

CHAPTER I
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The desirability of breast feeding the infant atleast for the first few months has been generally accepted because of several considerations. The presence in breast milk, of high quality protein, fat, and requisite amounts of vitamins and minerals, its immunising characteristics, availability as and when needed at the right temperature, freedom from contamination, easy digestibility, and finally, its conduciveness to the psychological well being of mother and child make it the infant food par excellence.

In poor countries such as India, prepared baby foods are out of reach for most people and the milk of cows and buffaloes is difficult to get in hygienic and unadulterated condition. The diet replacing breast milk in poor classes is usually comprised of cereals so that the infant gets malnourished soon after partial or complete weaning and consequently faces the hazards of protein deficiency diseases like Kwashiorkor. Although most Indian communities breast feed their infants for prolonged periods (Rao, 1959; Jelliffe, 1955; Belvady et al., 1959) it is necessary to assess the adequacy of milk with regard to quantity as well as quality, and to see whether the same can be improved by

controlling factors such as diet. For, it would be relatively easier to supplement the diet of the mother with cheap protein foods, synthetic vitamins etc. than to provide baby foods for infants.

Lactation has been reported to depend on several factors such as stage of lactation, age and parity of the mother, physical well being, hormonal influence, cultural and emotional factors etc. However, a good diet is recognised to be one of the most important requisites for the maintenance of lactation even in primitive communities, although their conception of what constitutes a good diet may be woefully off the mark. Even if lactation is successfully maintained on an inadequate diet, this can be achieved only at the expense of depleting the vital reserves of the mother, so that a systematic study of the relation between diet and milk becomes essential. Also, while some of the other factors mentioned may have a relatively greater influence on the output of milk, it would be reasonable to expect that the quality of milk may be more directly related to maternal diet. That the same may be grossly inadequate even when lactation is successfully maintained was dramatically demonstrated by Andrews (1912) who found that the milk of women whose babies died of beriberi had very low contents of the B vitamins and produced polyneuritis in puppies fed on the same.

If the composition of milk is influenced to any considerable extent by the diet of the mother, differences in the same may be expected between groups with widely differing nutritional standards. Thus chemical composition of milk in subjects from countries with high nutritional standards can be expected to be superior atleast in some regard to that in subjects in an undernourished country like India. However, it must be pointed out that the other factors such as age and parity, stage of lactation, differences in the methodology employed for the collection and analysis of milk samples etc. may tend to obscure the picture. Further, the selection of subjects in the two societies may be such that the comparison is not always made at homologous points. For instance, relatively prosperous subjects even in generally undernourished countries may compare quite well in regard to nutritional levels with less fortunate subjects in countries with a high standard of living. Such comparisons have therefore to be interpreted with caution. Nevertheless, it is relevant to consider in this context studies on the chemical composition of milk reported by different investigators for different groups of subjects for any possible light they may throw on the range of the variations in the composition of milk.

Values for the protein content of milk have been reported by different investigators and these expressed as grams percent include 1.06 for American (Macy, 1949), 1.07 for Japanese (Chiba et al., 1956), 1.16 for British (Kon and Mawson, 1950), 1 to 1.27 for Indian (Aykroyd et al., 1956; Ramanathan and Srinivasan, 1954; Belvady and Gopalan, 1959; Mukerjee and Anwikar, 1959), 1.04 for Nigerian (Jeffiffe, 1952), 1.35 for South African Bantu (Walker et al., 1954), 1.33 for Natives of New Hebrides (Peters, 1952), 1.44 for Philipino (Strancky et al., 1954), 1.41 for Australian (Wardlaw and Dart, 1926), 1.50 and 1.33 for Ceylonese (Gunasekara, 1956; Gunasekara and Wijesihna, 1956), and 1.12 for Congolese (Close et al., 1957), subjects. It will be seen that the values, barring those of obtained for Australian, Ceylonese and Philippino subjects, do not vary significantly. The possibility can not be ruled out that these exceptions are influenced by factors such as selection, number of subjects, techniques employed etc.

