc bioavailability have shown that the availability of zinc from protein rich foods is greater than from energy rich sources (E.J. Underwood, 1978).

Observations of the present study show that the availability of zinc is highest for the ragi diet, which also shows greater protein content and retention.

Manganese: Data pertaining to the intake, excretion, and apparent retention from the basal and the experimental diets by the selected lactating women is present in Table XI. Statistical analysis is given in Appendix II.

TABLE XI

MEAN DAILY INTAKE EXCRETION AND RETENTION OF MANGANESE BY LACTATING WOMEN ON BASAL AND EXPERIMENTAL DIETS

Subjects	Description of diets	Manganese intake mg/day	EXCRETION OF MANGANESE mg/day				Apparent Manganese retention or balance mg	Mean difference in average retention mg	't' value
			Urinary	Fecal	Breast milk	Total			
1	Basal	4.18	0.00	2.39	0.17	2.56	1.62		
	Ragi	5.24	0.32	2.95		3.44	1.80		
	Rice	5.30	0.36	3.27		3.80	1.50		
2	Basal	4.15	0.00	1.93	0.10	2.03	2.12		
	Ragi	5.24	0.12	2.62		2.84	2.40		
	Rice	5.30	0.00	2.31		2.41	2.89	$\bar{X}$ = 1.52 (Basal)	Basal Vs Ragi = 0.43
3	Basal	8.90	0.31	2.38	0.23	2.92	0.98		
	Ragi	5.24	1.70	2.01		3.94	1.30		Basal Vs Rice = 0.34
	Rice	5.30	1.48	2.52		4.23	1.07	$\bar{X}_1$ = 1.65 (Ragi)	
4	Basal	4.52	0.00	2.83	0.19	3.02	1.50		Ragi Vs Rice = 0.03
	Ragi	5.24	0.00	3.18		3.37	1.87		
	Rice	5.30	0.00	3.28		3.47	1.83	$\bar{X}_2$ = 1.64 (Rice)	
5	Basal	4.27	0.38	1.69	0.20	2.27	2.00		
	Ragi	5.24	0.00	4.22		4.42	0.82		
	Rice	5.30	0.67	3.49		4.36	0.94		
6	Basal	4.22	0.20	2.87	0.23	3.30	0.92		
	Ragi	5.24	0.18	3.12		3.53	1.71		
	Rice	5.30	0.22	3.22		3.67	1.63		

Mean retention indicates that though there is a high trend in retention during the experimental phase over the basal phase, statistically there was no significant difference between the basal and any of the experimental diets. WHO (1973) has reported intakes ranging from 2.5 to 10.7 mg in normal Indian females. In this investigation the intakes are well within the reported range. Schroeder (1978) has reported that manganese intake and output are normally equal and thus maintain balance. The positive balance observed brings out the efficiency of the local diets in maintaining balance of such trace elements.

The micro elements especially Zinc, Copper etc. play a very important role during lactation and their imbalances during lactation impair their availability and the availability of other related nutrients from breast milk to the extero gestate foetus, namely, the infant. When observed from this view point, the observations made on the lactating women in this study indicate the capability of these improved local diets in maintaining positive balance and retention of these minerals and the need to advocate them.

From these observations it is evident that the two low cost locally available diets ragi based and rice based are well absorbed by the lactating women resulting in positive retention in nitrogen, calcium, iron and other trace elements like zinc, copper, potassium and manganese.

It may be pointed out that as far as lactating women are concerned, the ragi based diet seems slightly superior to the rice based diet. Earlier observations of Devadass et al., (1982) with nursing mothers indicate that ragi based diets resulted in higher weight gain and greater milk output and consequently increased weight in the infants. However there were no statistically significant difference between ragi and rice based diets. Results obtained in this investigation are in the same as in the observation of Devadass et al. Lactation being a period of increasing demand made on the mother, individual metabolic requirements and hence individual variation is a possibility. However the results of the present investation indicates that taking into due considerations for all the demands of lactation the availability of the selected nutrients from the two local diets is good. Moreover as has been clearly indicated by Devadass and co-workers since these combinations of diets provide adequate nutrients without additional cost and could be well retained by using judicious combination of local diets in the present study due to the bio availability of nutrients from these diets they could be well be recommended or the masses may well be educated to consume these diets to avoid physiological strains dues to inadequacy of nutrients during lactation.

