

REVIEW OF LITERATURE

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The literature on maternal nutrition has been reviewed under the following sections :

1. Nutritional status of underprivileged pregnant and lactating women in India.
2. Food avoidances and special foods consumed during pregnancy and lactation.
3. Consequences of poor nutrition on the birth outcome and the lactational performance.
4. Effect of food supplementation during pregnancy and lactation.
5. Strategies to improve the nutritional status of the underprivileged pregnant and lactating women - Supplementary nutrition programs in India.
6. Problem of sharing of the maternal food supplement.
7. The concept of special mother foods to reduce sharing of the supplement; A case study of project 'Matru Ahar'.
8. Some considerations for product development.

Nutritional status of underprivileged pregnant and lactating women in India

It has been well documented that the nutritional status of the underprivileged pregnant and lactating women in India is poor. Several investigators in various parts of the country have assessed the dietary and nutrient intake of these women and have also carried out anthropometric, clinical and biochemical examinations. Table 1 and 2 summarise the nutrient intakes as reported by these investigators.

As early as in 1961, Gopalan observed that the most striking feature with regard to the nutritional situation in most under-developed countries was that the average dietaries of expectant and nursing mothers were grossly inadequate. In a survey of about 300 mothers in South India, the daily caloric intake ranged between 1400-1800 Kcal and the average protein intake was 40 g per day. The women gained only 6 kg between the 12th and the 40th week of gestation. An interesting observation was that the subjects were losing body fat during pregnancy. There was a progressive decline in the hemoglobin, serum albumin and serum vitamin A levels. A large number of women showed manifestations of B complex deficiency and anaemia.

Around the same time, in a study of nutrient intakes of 150 pregnant women from the low socio-economic groups attending an antenatal clinic in Delhi, Bagchi (1962) reported severe dietary restrictions of a chronic nature. The women consumed diets deficient in most of the nutrients especially calories and proteins. Anemia was universal; 88% women had Hb levels of less than 10 g/dl. The prevalence of angular stomatitis, glossitis and bleeding gums was 6, 8 and 3% respectively indicating the deficiencies of B vitamins and ascorbic acid.

Table 1. Energy intakes of underprivileged pregnant women in different parts of India.

Investigators and Year	Place of study	Reported intake KCal	Dietary deficit KCal	% RDA*
Gopalan 1961	South India	1400-1800	900	56-72
Bagchi 1962	Delhi	1920	580	77
Sunderraj and Pereira 1973	South India	1827	673	73
Belavady 1976	South India	1815	685	73
Vijayalakshmi et al 1975	Coimbatore	1503 ¹	997	60
		1716 ²	794	69
Devadas et al 1970	Coimbatore	1913	587	76
Devadas et al 1978	Coimbatore	1624	876	65
Vijayalakshmi and Devaki 1976	Coimbatore	1666	834	67
Ankegowda and Devi 1976	Mysore	1345-1665	1155-835	54-67
Agarwal et al 1981	Varanasi	1605	900	64
Kaur et al 1982	Hissar	1602 (Urban)	878	64
		1459 (Rural)	1041	58
NIN 1981	Hyderabad	I Trimester 947	1553	38
		II Trimester 1126	1374	45
		III Trimester 1139	1361	46
Rajalakshmi 1983	Baroda	1500-1600	950	60-64
John 1983	Baroda	I Trimester 1361	1139	54
		II Trimester 1398	1102	56
		III Trimester 1392	1108	56

*RDA (ICMR, 1981) 2200 + 300 (in 2nd half).

Table 2. Protein intakes of underprivileged pregnant women in different parts of India.

Investigators and Year	Place of study	Reported intake of protein (g)	Dietary deficit (g)	% RDA* net
Gopalan 1961	South India	41	18	70
Bagchi 1962	Delhi	48	11	81
Devadas et al 1970	Coimbatore	51	8	86
Devadas et al 1978	Coimbatore	34	25	58
Vijayalakshmi et al 1975	Coimbatore	36-47	12-13	61-80
Vijayalakshmi and Devaki 1976	Coimbatore	41	18	70
Sunderraj and Pereira 1973	South India	37	22	64
Belavadi 1976	South India	44	15	75
Agarwal et al 1980	Varanasi	56	3	95
Kaur et al 1980	Hissar	49 (Urban) 47 (Rural)	10 12	83 80
Ankegowda and Devi 1976	Mysore	32-45	14-27	54-76
NIN 1981	Hyderabad	I Trimester 25 II Trimester 30 III Trimester 31	20 15 28	55 69 53
John 1983	Baroda	40-41	5-19	68-91
Rajalakshmi 1983	Baroda	35-40	19-24	59-68

*RDA (ICMR, 1981) -- 45 + 15 g (in 2nd half of pregnancy).

The picture since then has not improved, as revealed by studies carried out in the seventies and some more recent studies - (Devadas et al, 1970; Sunderraj and Pereira, 1973; Vijayalakshmi and Devaki, 1976; Vijayalakshmi et al, 1975; Nath and Geerwani, 1978; Bamji, 1976; Ankegowda and Devi, 1976; Prema, 1978; Agarwal et al, 1980; Kaur et al, 1982). The conclusions from these studies are more or less similar and suggest a gross deficit in the intakes of energy, proteins and vitamins together with clinical signs of deficiency and lowered blood constituents like Hb and vitamins.

In a recent study conducted by the National Institute of nutrition (NIN, 1981), it was observed that the dietary intakes in pregnancy were lowest during the first trimester. There was no difference in the dietary intakes of pregnant and non-pregnant and non-lactating women. This was attributed partly to the economic constraints and partly due to a lack of awareness that pregnancy calls for an increase in dietary intakes. The average gain in the weight during pregnancy was 6 kg.

NIN (1980) also reported the incidence of B complex deficiency in women of the reproductive age. The incidence of glossitis and angular stomatitis increased progressively with increasing duration of pregnancy. The Hb levels also decreased in the 2nd trimester of pregnancy with no further changes in the 3rd trimester.

Studies conducted in Baroda also revealed a poor nutritional status of pregnant women. Rajalakshmi (1983) observed that the mean body weight of the women from low income group was 40 kg and the weight gain was 7 kg. Most of the women lived on a diet providing 1600 Kcal or less per day and did not appreciably increase their nutrient intake during pregnancy and lactation. The incidence of most of the clinical signs of nutritional deficiencies was high (vitamin A - 33-55%; pale tongue - 73%; fissured tongue - 39%). Forty one per cent women had hemoglobin levels of less than 10 g/dl. Vitamin A deficiency (serum vitamin A < 10 ug/dl) was observed in 28% of the subjects.

In studies conducted in this Department, John (1983) also gave adequate proof of nutritional deficiencies in terms of poor nutrient intakes, clinical manifestations and poor bio-chemical indices such as Hb and plasma proteins. No difference was observed in the nutritional status in the three trimesters. Table 3 gives the comparative figures of daily dietary intakes by pregnant women of the low income group in Gujarat reported by Rajalakshmi (1983) and John (1983).

Table 3 Daily nutrient intake of underprivileged pregnant women in Baroda, Gujarat

Nutrient	Rajalakshmi (1983)	John (1983)	RDA (ICMR, 1981)
Energy (KCal)	1500-1600	1400	2200 ± 300
Protein (g)	35-40	41	45 + 14
Iron (mg)	20-25	28-30	40
Retinol (ug)	125	67-75	750
Calcium (mg)	400	380	400 - 500 + 500
Vitamin C (mg)	10-15	33-53	40
Folate (mg)	0.5-0.7	-	.3
Vitamin ₁₂ (ug)	0.5	-	1.5
Thiamin (mg)	1.0-1.5	1.3-1.4	1.3
Riboflavin (mg)	0.5	1.0	1.5
Niacin (mg)	5-6	-	17

The nutritional status of underprivileged lactating mothers in different parts of India is no different from that of the pregnant women. They might be even worse off than the pregnant women, as the nutrient demands are further increased during the lactation period. Table 4 summarizes the reported intakes of calories and protein by the lactating women. As shown in the table there was a deficit of about 1000-1600 Kcal and 7 to 28 g of protein in the diets of these women. It has been reported that there is a loss of about 2 kg body weight in the first year of lactation (Prema et al, 1981).

Food avoidances and special foods consumed during pregnancy and lactation

Pregnancy and lactation are periods of physiological and psychological change and throughout the world precautions are taken to maintain the well being of the women during these periods. Frequently, these precautionary customs of pregnancy require a change in the diet which may lead to certain food avoidances and/or inclusion of certain foods considered to be good for the body.

Ferro-Luzzi (1973, 1974) extensively studied the food avoidances during pregnancy, puerperium and lactation in Tamilnad, India. Over a period of six months, 1200 women were interviewed. In pregnancy, practically all types of foods were avoided but the most important were those of fruits and grains. The main reason for abstaining from certain foods during pregnancy was fear of abortion caused by heating the body or by inducing uterine hemorrhage. The latter property was most frequently ascribed to foods like

Table 4. Energy and protein intakes of underprivileged lactating mothers in different parts of India.

Investigator and Year	Energy		% RDA* net	Protein		% RDA* net
	Reported intake KCal	Deficit in diet		Reported intake (g)	Deficit in diet (g)	
Karmarkar et al 1959	1440	1460	50	50	15	77
Karmarkar et al 1963	1300	1600	45	45	20	69
Gopalan and Belavadi 1961	1860-1890	1025	65	43-47	20	69
Devadas et al 1971	1325-1399	1538	47	35-39	28	57
Rajalakshmi 1971	1620	1280	56	56	9	86
Belavadi 1976	1800	1100	62	44.0	21	68
NIN, 1980	1500	1400	52	50.0	15	77
Thimmayamma, 1983	1465	1435	51	37.3	28	57
Devadas et al 1983	1678	1222	58	56	9	86
Dhaliwal et al 1983 -- Urban	1700 (Urban)	1200	59	50 (U)	15	77
-- Rural	1889 (Rural)	1011	65	58 (R)	7	89

*RDA (ICMR, 1981) Calories 2200 + 700; Protein 45 + 20.