Attempts were made to study the quality of proteins by quantitative separation of various nitrogenous constituents in milk. From the data reported by Friedham (1909), Macy et al. (1931), Nelson (1960), Chiba et al. (1956), Belvady (1959), the casein content is seen to vary from 0.18 per 100 ml for Indian subjects (Belvady, 1959)

to 0.5 g per 100 ml for American subjects (Macy et al., 1931). Thus although the protein content of milk does not vary much between the different groups, the casein content does pointing to differences in the quality of proteins in milk. Values with regard to lactalbumin are found to vary between 0.39 to 0.64 g per 100 ml. (Chiba, et al., 1956; Macy et al., 1931; Belvady, 1959).

The amino-acid composition of breast milk has been reported by Block and Bolling (1946), Macy (1949) and Miller and Ruttinger (1950) for American subjects, by Close et al. (1957) for African subjects, by Ganguly for Indian subjects (1958) and by others (Williamson, 1944; Srinivasan and Ramanathan, 1954; Soupart et al., 1954). The values (expressed as mg per 100 ml of milk) reported by Block and Bolling (1946), Macy ~~xxxx~~ (1949), and Ganguly (1958), include respectively 107, 97, and 90 for leucine, 76, 72, and 65 for isoleucine, 90, 73, and 75 for valine, 28, 24, and 25 for histidine, 67, 70, and 80 for lysine, 55, 40, and 25 for phenylalanine, 37, 43, and 40 for arginine, 45, 52, and 45, for threonine, and 24, 12, and 7 for methionine. Block and Bolling (1946) and Macy (1949) have also reported the values of 17 and 19 for tryptophan. It would appear that the values reported for Indian subjects compare well with those reported for American subjects, except for methionine and phenylalanine, the values for which are low. It is to be

noted, however, that the value 29 mg per 100 ml for methionine reported by Sreenivasan and Ramanathan (1954) for Indian subjects compares favourably with the value reported by Block and Bolling (1946).

Considerable differences appear to exist in the creatine and creatinine contents of milk, as can be inferred from the values of 1.1 mg each of creatine and creatinine per 100 ml milk for American subjects (Macy *et al.*, 1931) and 3.4 and 2.3 mg respectively for Indian subjects reported by Belvady (1959) who further report a fall in creatine level following supplementation and a rise to the original level when the supplementation is withdrawn. It would thus appear from the foregoing that even when the protein content of milk does not vary in different groups of subjects, the distribution of different nitrogenous constituents may show considerable variation.

Values reported for fat content (expressed as grams percent) are found to range from 2.8 to 4.95 in different groups of subjects investigated and include 4.54 for American (Macy, 1949), 4.78 for British (Kon and Mawson, 1950), 3.90 (Aykroyd *et al.*, 1951) and 3.42 (Belvady and Gopalan, 1959) for Indian, 3.8 for Natives of New Hebrides (Peters, 1952), 2.80 for Ceylonese (Gunasekara and Wijesinha, 1956), and 4.95 for Australian (Wardlaw and Dart, 1926), subjects. Even keeping in mind the fact that

the fat content of milk may be subject to fluctuation on account of diurnal variations and may depend on whether foremilk or aftermilk is taken, it is to be noted that generally higher values have been reported from countries with a higher standard of living. The fatty acid composition of milk fat, however, is found to be similar in different groups studied (Bosworth, 1934; Hilditch and Meara, 1944; Baldwin and Longnecker, 1944; Brown and Orians, 1946; Insull and Ahrens, 1959).

The lactose content of milk appears to show relatively little variation, the values obtained ranging from 6.8 to 7.51 g percent (Kon and Mawson, 1950; Aykroyd *et al.*, 1956; Belvady and Gopalan, 1959; Gunesekhara and Wijesinha, 1956; Macy, 1949).