CHAPTER V

SUMMARY AND CONCLUSION

The present investigation aimed at studying the availability of selected nutrients from low cost localy available diet mixtures for nursing mothers. It is based on the rice and ragi based diets tailored around the local dietaries developed and evaluated on experimental animals and through growth experiments on human beings by Devadass and Coworkers (1973, 1976, 1981). In order to study the availability of nutrients from the two diets, six mothers were selected from the local community and their co-operation was ensured. They were oriented on the discipline involved in balance studies. They were housed in their own village set up and placed on the metabolic study giving due consideration to all the precautions involved in the conduct of such studies. During the first phase of the experiment the women were fed on the basal diet similar to their home diet. During the second and third phase of the experiment the mothers were fed on the rice and ragi based experimental diets respectively. Each phase consisted of one week with a four day adaptation period and a three day collection period. Collection of samples of food, urine and feces during each phase was done as per standard procedure and samples analysed for calculation of retention of selected nutrients. Breast milk was also analysed for the calculation of retention of selected nutrients. The results obtained may be summarised as follows:

1. The nitrogen retention was low during the basal period (0.374). The nitrogen retention during the two experimental phases were 9.35 g/day and 8.68 g/day respectively which were statitically higher ($P > 0.01$) over the basal diet. The nitrogen retention between the two experimental diets was not statiscally significant.

2. Calcium retention was negative during the basal period (-0.82 g/day). The retention assumed an increase over the experimental periods. Calcium balance was found to be 0.54 and 0.69 g/day for the two experimental diets respectively. No significant difference was noticed between the rice and ragi diets.

3. The retention of iron during the basal period though positive (16.975 mg) per day was lower than that of the experimental diets. The iron retention during the experimental period I (26.45 mg per day) was significantly higher than

those of the basal and rice based diet (22.[illegible] mg per day). However no significant difference was observed between the basal and rice diets.

4. The retention of potassium followed the same trend as that of nitrogen and calcium and was significantly higher in the case of experimental diets, as against the basal.

5. Copper retention was found to be highest with the ragi diet which was significantly higher than the rice or basal.

6. Retention of manganese showed a higher trend during the experimental phase. Retention was the highest with ragi diet. However there was no significant difference in retention between the basal and experimental diets.

It may be concluded from the above that both ragi based and rice based diets facilitated better retention of nitrogen, calcium, iron and trace elements like potassium, copper, zinc and manganese, when compared to the customarily consumed basal diet, these two improved diets possess greater potential to maintain nutrient equilibrium for lactating women. From among the two experimental diets, ragi diet seems to have greater potential especially during lactation. These observations are similar to those observed by Devadas and coworkers (1982) on lactating women in terms of its nutritional status promoting value. It may also be pointed out that these two diets are economically feasible, culturally acceptable and easy for adoption as they are tailored around the local diets. In view of the above mentioned advantages, it is recommended that these diets could be well incorporated as dietaries for feeding programme and nutrition education could be given for its mass adoption. It would also be of interest to further evaluate the beneficial impact and bioavailability of these two diets in terms of their potentials to improve serum levels of nutrients and also the bioavailability for other age groups.

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Appendices

APPENDIX I

ESTIMATION OF IRON AND TRACE ELEMENTS

One g of the sample to be analysed was digested with 10 ml of triple acid (Nitric, Sulphuric and Perchloric acids in the ratio of 9:2:1) and made up to 50 ml. The made up sample was then fed into the Atomic absorption spectrophotometer for the analysis of Iron, Copper, Zinc and Manganese. For the estimation of potassium the made up sample was fed into the flame photometer.

$$\bar{X}_2 = \frac{\sum X_2}{n_2} = \frac{55.58}{6}$$

$$= 9.26333$$

$$(x_1-\bar{X}_1)^2 = 6.653844$$

$$(x_2-\bar{X}_2)^2 = 2.0111322$$

$$s^2 = \frac{6.653244 + 2.0111322}{6 + 6 - 2}$$

$$= \frac{8.6643762}{10}$$

$$= 0.8664376$$

$$s = 0.9308263$$

$$t = \frac{(0.374 - 9.3533)}{0.9308263 \sqrt{1/6+1/6}}$$

$$= \frac{8.9793}{0.5374125}$$

$$= 16.708394$$

$t_{0.01}$ for 10 df = 2.764

(b). Basal Vs Rice

Basal X_1	Rice X_2	$x_1-\bar{X}_1$	$(x_1-\bar{X}_1)^2$	$x_3-\bar{X}_3$	$(x_3-\bar{X}_3)^2$
2.21	9.8	1.836	3.370896	1.1233	1.2618778
1.582	9.39	1.208	1.459264	0.7133	0.5088444
-1.70	8.64	-1.326	1.758276	0.03667	0.0021778
0.2	8.63	-0.174	0.030276	0.04667	2.3307111
0.22	8.15	-0.154	0.023716	-1.52667	0.0513779
-0.27	8.45	-0.104	0.010816	-0.22667	0.0021778
2.242	53.06		6.653844		4.156332