U - Urban

R - Rural



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papaya and sesame grains. High protein foods were avoided because they were thought to cause exaggerated growth of the baby which would be undesirable for an easy delivery. Ginger, tamarind, and jaggery were believed to be hot foods or emmenagogues and therefore capable of inducing abortions. Food avoidances during lactation included meat, fish, eggs, butter milk, and curds, certain fruits, gourds, green vegetables, sweet potatoes and groundnuts. All abstentions were primarily conceived in the interest of the baby, to whom harmful influences could be transmitted through the breast milk. Somewhat similar observations were made by Devadas et al (1982).

The concept of hot and cold foods is prevalent even among the Chinese women (Tan and Wheeler, 1983). It has been reported that during pregnancy women change their hot/cold status. Conception puts the mother into a cold state and she is therefore more vulnerable. As pregnancy progresses, the body gets hotter. After delivery, the mother moves into a colder state. As soon as women are aware they are pregnant, they adhere to certain proscriptions. In the first trimester of pregnancy, the mother's body base becomes colder and she should avoid cold foods. These may cause stomach-ache which might in turn lead to a miscarriage. Examples of prescribed cold foods were beans, almonds, barley, watermelon, lager beer, banana, pineapple and seaweed. In lactation, fruits and vegetables are proscribed for at least the first ten days. The foods specially consumed during pregnancy include 'bo' (a class of edible substances which are said to repair body). It is usually a preparation of meat with medicinal substances, meat with alcohol or **herbs** with alcohol. Dried fruits, nuts or grains may also be included. Herbal soups, always part of the habitual diet are consumed more often in this period. Near term, certain foods are frequently prescribed on the grounds that they provide strength and energy for labour. These include **ginseng*** and meat cooked with plenty of ginger. Ginger is thought to help disperse wind from the body. A special preparation called **geung chou** (ginger vinegar) is exclusively used postpartum. A large quantity is made at one time and a small serving is dished out each time the mother wants to eat it. According to some Chinese mothers this preparation promotes contraction of the uterus.

In a study on social and economic aspects of pregnancy and lactation in Iran, Geissler et al (1978) interviewed the women for their beliefs concerning foods in pregnancy and lactation. During pregnancy, milk, meat, fruit and vegetables were considered good because of the vitamins, proteins and minerals. The majority believed that salt and eggs were bad because they cause edema. Also a traditional thick soup (ash) made of vegetables, legumes and noodles was considered bad because of the flatulence it caused, and any abdominal discomfort was thought to be harmful to the fetus. During lactation the same soup as well as other soups and milk were considered as good for increased production of milk.

*plant of which the aromatic root is used in medicine.

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Osman (1985) conducted a survey of dietary practices and aversions during pregnancy and lactation among Sudanese women. Majority of the subjects believed that food should be changed during the postpartum period to compensate for blood loss during delivery and to encourage the production of more milk. This period lasts for 40 days in which the mother should not do any household work and a special diet consisting of high protein, high energy food is given to her. This consists of chicken, pigeon, lamb meat, **nasha** (a thick porridge made of **fenugreek** to which are added milk, ghee, sugar and sometimes '**gardiga**' (CaHCO_3 dug from the soil)). In some other communities another type of **nasha** is offered. It consists of decorticated sorghum flour with sugar. Some women also consumed dates **madida** (dates with ghee). Sometimes **hargal** (herbs with a very strong smell) is boiled and sugar is added and is served as a drink. It is believed that this drink expels gases and soothes the stomach.

In Vietnam (Manderson and Mathew, 1981) a number of dietary taboos are invoked to protect the fetus and the mother. During the first trimester, the expectant mother is considered to be weak, cold and non-tonic. According to tradition, she is prescribed hot foods, while cold foods are avoided assiduously. During the second trimester she moves into a neutral state and cold foods may be introduced in moderation. In the third trimester the woman is considered to be in a hot and tonic state and hot foods are strictly limited to prevent indigestion and to avoid rashes and sores on the neonate's skin. Parturition places the mother in a state of extreme vulnerability. Dietary restrictions are traditionally observed for 30-100 days and are aimed at correcting the body's imbalance of an excess of cold and at protecting the mother and infant from external sources of cold and wind.

In a report of the Protein Calories Advisory Group, Eide et al (1977) have reviewed certain beneficial dietary customs during pregnancy and lactation in different places. There are several examples citing that women are given preferential treatment in these periods through dietary precautions. In some cases, there are special foods considered particularly appropriate for pregnant and lactating women. The Nagoni in Tanzania reserve millet solely for pregnant women who consume it in the form of beer fermented for 24 h. Among Chaggas in Kilimanjaro, the food of a young mother is **kitawa**, a dish of bananas and beans cooked with milk. In addition the husband is obliged to give his wife a special treat in the form of the **mlaso** meal which is a concoction of meat, fat, blood and milk. The blood is obtained from cattle by a special process of blood letting and fat is freely added to the entire **mlaso** meal.

In a study on the diet and nutrient intake of lactating mothers of Hyderabad - South India, Thimmayamma and Moya (1983) have reported that the diet during one to three days of lactation was generally restricted. In the first 40 days of lactation, 24% of the mothers consumed herbal medicines called **Chetla-mandu** mainly to prevent

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backache or cold and cough in the mother. This was generally started on 3rd to 6th day of parturition and continued for two and a half days. Foods such as milk, mutton, dal, spinach, tomato, pepper, garlic and ginger were considered as good for health. These foods were supposed to provide 'health and strength', milk secretion and warmth for the mother.

A survey of food habits and beliefs of pregnant and lactating women in Mysore city was carried out by Khanum and Umapathy (1976). Foods avoided during pregnancy were papaya, egg and sesame. These were considered as hot and abortive or believed to cause red patches on baby's face and body. Milk with saffron was considered to give strength and a fair complexion to the body. During lactation, women belonging to middle and higher income groups consumed foods like ghee, milk and dry coconut. Pepper, betel leaves, garlic were also supposed to provide warmth and stamina and increase secretion of milk. The food beliefs were mostly centred around the concept of hot and cold foods.

In an urban slum of Varanasi (Agarwal et al, 1980) 83% women did not avoid any food item during pregnancy and very few women avoided foods like pumpkin, jack fruit, bengal gram and pea because they were supposed to cause pain in the abdomen. During post-partum period, women received a decoction of turmeric, ginger and jaggery and a drink containing raisins, nuts, dried ginger, jaggery, wheat flour, turmeric and butter fat. These foods were believed to relieve pain of abdomen, help in expulsion of dirty clots and in involution of uterus.

Gopaldas et al (1982) studied the dietary and other related socio-cultural practices amongst pregnant and lactating women of a forest dwelling tribe of Gujarat. The women respondents were aware that a larger food intake was required in pregnancy but all ate less than they did when nonpregnant due to nausea and a feeling of heaviness. Jaggery, black pepper and wheat chappatis were considered good foods for pregnancy. Foods to be avoided were salt, chilis, urad dal, maize, sorghum, moth beans, ghee, groundnuts, curd, coconut, milk and new rice. Foods specially consumed during lactation were **bajra** (*Pennisetum typhoideum*), **rabdi** (cereal gruel) and **tuver dal** (*Phaseolus aureus*). **Sua-ka-pani**, a special drink made from the bark of a tree called **Sindhra** (*Vithenia somnifera*) was believed to give immunity to the child who was then protected against all possible diseases. Coconut, bajra, jaggery and ghee were considered very effective galactogogues. The woman was also given **Sheera** (Sweet pudding made of wheat), and Methi (fenugreek), and **Sonth** (dried ginger) after delivery.

Consequences of poor nutritional status on the birth outcome and lactational performance 15

The Subcommittee on Maternal and Infant Nutrition in Developing countries of the National Research Council, Washington (Food and Nutrition Bulletin, 1984), has extensively reviewed various aspects of maternal nutrition including the consequences of poor nutrition status of the mother. These are incorporated in the review which follows:

It is generally recognized that in populations where chronic undernutrition is common, risk of low birth weight has been associated with increased rate of severe undernutrition, poor growth and development and even death in infancy. In addition, famine during any part of pregnancy long enough to deplete maternal nutritional reserves has been shown to reduce birth weight and increase perinatal complications and mortality of both mothers and infants.

Weight gain during pregnancy is an acknowledged determinant of birth weight. In several studies, (Prema, 1978; Rajalakshmi et al 1978; Luke et al 1984; Hussain and Omolulu, 1983), the weight gain during pregnancy was found to be associated with the birth weight of the infant. An average, well nourished healthy woman irrespective of geographic or ethnic origin is estimated to gain 12.5 kg during pregnancy. Surveys of pregnancy weight gain conducted in Guatemala (Habicht et al, 1974), the Gambia (Thomson et al, 1966) and India (Venkatachalam et al, 1960) show that a large proportion of the women gained between 2.7 and 6.8 kg. Although not all the trials of supplementing pregnant women's diets have shown a positive effect on pregnancy weight gain, dietary supplementation studies in India (Raman, 1979; Iyengar, 1972), Bogota (Mora et al, 1979), Guatemala (Lechtig et al, 1975) and Mexico (Chavej et al, 1980) were associated with increased pregnancy weight gain, suggesting that the low weight gain is at least partially due to insufficient food intake.

It has also been suggested that placental growth and function are compromised by severe and moderate maternal undernutrition (Stein et al, 1975; Lechtig et al, 1975; Rosso, 1981). A number of studies in rats show a reduced rate of placental transfer of nutrients in malnourished rats (Rosso, 1977 [a,b], 1980). This could be caused either by reduced availability of specific nutrients (Rosso, 1980) or due to inadequate maternal blood volume expansion (Rosso, 1981).