The mineral composition of milk has also been studied in several groups of subjects. The values reported for calcium expressed as mg per 100 ml include 25.8 for New Hebride subjects (Peters, 1953), 28.4 for Australian subjects (Winikoff, 1944), 29.9 for British subjects (Kon and Mawson, 1950), 34.2 for poor Indian subjects (Belvady and Gopalan, 1959), and 34.4 for American subjects (Macy, 1949). Although there is a considerable amount of variation, there appears to be no obvious relation between dietary intake and milk content of this mineral as judged from the high value obtained for poor Indian subjects whose dietary intake of the mineral was found to be totally inadequate (Belvady and Gopalan, 1959). On the other hand, the values

11.9 and 2.6 expressed as mg per 100 ml for phosphorus and magnesium respectively for poor Indian subjects (Belvady and Gopalan, 1959) are considerably less than the values of 1.3 to 17.5 reported elsewhere for the former and 3.5 for the latter (Macy, 1949; Winikoff, 1944).

With regard to trace elements, the value of 0.115 mg per 100 ml reported for the iron content of milk in Indian subjects (Belvady and Gopalan, 1959) compares favourably with ~~these~~ 0.11 and 0.085 for American (Macy, 1949) and Finnish subjects (Kasanen and Ekman, 1955) respectively, ~~the~~ whereas the value of 0.03 mg per 100 ml reported for copper for Indian subjects (Belvady and Gopalan, 1959) compares poorly with 0.05 mg (Munch-Peterson, 1950) and 0.07 mg reported by others (Lesne and Briskas, 1937). With regard to zinc, the value 0.33 μ g per 100 ml for Indian subjects (Belvady and Gopalan, 1959) is well within the range of 300-500 μ g per 100 ml reported for Swedish subjects (Bergsten, 1952). A cobalt content of 0.60 to 3.20 mg per 100 ml of early milk has been reported (Zizum, 1958), but no basis of comparison is available.

The available data on trace elements in milk may be summarized thus. While the values for zinc and iron reported for Indian subjects compare with those reported for others, there are considerable differences in the copper content.

The greatest amount of variation is observed in the composition of milk with regard to vitamin content. The values for vitamin A range from 70 i.u. per 100 ml in a group of Indian subjects (Belvady and Gopalan, 1959) to 180 i.u. in American subjects (Leshner et al., 1948) and include 133 i.u. and 153 i.u. in German (Gunther and Stanier, 1951) and British subjects (Kon and Mawson, 1950) respectively. The values reported for vitamin D similarly range from 0.4 i.u. to 2.5 i.u. per 100 ml of milk (Van Nickerk, 1933; Harris and Bunker, 1939).

Similar variations with regard to water soluble vitamins have been reported. The studies carried out by Macy and her associates in U.S.A. (1931) and by Kon and Mawson (1950) on British subjects during and immediately after the war are of particular interest as the dietary intake of the subjects was also determined. It is significant that the milk of the subjects in the former who had a superior level of nutrition, was found to contain 46.9 μ g of riboflavin and 5.2 mg ascorbic acid as against the values respectively of 25.5 μ g and 3.2 to 4.0 mg obtained for the latter who had relatively inferior nutritional standards because of war and post war conditions. It is to be noted that studies of German subjects close to the post war period yielded values close to the latter. Belvady and Gopalan (1959) obtained still

lower values viz. 17.2 μ g for riboflavin and 2.6 mg ascorbic acid per 100 ml in poor Indian subjects whose diet was found to be very inadequate. Ramasastri and Indravati (1957) have reported a thiamine content of 12.4 g per 100 ml for Indian women of apparently normal health in a region where endemic beriberi was prevalent. This value compares poorly with the values 14.2 to 19.4 μ g reported in other studies (Kon and Mawson, 1950; Belvady and Gopalan, 1959; Gunther and Stanier, 1951; Roderuck *et al.*, 1945). Similarly, the value of 0.01 to 0.10 μ g per litre for cyanocobalamin in Indian subjects (Srinivasmurthy *et al.*, 1953) is considerably less than 0.32 and 0.41 μ g for French (Karlin, 1958) and American subjects (Collins *et al.*, 1951) respectively.