$t = 13.831784$

$t_{0.01}$ for 10 df = 2.764

(c) Ragi Vs Rice

X_1	X_3
2.81	9.8
1.582	9.39
-1.70	8.64
0.2	8.63
0.22	7.15
-0.27	8.45

$t = 1.9001428$

$t_{0.01}$ for 10 df. = 2.764

2. <u>CALCIUM</u>

(a) Basal Vs Rag

X_1	X_2
-0.9988	0.4624
-1.5149	0.4891
-0.0557	0.5795
-0.5003	0.5260
-0.924	0.6043
-0.919	0.5423
-4.9067	3.2836

$t = 6.326$

$t_{0.01}$ for 10 df = 2.764

(b) Basal Vs Rice

X_1	X_3
-0.9988	0.6096
-1.5149	0.5697
-0.0557	0.6304
-0.5003	0.6497
-0.9240	0.8730
-0.9190	0.7810

t = 0.6994

$t_{0.01}$ for 10 df = 2.764

(c) Ragi Vs Rice

X_2	X_3
0.4624	0.6096
0.4291	0.5697
0.5795	0.6304
0.5260	0.6497
0.6843	0.8730
0.5423	0.7810

t = 2.46

$t_{0.01}$ for 10 df = 2.764

3. <u>LASH</u>

(a) Basal Vs Ragi

X_1	X_2
14.67	23.40
13.57	20.90
17.40	21.18
22.08	30.87
14.68	29.93
19.45	32.39

$t = -3.7677712$

$t_{0.01}$ for 10 df = 2.764

(b) Basal Vs Rice

X_1	X_3
14.67	21.64
13.57	22.04
17.40	24.53
22.08	17.49
14.68	22.23
19.45	28.79

$t = 2.9685442$

$t_{0.001}$ for 10 df = 2.764

(b) [illegible] Vs Rice

X_1	X_3
-0.35	16.34
3.64	16.95
0.55	18.56
4.70	17.51
3.79	15.15
0.06	16.58

t = 14.129733

$t_{0.01}$ for 10 df = 2.764

(c) Ragi Vs Rice

X_2	X_3
16.35	16.34
16.29	16.55
15.58	14.56
16.38	17.51
17.98	15.15
16.48	16.58

t = 1.0800368

$t_{0.01}$ for 10 df = 2.764

5. COPPER

(a) Basal Vs Ragi

X_1	X_2
1.12	2.56
1.04	2.40
1.07	2.44
1.06	2.50
1.21	2.632
0.44	2.401

$t = 9.0422998$

$t_{0.01}$ for 10 df $= 2.764$

(b) Basal Vs Rice

X_1	X_3
1.12	1.86
1.04	1.84
1.07	1.91
1.06	1.80
1.21	1.72
0.44	1.77

$t = 7.1409866$

$t_{0.01}$ for 10 df $= 2.764$

(e) Ragi Vs Rice

X_2	X_3
2.56	1.86
2.40	1.84
2.44	1.91
2.50	1.80
2.632	1.72
2.401	1.77

t = 0.537

$t_{0.01}$ for 10 df = 2.764

6. [illegible]

(a) Bmeal Vs Ragi

X_1	X_2
11.32	13.30
11.20	13.06
10.86	12.52
11.03	13.25
10.77	12.96
11.62	14.40

t = 5.3082

$t_{0.01}$ for 10 df = 2.764

(b) Bengal Vs Rice

X_1	X_3
11.33	10.63
11.50	11.72
10.56	11.65
11.63	12.74
11.77	10.30
11.62	13.64

$t = 0.78459$

$t_{0.01}$ for 10 df = 2.764

(c) Ragi Vs Rice

X_2	X_3
13.30	10.63
13.06	11.72
12.52	11.05
13.85	12.74
12.96	10.30
14.40	13.34

$t = 4.5377$

$t_{0.01}$ for 10 df = 2.764

7. **MANGANESE**

(a) Basal Vs Ragi

X_1	X_2
1.62	1.00
2.12	2.40
0.98	1.30
1.50	1.07
2.00	3.82
0.92	1.71

t = 0.434815

$t_{0.01}$ for 10 df = 2.764

(b) Basal Vs Rice

X_1	X_3
1.62	1.30
2.12	2.09
0.98	1.07
1.50	1.03
2.00	0.94
0.92	1.63

t = 0.3423858

$t_{0.01}$ for 10 df = 2.764

(e) Ragi Vs Rice

X_2	X_3
1.80	1.50
2.40	2.09
1.30	1.07
1.87	1.83
0.82	0.94
1.71	2.03

$t = 0.0278664$

$t_{0.01}$ for 10 df = 2.764