Maternal blood volume normally increases by more than one litre during pregnancy (Hyttén and Chamberlain, 1980). The increase is regarded as an adjustment that allows the pregnant woman to expand blood flow to her uterus without reducing blood flow to other vital organs. It is postulated that reduced blood volume expansion in turn results in an insufficient increase in cardiac output, decreased placental blood flow and reduced nutrient transfer and placental size (Rosso, 1980; 1981).

Maternal acetonuria (Ketonuria) has been hypothesized to be responsible for some

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of the excessive perinatal mortality associated with low pregnancy weight gain (Adey, 1979). Increased plasma and urinary ketones are associated in pregnancy with the increased fat catabolism that occurs during starvation (Felig and Lynch, 1970) and/or after short term fasting (12-18 h) (Metzger et al, 1982). The increase in ketones (along with a decrease in glucose and other biochemical changes) is thought to be the result of the mechanisms operating to rapidly adapt the mother to the metabolism of fat so that glucose and amino acids can be spared for the fetus (Naismith, 1980). However some of the lipid products may also cross the placenta and it is not known whether they are completely innocuous in the fetus.

In most developing countries, the overall risk of exposure to various kinds of infections during gestation is considerable. Both overt and incipient intra-uterine infections may cause fetal growth retardation or other clinical syndromes that may affect the fetus (Mata et al, 1977).

Reinhardt (1983) reported that presence of malaria in pregnant subjects was associated with low birth weight. However, the relation of these infections to nutritional deficiencies has not been thoroughly investigated. In our Department, John (1983) undertook a study to determine the effect of infections such as malaria on the nutritional status of underprivileged pregnant women. However, no conclusions could be drawn because of the small number of subjects who had malaria or any other illness at the time of the survey.

Unlike the effects on pregnancy outcome, the effects of malnutrition on the lactational performance in terms of breast milk quantity and quality are not so clearly defined. Whitehead (1983) has extensively reviewed the effect of diet on the composition and the quantity of milk. According to him, except in extreme maternal undernutrition, the concentrations of total energy and protein in breast milk are maintained at remarkably normal levels. According to Hambraeus (1983), the milk fat resembles that of the mother's diet when her plane of energy intake is good, but when there is a shortage of food energy the milk fatty acid pattern resembles more that of the mother's subcutaneous fat stores. However, maternal fat intake has no effect on the total triglyceride content. The fat content of the Gambian diet was no greater than 10 per cent of the total energy (Prentice et al, 1980), while in UK it was over 40%, yet the fat concentrations in the breast milk were essentially the same (3.86 g and 4.2 g per 100 ml respectively). The lactose and protein content of the milk are reported to be remarkably stable to changes in the maternal diet.

In contrast to the proximal constituents, vitamin content - particularly of the water-soluble vitamins-is very sensitive to dietary intake. The contents of thiamin, riboflavin and vitamin C have been reported to change with the amounts in the diet. The situation with the fat soluble vitamins is less dramatic but nevertheless clear (Whitehead, 1983).

In a review on the volume and composition of human milk in poorly nourished communities, Jelliffe and Jelliffe (1978) have also concluded that the volume and composition of human milk is surprisingly good, possibly due to some metabolic adaptations. However, it is often suboptimal in quantity and in quality with lower values of fat, water soluble vitamins, vitamin A and somewhat lower calcium and protein.

As regards the diet and the quantity of milk produced, the general consensus is that the content of the proximate constituents of milk can be maintained within normal limits even in markedly undernourished mothers, and it is considered more likely to be the total volume produced that suffers. Roberts et al (1982) and Prentice et al (1981) reported seasonal changes in the output of breast-milk in rural Gambian women. It was postulated that a fall in breast milk output upto 10% per day might have occurred in the farming season wherein the activity increased and caloric intakes were lower.

Coward et al (1984) compared the energy intake and milk output in several countries. It was observed that there was no positive relationship between the two. The investigators observed that the impact of variations in nutrient intake on lactational performance was limited. Similar observations were made by Gopalan (1962) who reported that inspite of their inadequate diets, women of the low socio-economic group put out 400-600 ml of milk daily for periods extending to over a year.

Lunn et al (1980, 1984) noted that an improvement in maternal diet produced significant reductions in plasma prolactin concentrations at all stages of lactation of Gambian women. The prolonged high prolactin concentrations found in undernourished mothers might ensure milk synthesis when food intake is limited by preferentially channelling towards the breast.

Effect of supplementation during pregnancy on the birth outcome and maternal health

Lechtig et al (1979) reviewed the results of eight maternal nutrition intervention studies. The results have been summarized by the same investigators and are reproduced in Table 5. The conclusions from these studies were as follows :

1. **Changes in birth weight :** All the studies showed that in malnourished populations, nutritional supplementation during pregnancy increased birth weight. The changes in the birth weight although small, may be important in terms of resultant decreases in the proportion of low birth weight infants, reductions in perinatal and infant mortality and their effects on subsequent child development. These studies showed that supplementation provided during the third trimester of pregnancy increased birth weight. Several studies revealed benefits from supplementation initiated during earlier periods of gestation. The Guatemalan study suggested that the total amount of supplement nutrients consumed during pregnancy is a more important factor rather than

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Table 5 : Summary of studies on the impact of maternal nutrition interventions during pregnancy on infant and child health

Dutch Famine Study	Bogota Colombia	Guatemala/INCAP	India	Mexico	Montreal
STUDY OBJECTIVE	Impact of acute starvation, during pregnancy on birth weight and subsequent development in 18-year-old men.	Effect of prenatal and postnatal nutritional supplementation on birth weight and child development.	Effect of prenatal and postnatal nutritional supplementation on birth weight, child development and infant morbidity and mortality.	Impact of maternal supplementation on birth weight, lactation, and development in the young child.	Impact of prenatal dietary improvement program on birth weight and infant survival.
RESEARCH DESIGN (Strategy)	Retrospective study of records from maternity hospitals vital records and military services for a cohort of all births to women exposed to acute famine during World War II. Records available of weekly rations provided to population segments.	Prospective intervention study of offspring of women supplemented in third trimester and/or during lactation with available foods to meet recommended dietary allowances; medical care provided.	Prospective intervention study of offspring of women supplemented in pregnancy and lactation and children supplemented to 7 years of age. Liquid supplements consumed in community center; medical care provided.	Poor malnourished women indentified in last trimester and hospitalized to assure supplement intake. Project consists of several small clinical studies.	Prospective study of patients entered through public prenatal clinic; supplementary foods based on dietary and clinical characteristics; education and health care provided.

Dutch Famine	Bogota Colombia	Guatemala/ INCAP	India	Mexico	Montreal
males whose mothers were not exposed to famine.					
DESCRIPTION	n=40,000 births.	n=1,536 pregnancies in 4 rural villages. Estimated average daily intake for pregnant women was:	Urban subjects. Basal intake was; 1,600-1800 calories 40 g protein.	n=39 pregnancies. Rural village. Estimated daily intake of pregnant women was; 1,950 calories 50 g protein. Clinical indicators of malnutrition and anemia.	n = 1213 poor white urban patients. Genertly low income women with prior history of low birth weight.
POPULATION	Dutch aties under Nazi occupation; well-fed up to 1940; food rationing 1941-4; near starvation 1944-45; rehabilitation 1945-6.	pregnant women in slums. Pregnant women identified as having prior malnourished children. Their estimated average daily intake was; 1,600 calories 35.5 g protein.			
DIETARY MODIFICATION	Starvation due to Stoppage of external food supplies (1944-1945); then restoration to high dietary intake.	Selected foods provided for entire family. Net increment for pregnant women was 133 calories and 20 g protein	Liquid supplements; 1) Fresco=low calories, no protein, vitamin-mineral fortified. 2) Atole=proteins plus calories. vita-	2-3 glasses partly-skimmed milk to provide average daily supplement in pregnancy of; 205 calories 15 g protein.	Free foods provided on "prescription basis" coupled with nutrition education, dietary histories taken regularly.

Table 5 Continued

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	Dutch Famine	Bogota Colombia	Guatemala/ INCAP	India	Mexico	Montreal
			min-mineral fortified.		During lactation about 50% greater.	
			Ad libitum intake measured at level of individual.		Mineral supplement also provided.	
INCREASE IN BIRTH FOLLOWING DEATH TARY IMPROVEMENT	Yes: 400 g maximum when diet improved for first half of pregnancy. Moreover, as the famine continued birth weight declined to a maximal mean decrement of 300 g from the pre-famine level.	Yes: average mean increment of 50 g for all supplemented, 77 g for those supplemented one trimester or more. Data suggest increased birth weight associated with increased protein intake.	Yes: 28 g per 10,000 supplemental calories consumed during pregnancy (based on 405 births). Data suggest increased birth weight associated with increased energy intake.	Yes: upto 600 g average increment.	Yes: 180 g average increment in supplemented groups; marked decrease in number of low birth weight infants reported.	Yes: 40 g average increment.