Values reported for the other vitamins include 203 and 223 μ g for pantothenic acid, (Macy, 1949; Karlin, 1958), pyridoxine (Macy, 1949; Karlin, 1959), 0.38 μ g for biotin, 173 μ g for nicotinic acid, and 0.22 μ g for folic acid (Macy *et al.*, 1950).

While the studies cited above are sufficiently suggestive of a positive relation between dietary and milk vitamin contents, the picture is not so clearcut with regard to constituents such as calcium and protein. If such a relation exists it would be reasonable to expect that dietary supplementation should have a salutary effect on milk composition. From this point of view it would be of

interest to consider the effects of dietary supplementation with regard to different constituents on their milk levels.

The reported effects of dietary protein supplementation on milk protein are not uniform. Ruzicic (1934) found evidence to show that diet had a slight but not statistically significant influence on the protein content of milk. Escudero and Pierangeli (1940-41) found that when dietary protein varied from 1.0-1.5 g to 2-2.5 g per kg. body wt, there was a significant difference in milk protein level from 1.095 g to 1.259 g per 100 ml. On the other hand, Hoobler (1917) while attempting to assess the effect of type and quantities of dietary protein on milk production did not find differences in the former to reflect the protein content of milk. Gopalan (1958) showed that an increase in dietary protein from 61 to 99 g daily did not result in an appreciable increase in the total protein out-put in 24 hours. However, the subjects in their investigation already had an adequate protein intake and the author does not rule out the possibility that beneficial effects may be obtained with subjects subsisting on low levels of protein.

Similar inconsistent results have been reported on the effect of fat supplementation on the fat content of milk. Moll (1908) gave a high fat diet to nursing mothers for a period of 10 days and observed that the fat content of milk was greater when the mother consumed extra dietary fat. Ruzicic (1934) found a similarly high fat content to be

associated with liberal amounts of butter and meat in diet. Deem (1931) supplemented with fat the diet of lactating women who were in established lactation and were secreting 500-1500 ml of milk daily, and found a significant increase in the fat content of milk throughout the experimental period. Consistent with the above observation is that made by Engel (1910) that reducing the fat intake of the mother is accompanied by a decrease in the fat content of milk. On the other hand, Plauchu and Pendu (1911) failed to find any beneficial effect of supplementing the diet with butter fat. Kleiner et al (1928) found no change in the fat content of milk after supplementing the diet with 100 g of cream daily. However, it must be noted that their subjects were already receiving a high fat diet and were in the early days of lactation, which might have obscured the picture. Similarly, Gunther and Stanier (1951) found no significant differences in milk fat between groups supplemented with vitaminized margarine and isocaloric diet and a group receiving no supplementation. Here again, all the three groups were having a more or less adequate diet at the commencement of the experiment.

The effects of calcium supplementation on the calcium content of milk have received considerable attention, but here again the reported results are far from presenting a consistent picture. Herz (1933) noted an increase of 8 to 15

percent in the calcium content of milk by change from calcium poor to calcium rich diet. Hunæus (1909) on the other hand, found calcium supplementation to have no effect on calcium content of milk. Richie (1942) observed that calcium lactate given alone was ineffective, but given along with vitamin D raised milk calcium content by about 25%. The intriguing observation has been made by Gopalan and Belvady (1960) that calcium supplementation at the level of 180 mg daily in the form of calcium gluconate for about 1 to 3 months brought about a fall in the concentration of calcium in milk from an initial value of 41 mg to 25 mg per 100 ml. The conflicting findings may be due to the fact that the effective utilization of calcium depends on the availability of optimal quantities of vitamin D and on adequate circulating plasma proteins(Harter, et al., 1960)

With regard to vitamin A, large doses of the order of 50,000 to 200000 I.U. have been found to produce beneficial effects on milk vitamin A level(Kon and Mawson, 1950; Belvady and Gopalan, 1960; Neuweiler, 1935; With and Friderichsen, 1939). Belvady and Gopalan (1960) using poor Indian subjects, found that even prolonged supplementation at 2,000 i.u. for a period of 40 to 129 days did not produce significant changes in the vitamin content of milk.

The subjects used in the study were in established lactation and their vitamin intake was far below the supplementation level. The authors suggest that the hepatic stores of vitamin A in these mothers might already have been depleted so that the results of such supplementation may not be evident till the same are replenished.

Invariably positive results have been reported for ascorbic acid supplementation. Massive doses of ascorbic acid administered orally (Gashtgens and Werner, 1937; Rangnathan and Sankaran, 1937; Ingalls *et al.*, 1938; Kucerova, 1939) and parenterally (Cutroneo *et al.*, 1955) have been found to increase the milk content of this vitamin. Prolonged supplementation at lower dosage levels has been found to increase milk levels moderately by Kon and Mawson (1950) and to a ceiling level by Traversaro and Quesada (1938). Belvady and Gopalan (1960) increased the level of supplementation gradually and found a dose of 200 mg to be necessary to reach a ceiling level in subjects whose initial intake was low.

With regard to thiamine, although Gunther (1952) found no immediate increase in milk thiamine following oral administration, generally beneficial results have been reported by other investigators (Kon and Mawson, 1950; Neuweiller *et al.*, 1938; Morgan and Haynes, 1939; Iwasaki,

1955; Pechnikova, 1956) Supplementation at 10.15 mg thiamine orally for a few days has been found to increase milk levels by Kon and Mawson (1950), Ramasastry and Indravati (1957) and Morgan and Haynes (1939). In the last mentioned study supplementation at 14 mg was found to be more effective than at 5 mg whereas higher levels resulted in no further increases. On the other hand, Pechnikova (1956) concluded that supplementation at 5-10 mg was ineffective although beneficial effects were obtained with supplementation at 25-30 mg thiamine. However, Belvady and Gopalan (1960) concluded that oral supplementation at 25 mg for short period was no more beneficial than that at 10 mg for prolonged periods. Thus the evidence is far from being clearcut on the usefulness of oral supplementation at small dosage levels. Parenteral administration has been employed effectively by Neuweiler (1938), Iwasaki (1955). The latter demonstrated that intravenous and subcutaneous injections were more beneficial than oral doses in elevating milk vitamin levels.

With regard to riboflavin, Kon and Mawson (1950) and Kalinnikova (1948) found significant increases in the riboflavin levels of milk with oral supplementation the former using 3 mg for two weeks, and the latter 1.8 mg from yeast source for 10 days. Belvady (1962) obtained ceiling levels at a supplementation of 3 mg riboflavin per day.

Blazso and Dubrausky (1943), using parental administration of 6 mg of riboflavin daily, to two groups, one in the first week of lactation and the other in the established lactation, observed beneficial effects only in the latter. Morishima (1955) found oral administration to be less effective than subcutaneous and intravenous administrations.

Supplementation studies with regard to nicotinic acid with different modes of supplementation, have invariably yielded beneficial effects, the dosage levels used ranging from 60 mg to 1.0 mg of Nicotinic acid or its amide (Lwoff, and Morel, 1942; Neuweiler, 1944; Nichele and Rovelli, 1952; Sivieri, 1958; Alt'shuler, 1951). Comparatively few studies have been made on the effects of supplementation with pyridoxine on the milk levels. Massive doses ranging from 50 mg to 1 g were observed to produce significant increases within a few hours although the values were found to return to original levels after 5 to 7 days (Neuweiler and Fischer, 1954; Karlin, 1959). Essentially similar results were obtained with regard to biotin (Neuweiler and Ritter, 1949) and calcium pantothenate (Schmidt, 1950).