Table 5 Continued

	Dutch Famine	Bogota	Colombia	Guatemala/ INCAP	India	Mexico	Montreal
INFLUEN- CES OF GESTATIO- NAL AGE ON RES- PONSE TO DIETARY CHANGE	Nutrition rehabi- litation during third trimester was sufficient to restore mean birth weight to per- famine level.	Last trimester or more showed eff- ect.		No effect detected; birth weight incre- ment depended on total calories inges- ted during preg- nancy.	Treatment to third trimester.	None reported.	No effect detected.
INFLUEN CE At height of OF SEX OF famine decre- INFANT ON ment, birth wei- RESPONSE ght was greater TO DIETARY for males than CHANGE for females.		Increment in ma- les (100 g) greater than in females (12 g).		None detected.	None reported.	Not reported.	Not analyzed.
EFFECTS ON MOTHER	Measure of ma- ternal weight at 10 days post-par- tum showed ma- ternal weight de- crement preced- ing decrease in birth weight. Du- ring alleviation of famine, mate- mal weight inc- reased before	Greater maternal weight gain asso- ciated with supp- lementation.		Supplements intake associated with increased weight gain during pregna- ncy; placental wei- ght; placental RNA- ase activity and with shorter post- partum amenorr- hea and birth interval.	Maternal weight gain with supple- ment.	Supplemented wo- men gained 6.4 kg more than unsupp- lemented women.	Maternal weight gain not significant- ly increased by added dietary intake.

Table 5 Continued

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Dutch Famine	Bogota	Colombia	Guatemala/ INCAP	India	Mexico	Montreal
and continued to increase as full feeding continued.						
ADVERSE EFFECTS OBSERVED	An excess in the number of very early premature and increased perinatal mortality was reported when *starvation occurred in the first trimester with refeeding in second and third trimesters.	None reported.	None detected.	None reported.	None reported.	None reported.
ADDITIONAL OUTCOMES :						
INFANT MORBIDITY AND MORTALITY	Starvation associated with increased infant mortality at least up to 90 days post-partum.	Supplementation associated with reduced perinatal mortality. Infant and child morbidity data not yet analysed.	No relationship between supplementation and consumption and duration of diarrheas; supplementation plus frequent medical care usage associated with decreased infant mortality (1,536 births).	Not reported.	None reported.	None reported.

Table 5 Continued

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	Dutch Famine	Bogota	Colombia	Gautemala/ INCAP	India	Mexico	Montereal
BEHAV- IORAL EFFECTS	No changes in young adult males born to mothers starved during pregnancy.	More rapid habituation in supplemented 15-day-old infants.	Advanced psychomotor performance in supplemented infants and children to 4 years of age.	Not studied.	Supplemented infants "more active" throughout study.	Not studied.	

the gestational age at which supplementation is begun. One study which included a high proportion of women who smoked showed that an associated decrease²⁴ in birth weight appeared to be offset by nutritional intervention.

2. **Morbidity and mortality** - The Guatemalan study demonstrated that food supplementation and medical care during pregnancy and lactation were associated with a marked reduction in infant mortality. In Bogota, supplementation was associated with a comparable decrease in perinatal mortality.

The morbidity data were obtained in several studies but not analysed in detail. No association was observed between supplementation and the incidence or duration of diarrhea in the Guatemalan infants. A confounding factor in interpreting the findings on morbidity and mortality was the difficulty of separating supplement consumption and the use of health services.

3. **Physical growth of offspring** - Data were available in the Bogota, Guatemala, Mexico and New York studies concerning the impact of maternal supplementation during pregnancy and lactation on fetal and infant growth. In the Latin American studies, a positive impact of the additional nutrients was readily clear; whether protein or energy was more important appeared to depend upon the environmental circumstances and cultural practices. Separation of the relative importance of prenatal versus postnatal maternal supplementation proved to be a difficult task. No effects of supplementation during pregnancy alone were noted in the New York study. However data suggested that in this population there was no real dietary deficiency.

4. **Psycho-social development of infant and child** - In the Bogota study, visual habituation at 15 days of age was more rapid in the group receiving prenatal supplementation than in the control subjects. High protein supplementation during pregnancy was similarly associated with more rapid habituation responses at one year of age in the New York study. Both the Guatemalan and Mexico studies also revealed significantly improved psychomotor development throughout the first year of life in the supplemented group.

5. **Effect of intervention on the mother** - Four studies (Bogota, Guatemala, Mexico and New York city) showed an increased maternal weight gain associated with supplement consumption during pregnancy; the Montreal and Taiwan studies did not show this association.

Besides the eight studies reviewed in Table 5, several other studies have also been carried out on the effect of supplementation during pregnancy. These studies are summarized in Table 6. The outcome of most of these studies was similar to what is mentioned above. In most of the studies, there was a small

Table 6 : Summary of nutrition intervention studies during pregnancy

Study	Objective	Research Design	Description of Population
Bhatnagar et al (1983) India	Effect of food supplement in the last trimester of pregnancy and early postnatal period on maternal weight and infant growth.	Prospective intervention study of offsprings of women supplemented from 24th week of gestation. Weight of the infants monitored for 3 months.	Urban slum ICDS and non-ICDS population of Delhi. n-ICDS = 140; non-ICDS = 170. Estimated Caloric intake was 1166-1196 and protein 38 g/day.
Prentice et al (1983) Gambia	Effect of prenatal dietary supplementation on birth weight.	Prospective intervention study of infants born to women supplemented during pregnancy (after 8-10 weeks).	All pregnant women in Kenedy village of the Gambia were enrolled. Pre-supplement dietary energy intake 1480 in dry season; 1300 in wet season.

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Study	Objective	Research Design	Description of Population
Viegas et al (1982) (a, b)	Effect of protein and energy supplementation (selective and unselective) during 2nd and 3rd trimesters.	Prospective hospital based study. Supplementation (with vitamin [V], energy-[E]) and vitamins or V+E + proteins of pregnant mothers either at risk or not at risk.	153 Asian mothers (unselected) attending a maternity hospital in Birmingham. 45 mothers (selected or nutritionally at risk - triceps increment < 20 um per week).
Adams et al (1978) USA	Effect of nutritional supplementation (protein) on the outcome of pregnancy.	Prospective supplementation study of women judged to be at high risk of delivering low birth weight babies.	All women enrolled in obstetric clinic during 1971-72 (n=277). Criteria for high risk; Hypertension; fetal loss; neonatal disease, heavy smoking, out of wedlock, short stature and underweight. Calorie intake 1844.
Devadas et al (1970)	Impact of an applied nutrition program (ANP) on the nutritional status of women and infants.	Evaluation of the nutritional status supplementary nutrition on in an ANP project versus non-ANP site.	n=20 (10 in each group) Calorie intake ANP - 2114 Protein 65 g Non-ANP - Calorie - 1913 Protein - 51 g

Study	Objective	Research Design	Description of Population	Dietary Modifications
Devadas et al 1982	Nutritional outcomes of a rural diet supplemented with low cost locally available foods (impact on expectant women).	Prospective intervention trial of expectant mothers and compared with a control group receiving no supplements.	Study conducted on 50 women from 2 villages of Coimbatore (experimental)- 25 control subjects from a similar village.	Group I: Ragi based diet Group II: Rice based diet Group III: Normal diet (Amounts or nutritive value of the supplement not mentioned).
Tontisirin et al (1983)	To improve the nutritional status of rural pregnant women by supplementation.	Prospective intervention trial of pregnant women in third trimester.	Study conducted on 43 subjects enrolled in a rural MCH centre.	Six formulae were developed with locally available raw materials. Provided 13 g protein and 350 Kcal.

Table 6 contd.

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McDonld et al (1981)	Maternal nutritional status and birth weight of offspring	Randomized controlled dou- ble blind trial on the effect of nutritional supplementation of pregnant/lactating women on their offspring. Duration of study 6-1/2 years. Supple- mentation began after 3 weeks of the delivery of a first study infant, continued throughout lactation and through the pregnancy and lactation of second study infant.	294 women from 14 villages in Taiwan. Calorie intake 1200. Protein 40 g per day.
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but significant increase in the birth weight as a result of supplementation accompanied with a change in other anthropometric parameters such as length, arm, head and chest circumference. The mothers also gained more weight during pregnancy. In one study the growth of the infant was found to be better upto 3 m of age (Bhatnagar et al, 1983).

Effect of supplementation on the lactational performance

Several studies have been carried out to evaluate the effect of food supplementation on lactational performance. These are summarized in Table 7. The effect of supplementation on lactational performance is not as clear and unequivocal. While some investigators observed a beneficial effect, others failed to do so.

Whitehead (1983) has discussed the effect of diet on maternal health and lactational performance in an extensive review. He has concluded from the available literature that except in extreme maternal undernutrition the concentrations of total energy and protein in breast milk are maintained at remarkably normal levels. In the Gambia, where even during good times of the year dietary mean intake was only 1700 KCal/day, the average energy content of the mother's milk was maintained at 72 KCal/100 ml which compared well with the mean content of British mother's milk at 69 KCal/100 ml. Even when mean intake was 1120-1200 KCal/day the energy content only dropped by about 10 per cent. The concentrations of fat, lactose and protein also are reported to be remarkably stable despite changes in the maternal diet. In contrast to the proximate constituents, vitamin content particularly of the water soluble is very sensitive to dietary intake.

Most studies on the effect of supplementation have also failed to reveal a significant improvement in the lactational performance. According to Whitehead (1983) there are a number of theoretical reasons why this might have been so, but one stands out : there has been generally too little attention given to the size of the deficit that needs to be filled. The energy gap between mean intake and the RDA is at least 1000 KCal/day (Table 1) but few investigators have attempted to provide anything like this amount. Some of the studies have also been short-term ones and it would not be surprising if this failed to overcome a chronic problem. Furthermore, few investigators have attempted to assess the effect of their supplement on customary food intake and it is always possible that it had only a substitution effect. Whereas, ideally the supplement should bridge the total energy gap, practically it may not be feasible and therefore there is a need to target the food already given as supplement.

Table 7 : Summary of studies on the effect of food supplementation on the lactational performance

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Study	Objectives	Research Design	Description of Population
Devadas et al (1971)	Impact of ANP Program on the nutritional status of nursing mothers.	Evaluation of ongoing ANP program.	12 subjects from ANP village and 12 subjects from non-ANP village had of home diet of 1325 Kcal and 35 g protein/day.
Devadas et al (1983)	Effect of supplementation on lactational performance.	Prospective intervention trial of supplemented versus control group. Duration of experiment 18 months.	Study conducted in 2 villages of Coimbatore. n - not given home diet 262-350 Kcal and 8 - 9 g protein.
Prentice et al (1980, 1983)	If dietary intervention could improve the lactational capacity.	Prospective intervention trial of lactating mothers versus retrospective controls. Duration of experiment - 1 year.	130 nursing mothers in Keneba, the Gambia. Home diet : 1968 Kcal.

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Girija et al (1984)	Effect of dietary supplementation during pregnancy on the lactational performance.	Prospective intervention trial of supplemented versus control women. Supplemented in 3rd trimester of pregnancy.	20 under-privileged women from Hyderabad-10 - Experimental 10 - Control. 31
Belavady (1980)	Effect of dietary supplementation on yield and composition of milk.	Prospective intervention trial.	Hospital patients Average weight of the women 42 kg and height 148 cm. Home diet : 1800-200 Kcal + 40 - 50 g protein.
Chavez and Martinez (1980)	Effect of dietary supplementation on milk production.	Prospective intervention study.	34 mother-child units from a poor rural community of Mexico 17 - Control 17 - Experimental.

Present strategies to improve the nutritional status of the pregnant and lactating women.

Supplementary Nutrition Programs : The Government of India started three programs with the aim of improving the nutritional status of underprivileged pregnant and lactating women. These programs are :

1. The Applied Nutrition Program (ANP)
2. The Special Nutrition Program (SNP)
3. The Integrated Child Development Services (ICDS).

The ANP and the SNP are gradually being either discontinued or merged into the ICDS which is the most promising ongoing program. Since the present study was conducted in the ICDS setting, the details of this program, especially the supplementary nutrition component are reviewed in this section.

The ICDS was started in 1975 by the Ministry of Social Welfare, Government of India with 33 projects all over the country. The promise shown by these projects led to the expansion of the scheme and by the end of the Sixth Plan 1136 projects were sanctioned including some by the State Government (NIPCCD, 1986). The specific objectives of the program are :

1. To reduce malnutrition, morbidity and mortality of children in the age group of 0-6 years.
2. To improve health and nutritional status of children in the age group of 0-6 years.
3. To provide the environmental conditions necessary for their psycho-social and physical development.
4. To bring about effective coordination in the work of various agencies involved in child development programs.
5. To enhance the mother's capabilities to take care of the nutritional needs of her children.

To achieve these objectives, the ICDS provides the following package of services to children below 6 years of age, pregnant women and nursing mothers :

- (i) Supplementary nutrition
- (ii) Immunization
- (iii) Health check up
- (iv) Referral services
- (v) Nutrition and health education
- (vi) Non-formal preschool education.

The focal point for the delivery of the package of services is an Anganwadi

(ICDS centre) to cover a population of about 1000 in urban and rural areas and 700 in tribal areas. The Anganwadi is run by a local woman called the Anganwadi workers (AW) who is assisted by a helper. A group of Anganwadi workers is supervised by a Supervisor. A Child Development Project Officer (CDPO) is directly in charge of each ICDS project which generally covers a population of about 1,00,000 in urban areas. The health infrastructure in the project area is strengthened by a Medical Officer, Lady Health Visitors (LHV) and Auxiliary Nurse Midwives (ANM). The Departments of Social Welfare, Health, Rural Development, Community Development, Tribal Welfare and Women and Child Welfare are all involved in the functioning of the project (Rajendran, 1980). Figure 1 outlines the organizational set up of the ICDS.

The supplementary feeding in the ICDS is provided to children below six years, pregnant and nursing women on the basis of criteria laid down. The scheme covers pregnant and nursing women from scheduled castes and tribes, landless labourers, backward and other poor groups. Pregnant women are enrolled at the Anganwadi from the sixth month of pregnancy. Nursing women are given supplementary feeding until six months of lactation.

The supplementary feeding aims at providing 500 KCal and 20 g of protein to pregnant and nursing women. Feeding is expected to be conducted on site for 300 days in a year. The cost per woman beneficiary per day is Rs.1.05 (Khanna & Ohari 1986).

A variety of foods are provided as supplements in the ICDS scheme. In the initial stage emphasis was laid on the use of locally available foods. However, due to the decision to expand ICDS, the Government of India requested food assistance from CARE and the World Food Program (WFP).

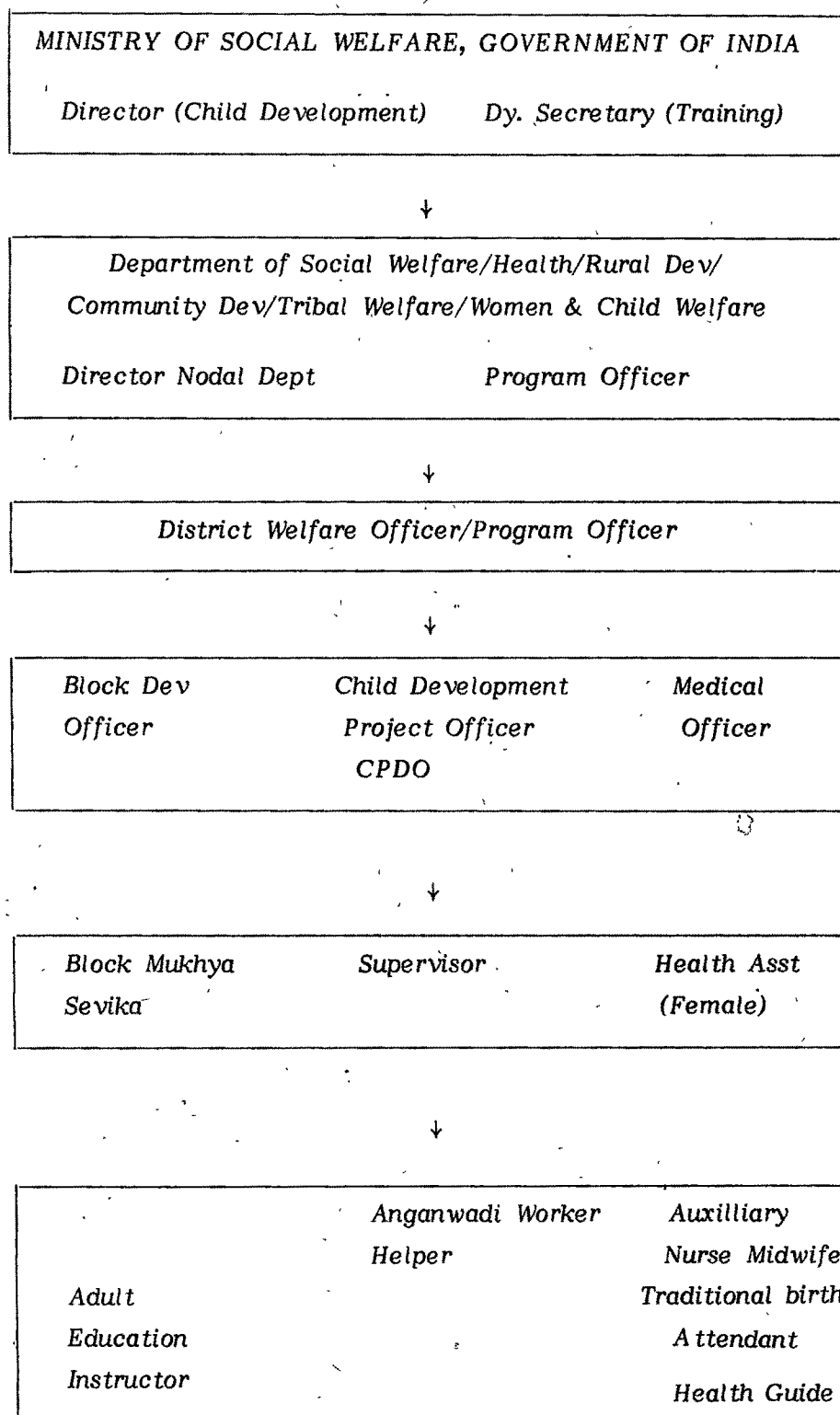


Figure 1 : Organizational set up of ICDS (NIPCCD)

The food supplement distributed at the Anganwadis is of two types :

(i) Ready-to-eat foods or the RTEs and (ii) Food cooked at the centre. the RTE is essentially pre-cooked and is available in a form which does not require any cooking. Sufficient data are not available on the type of food supplements provided in the ICDS. However, in Baroda, the children are generally given biscuits, murmuras, (extruded food), bread or a mixture of roasted bengal gram (whole) and peanuts. The pregnant and lactating women receive Baroda Mix which consists of wheat flour (60 g); bengal gram flour (20 g); groundnut flour (15 g) and sugar (5 g) and provides 300 Kcal and 15g protein.

In a comprehensive review on Supplementary Feeding, Anderson et al (1981), have raised and discussed several key questions related to supplementary feeding programs. Some of them related to the present study are :

1. How does one determine what food to use as the supplement?
2. What determines the acceptability?
3. What are the requirements for nutritional adequacy?
4. How should one determine the size of the supplement?
5. What are the nutrient requirements of the target group?
6. What are their deficits?
7. What supplement leakages might the program incur?
8. With what frequency should supplement be distributed to beneficiaries?
9. How long should a participant remain in the program?
10. What are the principal weaknesses and strengths of different forms of intervention programs such as the 'take home' and 'on the spot' feeding programs?

Although the above questions are mostly related to child feeding programs, they are equally applicable to the feeding programs for pregnant and lactating women and therefore have been reviewed below:

According to the authors the choice of food for a supplementary feeding program is determined by acceptability to the recipients, availability, cost, shelf life and its nutritional adequacy.