Parenteral administration of cyanocobalamine with or without cobalt acetate, has been found to have beneficial effects on milk levels (Karlin, 1954; Burgio et al., 1959). However, oral administration has been found to be less effective (Karlin, 1954; Heinrich, 1954).

Thus the results of the supplementation studies point to the existence of a relation between diet and milk with regard to vitamins, but fail to provide clearcut evidence for such a relation with regard to other constituents such as protein, fat, and calcium.

It is important to consider not only the nutritional qualities of milk, but also its availability in amounts adequate for the infant. Several attempts have been made to determine the factors influencing milk yield. While western investigators do not appear to be in agreement over the period of lactation during which maximum yield is reached and maintained, the maximum yields reported by them are in close agreement, a range of 800-1300 ml in established lactation being generally reported, as against 450-750 ml reported by the Indian investigators (Rao *et al.*; 1959; Gopalan, 1956). The latter, however, report the continued maintenance of lactation for well over a year and the adequacy of the yield for infant requirements. The difference in yield reported by Indian and Western investigators, raise the question as to the effect of nutritional status on milk yield.

Serial changes in average body weight of a group of infants were recorded by Gopalan (1956) who found that actual body weights of poor class Indian infants were lower

than those reported at the 50th percentile for American infants of corresponding age. After the first six months, the divergence between the American and Indian growth curves were found to become progressively more marked. This is not surprising in view of the prevailing methods of infants rearing in this country. Whereas in the western countries a decrease in yield and an increase in infant requirement is accompanied by the introduction of adequate supplementary foods, in India weaning is accompanied by a progressive increase in cereal intake. The chief sources of protein in the adult Indian dietary such as pulses, are often considered difficult to digest by infants and hence not included in any quantity in infant diets. In this connection, Gopalan observed that the best bet against infant malnutrition would be to postpone weaning and prolong lactation as long as possible (Personal discussion).

In order to investigate the effect of diet on milk yield, Deem (1931) subjected a group of 5 subjects to 7 successive diets viz. (i) institution, (ii) high protein, (iii) home, (iv) high protein plus B vitamins, (v) high sugar, (vi) high fat, and (vii) low protein, each lasting for a week. It was found that on institution diet, the milk yield was lower than in any other diet whereas it was found to be maximum under conditions (ii), (iii), and (iv). However,

the
Deem's data have to be considered in the light of possibility
that week's supplementation may be too short a period and
the carry over effects from the previous diet may be
substantial. Nevertheless, the considerable differences in
the milk yield under different conditions broadly indicate
that yield may be influenced by diet. On the otherhand,
Adair (1925) studying four groups of nursing women subsisting
on different diets, viz, high protein, high fat, high
carbohydrate and balanced diets, found that the milk yield
was the same as judged from the amount of milk received by
the baby. However, it must be pointed out that in none of
the groups dietary intake was grossly inadequate and all of
them had atleast adequate calorie intake. Gopalan (1958) found
that an increase in dietary protein from 61 to 99 g daily
for a period of ten days resulted in an appreciable
increase in milk yield in 5 out of 6 subjects studied.
However, a further increase to 114 g was found to have no
effect.

Both the quality and quantity of milk have been found
to vary with the stage of lactation. With regard to the former,
it has been found that colostrum is richer than the mature
milk in several constituents. For instance, the total
protein content in milk has been found to show high values
soon after parturition, register a steady decline thereafter

for two to three weeks and remain fairly steady there after (Kon and Mawson, 1950; Belvady and Gopalan, 1959; Bell, 1928; Widdows et al., 1930; Castellanos and Lizarralde, 1943).

A similar pattern of changes has been observed with regard to lactalbumin, casein, nonprotein nitrogen (Belvady and Gopalan, 1959) and amino acids (Miller and Ruttinger, 1951; Block and Bolling, 1946).