The foods to be used in feeding programs must be designed to ensure cultural and sensory acceptance by the users. Acceptability trials must be carried out in the setting in which the product is to be served and they should be repeated.

In addition to acceptability, the foods must be nutritionally adequate to address the identified nutrient deficiencies. While bulk has been recognized as a problem in getting enough food into the child, it also needs attention when developing food supplements for pregnant and lactating women. Thus focus should be on high calorie-low bulk foods.

To ascertain the size of the supplement, one must consider the nutritional requirements and deficits of the target group and possible leakages of the foods. The problem of sharing which is most common in 'take home' feeding has been discussed elsewhere in detail since this research seeks to address this problem.

As regards the period when supplementation should be done, it was found that severe nutritional deprivation during the first half of pregnancy did not affect birth weight (Mora et al, 1976, 1979). A high consumption of calories and protein in the second half or even in the last trimester of pregnancy could increase fetal growth in mothers whose diets were inadequate during the first half, but supplementation must take place for at least 13 weeks. Thus the crucial time for supplementation for pregnant mothers is during the last trimester. However, maternal fat stores laid down during the early months of pregnancy as a result of supplementation can be beneficial to fetal growth later in pregnancy.

The frequency of ration distribution is another important issue in the feeding programs, rations in dry form are usually distributed to mothers weekly, biweekly or monthly. However, daily distribution may also take place particularly when commodities are in prepared or semi-prepared form. The major considerations for deciding the appropriate frequency of distribution are staff time, convenience, shelf life of the ration, and opportunities for diversion of the ration.

The authors and several others (Gopaldas et al, 1975; Beaton & Ghassemi 1982) have also reviewed the pros and cons of the form of intervention, i.e. 'on-the-spot', or 'on-site' feeding and 'take-home' feeding. In order to ensure that the food supplement provided has maximum impact, the ICDS scheme stresses that the supplement be eaten by the beneficiaries at the Anganwadis. Whereas it is a good system for preschool children (not the under threes); it was found in a study undertaken by WFP (1986) that none of the women recipients ate the food at the centre. They were taking the food home because of insufficient time at their disposal and because the communal type feeding was socially unacceptable to them. Also the women did not hide the fact that they would be sharing the food at home with other children, not participating in the program. Gupta et al (1979) also observed that on-the-spot feeding for pregnant and lactating women at the Anganwadis was one of the problems faced by the Anganwadi workers. Thus 'take-home'-system becomes the only possible way of distributing food sometimes. Another advantage of this system is that the ration can be fed in more frequent smaller portions than is possible in on-site, resulting in higher nutrient intake.

Problem of sharing of the maternal food supplement

One of the biggest shortcomings of the 'take-home' supplementary nutrition

programs is that they easily facilitate the consumption of the supplementary ³⁷ food by nontarget group members (Anderson et al, 1981).

Sharing of the food supplement has been observed in the programs **both for children and pregnant and lactating women**. Anderson et al (1981) examined the results of an evaluation carried out by CARE in 1976 of take home feeding programs in Columbia, the Dominican Republic and Pakistan. In two programs i.e. Columbia and the Dominican Republic, only half the children were reported to have eaten the ration on the previous day of interview. In Pakistan the percentage reported was even lower at 18% but this was owing primarily to poor acceptability of the foods received. When mothers were asked why their children had not eaten the ration, they replied most often that they had run out of the ration because **it was shared with the entire family**. In Columbia, 65% of those who had not given the ration to their child on the previous day stated that they had no food left and in Pakistan 73% of those not giving it had run out of CARE foods ahead of schedule. The number of people sharing the ration emerged as one of the strongest factors associated with low nutritional impact in two programs i.e. Columbia and the Dominican Republic, where the number of people sharing the ration was higher at low impact centres.

The impact of the 'take home' food on preschool children, pregnant and lactating women in Central India was evaluated by CARE (Gopaldas et al, 1975). The supplement for the preschool children was shared by the siblings (generally upto the age of six and sometimes upto ten years) as admitted by 75% families interviewed. Only about 40-50 g of the daily take home food ration of 100 g reached the toddler (1-4 yrs). The infant received only 11 g/day of the food supplement on an average. In some of the poorest homes, the whole week's supply of Poshak (food supplement) was often consumed within 5 days because it was used as a substitute for the family food.

Pregnant and lactating women were given 200 g of food supplement per day. The mean consumption by pregnant women was 24 g (providing 91 KCal) per day. On an average, approximately a tenth of the daily 'take home' ration reached the women and nine-tenths of it was dispersed to other members in the family, mostly to children under 6 years of age. Nursing mothers on an average consumed over a fourth of the daily ration, the rest being dispersed to the children. The mean intake was 58 g which provided 200 KCal per day.

The aspect of sharing was also explored in the India Population Project in Karnataka (NIN, 1981). About 200 pregnant and lactating mothers were given a food supplement (Energy food) which consisted of wheat (60 g) roasted bengal

gram (10 g), groundnut flour (10 g) and jaggery (30 g) in a powder form. It was observed that nearly 80% of the mothers shared the supplement. Most common sharers were children. More than 75% of children who shared the food were between 3-6 years while the rest were older. In some of the families surveyed, though older women were found to occasionally share the supplement, in no instances were adult men found to do so. In about 50% of the cases, usually one or two persons were found to share while in more than 24% of cases sharing was done by three or more persons. It was postulated that mothers would have received only half to one-third or even less of the amount of ration provided to her. Thus instead of receiving about 400 KCal, the mothers obtained only 130-200 KCal per day. Devadas et al (1971) have also reported sharing of the food supplement by nursing women beneficiaries of the Applied Nutrition Program in Tamil Nadu, India.

The cause of sharing are : (1) extreme poverty; (2) psychological and traditional inhibitions of the mother, the wife or the daughter-in-law which compel her to share her food ration with her family and children if it is offered as food per se; (3) fear of a difficult delivery resulting from extra intake of food and (4) lack of awareness that the dietary needs are increased during pregnancy and lactation (Gopaldas et al, 1975).

In a review on 'supplementary feeding programs' Beaton and Ghassemi (1979) have commented that one might assume that sharing within the family is a reflection of need by other members of the family, but it is not so as suggested by two pieces of evidence. If that were the case, it might be expected that the larger the energy gap (assuming this characterised the family situation), the greater would be the extent of sharing. However, across the programs which the authors have reviewed, there was no apparent relationship between either sharing or displacement by ingested supplement and the magnitude of the energy gap. The second piece of evidence came from the studies of Mora and co-workers in Columbia (Mora et al, 1978 a). These workers were interested in food supplementation of pregnant women. In the hope of overcoming the effects of sharing and displacement, they distributed supplementary food for all members of the family in the following schedule : pregnant and lactating women - 856 KCal/day; children - 430-670 KCal/day; other family members - 623 KCal/day (Mora et al, 1978 b). When the actual intake data for the pregnant women were examined, it was found that the net increase was only about 16% of the intended increment (133 instead of 856 KCal). The food displacement phenomenon accounted for 42% of the supplement offered and sharing represented about 42% of the food provided. Thus it is postulated by the authors that family need, examined in physiologic terms is not the major determinant of "leakage" of supplementary food. Rather the provision of food supple-

ments, either as meals or 'take-home foods', effectively increases family purchasing power and that a number of non-nutritional factors affect the manner in which this buying power is used. It was concluded by the authors that the displacement of food is generally greater in supervised feeding programs than in 'take home' programs. Whereas displacement may not be affected by the nature of the foods used, sharing is more pronounced when the food has wide acceptability for the whole family. Thus this raised the question of sharply targetting the food supplement in the 'take home' supplementation programs.

The concept of special mother foods to reduce sharing of the supplement : A case study of Project 'Matru Ahar'*

As already pointed out sharing with her family of take home supplementary food given to pregnant and lactating women has been a bane of group feeding programs. Sharing is most likely to occur when the same food has been used for distribution to both the mother and child, as it is identified as an 'extra ration' for the household. If the food could be identified as a 'special' food or medicine it is less likely that it would be dispersed. The concept of a special food and a special diet for the pregnant and lactating women is firmly entrenched in most regional cultures of the country. It was suggested that culturally acceptable food supplementation program should be attempted incorporating nutrients in some special form, to make a significant impact on the nutritionally deprived expectant and nursing women (Gopaldas et al, 1975).

In 1977, the Protein Foods and Nutrition Development Association of India (PFNDAI, 1977) undertook a project - 'Matruahar' or mother's food to examine whether such sharing could be overcome by way of fashioning foods that are based on special preparations eaten during pregnancy and lactation in many parts of India. Details of this project are reviewed since it is the only study exemplifying the concept of a 'Mother's food'.

Anand in Gujarat State was chosen as the venue of the project. An initial dietary survey among pregnant and nursing women with family incomes below Rs. 500 per month, attending 3 hospitals in Anand area, showed that the special foods used by them were **Methipak, Suntpak, Gunderpak and Sheera** (please see Glossary for explanation). These foods were the basis of subsequent product development.

Recipes were formulated with **Balahar** - a cereal - oilcake-pulse mix, fortified with vitamins and minerals, that is widely used in feeding programs in India. To this mix was added a heavy spice component. The accent was on food types that could be factory-manufactured rather than on those requiring individual hand shaping or preparation. Cost was borne in mind, but not unduly emphasised at this stage. During actual preparation, several adjustments of the recipes were required in terms of components, procedures and spice levels. Eventually some recipes were rejected because of poor physical form, low keeping quality or probable cultural unsuitability as a potential food.

***Matru Ahar** : Hindi and Gujarati word for 'maternal food'.

Eventually 4 food types, namely, biscuits, **nankhatai**, **custsquares** and **sukhadi** each in 8 flavours (cardamom, cinnamon, cloves, ginger, **jaiphal**, **jeera**, liquorice and **methi**) emerged as product types and flavours for testing. Two synthetic flavours, cinnamon in biscuits and ginger in nankhatai, were included since the same flavour level is achieved at much lower cost than by using natural spices. These foods were preference-tested at 3 hospitals among 131 target women each of whom viewed the food, expressed her first choice, and then tasted the chosen food in four different flavours. The outcome of such testing showed preference for food types and associated flavours in the following order : nankhatai (ginger synthetic, methi); biscuits (cinnamon synthetic, cinnamon natural and ginger); custsquares (methi, ginger) and finally sukhadi (methi, liquorice, ginger).

Nankhatai and biscuits are related baked food types; sukhadi has poor keeping quality. Methi and ginger were found to be popular food flavours. Hence the foods selected for the field testing were biscuits in the two flavours, custsquares in the two flavours, and traditional methipak as a control and yardstick. A coloured pictorial poster was developed to promote the concept of Matruahar or mother's food by giving one to each beneficiary, and inserting a copy in the food package.

Each woman was given enough of one food type (700 g) to last a week, and then an equal quantity again for another week; thereafter the food type was changed, and rations were distributed for a second fortnight in two-weekly lots. After the first fortnight, answers were recorded to questions about her reactions to the food, quantity left unconsumed and food sharing, if any, and with whom. After the second fortnight, these queries were repeated for the new food and the subject was further asked whether the foods had helped her and if she would buy them if available. A total of 106 women completed the total four-week schedule at the three hospital centres. Another 30, termed unscheduled beneficiaries, did not follow the exact schedules, but did draw food of some type for the total four-week period. Seventy four women grouped as Incomplete schedules, dropped out and could not be reached at some stage of the total period, but had stated their reactions to whatever food types and flavours they had actually received. These 210 results were each analysed and pooled in terms of (a) positive responses, negative responses or neutral stances; (b) degree of sharing and incomplete consumption; and (c) approval of the Matruahar concept and willingness to buy such food.

The data revealed that acceptance even of traditional methipak, made to a home recipe, was by no means total. Biscuits with methi were remarkably similar in scoring pattern (both positive and negative responses) to methipak, and were equally acceptable as methipak. These biscuits were hard and could be further

improved with better technology. Biscuits with ginger did not fare well, and though **suntpak** is a popular traditional mother's food, the image of dry ginger or **sunt** as a 'hot' food seemed to prevail. Custsquares with methi and custsquare with ginger both had poor acceptance. Use of synthetic flavours was not found to diminish acceptance.

About 20 per cent each of distributed amount of methipak or of biscuits with methi or of biscuits with ginger remained unconsumed, and many women stated that the amount given (100 g/day or 18 biscuits) was too large. Sharing occurred in just 10 per cent cases which was mostly by way of a small bit given to a child. Sharing of custsquares, both ginger and methi was much higher at 25 per cent and here only 5 per cent was left unconsumed. These custsquares were designed to be sugar-rich sweet foods carrying spices and therefore sharing was decidedly high. There was ready acceptance of the concept of extra food before and after motherhood but little willingness to buy was expressed by these women.

Use of hospitals as venues for food distribution, endorsement of the food by doctors and suitable pictorial promotion all emerged as important factors in ensuring acceptance of food by women.

The above results of food types and food flavours were specific to area in which field work was conducted i.e. Anand. In widening the concept, it was surmised that shaped food have possibilities in these programs since they can be readily factory produced, packed, stored and apportioned by number. Moreover, when taken home, they could be conveniently spread out as snacks through the day. Strong colouring and flavouring, though these vary in nature, seemed to characterise pregnancy and lactation foods in many parts of the country (garlic, pepper, coconut, betel and saffron in Karnataka; jaggery, asafoetida and herbs and spices in Tamilnadu and Kerala; methi and dried ginger in Maharashtra). The study showed that it was possible to devise special foods for each region based on concepts prevalent there. Synthetic flavours, usually far cheaper than natural flavours were no barrier to acceptance. The study showed that a balance will have to be brought out between spicing or colouring the food at a sufficiently high level to minimise food sharing, and ensure acceptability to the pregnant and lactating women.

Some considerations for Product Development

Since product development was an important part of the study, this section briefly reviews some of the sensory evaluation methods used in product development and food sciences aspects of biscuit preparation.

Sensory evaluation methods

There are four primary types of sensory tests (Sidel et al, 1981) which may be classified as :

- Affective
- Discrimination
- Descriptive
- Quality tests

In the present study affective and descriptive tests were used which are described below :

Affective tests : These are tests in which subjective attitudes such as product acceptance and preference are measured. In affective tests, the task is to indicate preference or acceptance by either selecting, ranking or scoring samples. The paired preference and 9-point hedonic scale are examples of these types of tests. Respondents are usually consumers who are selected on their current or potential use of the product. In laboratory situations, consumer demographics often are substituted in favor of accessible respondent (e.g. employees) whose preference and acceptance behavior correlate with those of target consumer population. Laboratory type acceptance tests can be done with 25 to 50 respondents. In field studies where the target population is used, minimum numbers are 75 to 200 or more.

Descriptive tests : These tests are designed to describe sensory properties of products and measure the perceived intensity of these properties. The most popular descriptive methods include flavor profile, texture profile and quantitative descriptive analysis. Typically 6 to 12 subjects may be used to evaluate a product. Consumers are inappropriate for discrimination, descriptive and quality tests. Similarly trained subjects and experts are inappropriate for typical acceptance and preference tests (Sidel et al, 1981).

Different steps for product development or product optimization have been suggested (Giovanni, 1983) and are as follows :

- (1) **Identify factors :** The first step is to identify two or three factors which are critical to the product being tested i.e. the factors which account for most of the variation in the product. This step presumes that the product

developer knows what these factors are. Of the factors not known, preliminary experiments must be conducted to determine these factors. For example, the factors in the present study were fenugreek seed powder, sweetener, shortening etc which were the ingredients for biscuits.

- (2) **Define factor level :** The second step is to define the range of factor levels which will encompass the physical specification of the samples. Once the factor levels are set, a preliminary sensory test with samples representing the mid points of these should be performed to establish that the levels are appropriate.
- (3) **Select test samples :** The third step is to establish the specific samples to be tested, using appropriate experimental design. These designs select a subset of samples which could be tested. While covering the range of factor levels specified in the experiment, the experimental design emphasizes those samples closest to the mid points of these ranges, thereby decreasing the total number of samples which must be tested. After the samples are specified, experiments are conducted to test these samples and obtain quantitative data to use in the statistical analysis.
- (4) **Data analysis :** The fourth step is to analyse the data using appropriate statistical methods. The results of this analysis are best interpreted cooperatively by the statistician, product developer, sensory scientist and others who may have been involved in data collection. The conclusions drawn from this analysis should then be confirmed by follow-up experiments with the optimum product.

Food Science Aspects of Biscuit Preparation

Smith (1972) has defined or given specification of a biscuit. According to him it shall :

1. be based on a cereal content-wheat, maize, barley, soya, rye etc;
2. contain less than 5% moisture;
3. not be considered a biscuit when more than 60% of its total weight is not cereal based;
4. be considered a biscuit if so called by tradition, custom or habit. Biscuit and cookie are synonymous.

The following steps are involved in the production of biscuits. Since, the biscuits were prepared in the laboratory, the emphasis is not given to plant technology.

1. Selection of Raw Materials
2. Mixing biscuit dough
3. Cutting / shaping
4. Baking
5. Cooling biscuits
6. Packaging

Raw materials

1. **Cereals** : The most important raw material on which the quality of biscuits depends is the cereal flour. The flour specification differ for different types of biscuits and with the manufacturer. Smith (1972) has given the following specification :

Moisture : maximum 15%

Extraction Rate : 70 - 72 %

Ash : 0.4 to 1 %

Protein : 8.2 to 8.7 and 8-9 - 9.4 % (different types need different protein content)

Particle size : Apperture (0.22 mm) - 98 -100 %

(as determined by the " (0.188 ") - 70 - 80 %

sieving test) " (0.13 ") - 20 - 30 %

" (0.11 ") - 0 - 2 %

Viscosity : 35⁰ - 45⁰ Mc Michael (Indicates the quality of gluten)

Soya Flour : Soya flour is widely used in biscuits manufacture these days.

Food Quality Soya Flour (FQSF)

Soya flour contains no true starch. The proteins present in soya are of high biological value resembling those of animal rather than vegetable origin. The oil content of the beans ranges from 30 - 50 %.

FQSF is the finely milled flour containing all the natural fat, protein and lecithin with only the husk and the bitter principle removed. Complete removal of the latter is absolutely essential to ensure a bland tasting product, and that no enzymic activity shall be set up when used in products containing other fats.

FQSF imparts a better texture, better 'bloom' and a longer shelf life to baked products. It facilitates production because it could reduce the cost.

Soya protein, like egg albumen can imbibe and hold water and create a foam with water and other materials. The natural lecithin in soya can stabilise such a foam or emulsify shortening, water and other materials.

In using soya flour in a biscuit dough two conditions should be considered

1. It must always be added with the fat at the creaming stage or mixed with the fat separately and
2. Extra water must be added without which the dough containing soya will become tight and apparently drier.

The quantity of soya flour recommended is 3-6 g/100 g water. It has been reported that the shelf life of biscuits with soya flour is extended. It has been ascribed to the antioxidant effects of FQSF. Biscuits containing soya flour have been stored for more than 200 days without spoilage while control biscuits developed a stale taste around 100 days.

FQSF also tends to eliminate fat bloom (a film of fat on the surface of the biscuits during storage).

Shortenings

The following vegetable fats are generally used.

Coconut : refined, hydrogenated (76 - 110°F), palm kernel, plasticised corn oil, palm oil, cottonseed, sunflower oil, soya bean, peanut, rapeseed, sesame (oils or hydrogenated fats). hydrogenated shortenings may be all vegetable or mixed vegetable and animal in almost any proportion.

Margarine - It is the same as hydrogenated shortening but is usually yellow colored and flavored due to the admixture with milk that has been allowed to sour by a lactic acid culture.

The following characteristics are desired in a shortening :

1. It should have the physical properties and plastic range to suit particular production techniques and the product.
2. A bland clean flavor for a shortening and a simulated butter flavor in margarine
3. Good color - a white shortening - a yellow margarine.
4. Stability to rancidity development
5. Stability of crystal structure both at the mixing stage and after baking.
6. A blend of oils from which the shortening is made that will not cause bleeding or fat 'bloom' on the biscuit during storage.

Sugar : There are four primary forms of sugar

1. Crystals of any particle size as desired.
2. Pulverised or crushed crystal.
3. Liquid sugar
4. Fondant.

The functions of sugar are :

1. It imparts sweetness
2. It increases tenderness
3. Contributes to volume
4. Develops a pleasing crust color
5. Creates a proper balance between liquids and solids responsible for contour
6. Acts as a vehicle for other flavors
7. Assists the retention of moisture
8. Gives an attractive finish

Baking Powder : Carbon di-oxide is vital in helping to texturise the crumb structure. Its chief sources are the chemicals ammonium bi carbonate and sodium bi carbonate.

The following characteristics are desirable in baking powder :

1. Maximum gas strength - greatest volume of gas for least weight of the product.
2. Proper balance of ingredients to prevent any impairment of the taste or appearance of the biscuit.
3. Innocuous ingredients and residues
4. Optimum velocity of reaction to be susceptible to control.
5. Keeping quality under diverse and extreme conditions to remain unimpaired over reasonable periods of time.
6. Minimum cost of production, economical in use.

Lecithin : This is known as phosphatide, contained in and related to natural fats. It has a very pronounced emulsifying action on fats and liquids, particularly water. It facilitates the dispersion of one phase very intimately in the other, so that the dispersed droplets of either the fat or the liquid caused by the mixing action will not easily coalesce into separate phases. In short, lecithin produces a stabilised emulsion. It is commercially obtained from soya bean and cottonseed oil and as commercially available, usually contains about 30 % of the oil from which it is extracted. It is soluble in oils and fats but not in water. When used in doughs, either added with the shortening at the time of plasticisation, lecithin helps to produce smooth, intimately mixed creams which are then more evenly dispersed throughout the cereal contents of the dough to give very smooth doughs. The amount used should be about 1% to 2% of the shortening weight.

II. Dough Mixing

When water is added to and mixed with flour - wheat flour, a dough is formed. This effect is peculiar to wheat flour, for doughs are not easily produced from meal or flour of other cereal grains. As the water makes contact with the flour a dough film is formed at the interface of the flour and water so that the system of 'flour-dough film - water' remain in a somewhat stable state. Thus the surface tension at the film interface is very great.

It is not until agitation (mechanical mixing) takes place to overcome this surface tension and thus break down the initially formed dough film that more water can contact more flour and produce more dough films. As mixing continues, many of the flour particles become surrounded by water which not only envelops agglomerates of flour particles but also penetrates into some of the particles.

The protein material in the matrix has a much greater affinity for water than does the starch and it is this union of water and protein that produces the so-called gluten complex. It is due to this complex - a mixture of **glutenin** and **gliadin** that wheat flour is unique in its dough forming potential.

There are several permutations of mixing methods. These are :

1. Cream sugar and shortening. Add eggs (if any) add water, add flour.
2. Mix shortening and flour, add eggs, add water.
3. Cream shortening with half the flour : cream sugar and eggs separately then add to shortening-flour mix. Add water and balance of flour.
4. Mix flour, shortening and eggs. Gradually add water
5. Cream sugar, shortening and eggs. Add water, add flour.
6. Cream water, sugar and other ingredients. Add flour, add shortening.

III. Cutting : The dough is shaped or cut into circles, rectangles and other shapes of various thickness. Shaping by hand usually gives inconsistent sizes and is eventually replaced by hand operated cutters made of wood and metal. The cutting operation depends to a great extent on the quality of the dough.

IV. Baking :

Within the oven, dough pieces undergo two types of change - physical and chemical

Physical changes

Formation of a film crust on the dough : On entering the oven, the outside of the dough piece soon becomes coated with film or crust, the thickness of which develops as moisture is evaporated from the outside surface. This crust formation starts at as low a temperature as 80°F and proceeds rapidly at around 100°F . It is necessary that it be so formed and achieve sufficient thickness to allow it to become elastic. The degree of elasticity attained is a direct function of the moisture content or humidity of the oven.

If the top heat is too great the film will become too thick and as the gases and water vapor are subsequently formed within the dough piece, this top crust having lost its elasticity will burst open. Thereby in some biscuits, collapse of the internal structure will be evident.

Melting of the fat in the dough : The aggregates of fat particles melt as soon as their immediate area in the dough pieces reaches the melting fusion or slip point temperature of the fat structure. While some portion of the fat with lower melting point fractions, will seep into the enveloping structure, the pockets of fat will remain more or less within their original position in the dough structure, thus the contribution of fat to biscuit texture.

Gas Expansion : The CO_2 formed by chemical reaction within the dough piece, under the influence of increasing temperature, will increase the volume and stretch the dough piece. Depending on the strength of the structure of the gluten/starch/sugar/fat matrix, the mass will be opened up by the expanding gases to help create the texture of the crumb.

Water Converted to Steam : The expansion of the dough piece due to formation of steam is much greater than the expansion due to CO_2 and / or ammonia. However, CO_2 is evolved much earlier in the oven than the steam from the water contained in the dough.

Escape of CO_2 other gases and steam : As these are removed, the dough piece becomes reduced in overall volume. Too great a loss too soon will cause the structure to collapse resulting in hollowed tops and cracked surfaces. Not all the internal gases must be allowed to escape until the structure has become more or less set, otherwise the texture through the final baking stages and the cooling will not be maintained.

Chemical changes

Gas Formation : The reaction of acid + carbonate or carbonate alone can be regulated by :

- (1) The solubility of the particular acid and/or carbonate in the moisture of the dough ,
- (2) The temperature and
- (3) The decomposition range of the carbonate.

Starch Gelatinization : If starch is mixed with cold water, the starch will absorb about 30% of its own weight of water, with very slight swelling of the starch granules. Removal of water leaves the starch practically in its original state. However, if the starch/water mixture is heated above 130°F the absorption of water is much greater and the starch granules will swell to many times their original size. This reaction is irreversible in that the starch cannot be recovered in its original state.

Depending upon the moisture content of the dough, starch gelatinization will start at around 125°F and continue until about 200°F within the dough piece being baked, moisture migration is not only from the dough to the oven atmosphere, but also from the protein (gluten) formed during the mixing to the starch. This is in addition to the effects of the 'free water' in the dough.

Protein changes : Protein (gluten) begins to coagulate at temperatures from 145°F upwards. It is this coagulation of protein which imparts strength to the biscuit structure. At around 165°F the proteins undergo an irreversible denaturation when they become less soluble and the protein fibres become less extensible. In the baked biscuit the coagulated protein is the 'drier' portion; the starch holds the moisture the fats give tenderness and all combined give shortness. During shelf life and so called staling, the moisture in the biscuit gradually migrates from the starch to the protein even without loss of moisture from the biscuit to the atmosphere.

Caramelisation of Sugar : This occurs around 300°F possibly accompanied by the formation of **melanoidins**, and is the reason for the brown crust development quite apart from the 'browning' due to the toasting of the cereal portion of the dough.

Dextrinization : At temperatures slightly higher than 300°F the starch begins to convert to dextrins. If a slight degree of dextrin can be formed on the dough piece surface during baking without undue caramelisation, then a surface will be developed.

Cooling Biscuits : As biscuits are removed from the oven they are very hot, soft and usually very moist. On cooling, the biscuits lose about 16 to 25% moisture. The starch of the biscuit changes from a gel to a paste to a dry complex structure.

Moisture loss, temperature reduction and consequent changes in the state of main ingredients affect biscuit dimensions causing actual shrinkage, often very noticeable in thickness alteration. All this must cause stresses to be set up within the biscuit in reaching the set, non-molten condition. Such are the stresses that they can and do, under adverse conditions cause the biscuit to crack, consequently, 'Checking' to a greater or lesser degree. Sudden cooling is often blamed for checking. Thus gradual cooling is very important.

Packaging : The functions of packaging are as follows :

1. To protect the contents against mechanical damage.
2. To protect the contents, against gain or loss of moisture and against foreign odor contamination.
3. To prevent the onset of rancidity which is materially aided if the packaging material contains any iron or copper salts in quantities above 10 parts per million.
4. To protect against attack by insects, bugs, bacteria, molds, dust and other air borne contamination.
5. To prevent against light, the ultraviolet rays of which do cause color fading and flavor deterioration.
6. The printing on the package must meet the legal requirements of the country in which it is sold.

Based on a review of literature, a need to improve the nutritional status of the underprivileged pregnant and lactating women clearly emerged. Direct supplementation of meagre home diets with adequate quantities of a culturally and psychologically acceptable 'mother foods' also emerged as a promising approach. One of the most formidable blocks to effective delivery of a maternal food supplement to needy target populations of pregnant and lactating mothers is the extensive sharing of the maternal supplement by the other members of the family. The major effort in the present investigation has therefore, been to indentify an existing culturally acceptable 'mother food' of Gujarat, and to investigate the various habits regarding its consumption. The major focus has consequently, been on the development of a 'maternal food supplement' that would have maximum cultural acceptability and yet address the problem of 'sharing' by other members of the family.