Widdows et al (1935) found about 3 g percent lactose in antenatal and first day secretions, about 7 g percent on the 5th and 7.3 g on the 8th day. A similar trend has been observed by other workers (Woodward, 1897; Escudero and Sola, 1943). If 10 days are accepted as the period of attainment of mature milk, there is no perceptible trend up or down thereafter.

No consistent trend has been observed with regard to variation in the fat content of milk with the progress of lactation. On the one hand Golz (1940), Fox and Gardner (1924), Elsdon (1928), Hytten (1954), and Widdows and Lowenfeld (1933) report increases in milk fat upto a month after parturition. On the other hand, Belvady and Gopalan (1959) report a decline during the same period. The values in both cases were found to be steady by the end of first month.

Similar inconsistent results have been reported with regard to the mineral composition of milk. With regard to

calcium and phosphorus Winikoff (1944) and Widdows et al., (1935) reported a rise in milk calcium and phosphorus levels immediately after parturition, a constant level being reached after 3 days with regard to the former, and by the third month with regard to the latter. The reverse trend, however, has been reported by Belvady and Gopalan (1959).

Magnesium contents have been reported to be high in the early days after parturition and to decrease in the later stages (Belvady and Gopalan, 1959; Macy, 1949; Winikoff, 1944; Schlemmer, et al., 1932).

With regard to trace elements, Lesne and Briskas (1937) and Belvady and Gopalan (1959) report higher levels of copper in milk immediately after parturition which decreased progressively as lactation advanced. The latter have reported similar results with regard to iron which are at variance with those of Kasanen and Ekman (1955).

Colostrum milk has been generally reported to be richer in vitamin A than mature milk (Kon and Mawson, 1950; Belvady and Gopalan, 1959; Leshner et al., 1948).

The ascorbic acid content of milk has been generally found to register an increase during the first few days after parturition and to decline thereafter, the increase being observed within the first 10 days after parturition (Kasahira and Kawashima, 1936; Munks et al., 1945) although Winikoff (1946) reported a continued rise till

the second month. Neuweiler (1935) and Yuceoglu, (1949) however did not find any consistent changes in the ascorbic acid level of milk during lactation. Kon and Mawson (1950) ascribe the disparity in the findings to the possibility that the wide variations in dietary intake of ascorbic acid might obscure the effects of other factors.

The thiamine content of milk is reported to increase for about a month from the commencement of lactation, the value remaining fairly steady thereafter (Kon and Mawson, 1950; Belvady and Gopalan, 1959; Ramasastri and Indravati, 1957; Kendall, 1942; Slater, 1942). The Riboflavin content has been reported to show similar increases (Roderuck et al., 1945, Kon and Mawson, 1950) but observations to the contrary have also been made (Belvady and Gopalan, 1959; Morishima, 1955).

Reports on nicotinic acid levels in milk during the progress of lactation are characterised by the same ~~in~~ inconsistency. Bori (1943), Kawashima (1949), and Alt'shuler (1952) found high levels during the first eight days post partum, followed by a decrease in the later periods. On the other hand, Chanda et al., (1951), Lwoff and Morel (1942), ^{and} Coryell et al. (1947) reported low levels in the first three days, followed by rise to the peak level within the first month and a gradual decrease towards the end of the first month. Pantothenic acid content was found

to increase considerably by the 10th day of lactation (Karlin, 1958; Coryell et al., 1947; Pelligrini and Chiari, 1955).

With regard^t milk yield, the same is reported to be low initially and to increase gradually to a maximum value, by the tenth day according to Escudero and Esquef (1944), and Roderruck et al. (1946), and between 40 and 100 days according to Laurentius (1911), Bodsky (1914), and Kollman (1927). However, both groups report that the yield is maintained at this level for a fairly long period of 3 to 7 months.

Other variables such as age and parity of mother are also found to affect both the yield of milk and its composition with regard to certain constituents. The former has been reported to decrease with increasing age (Strom, 1948; Walker, 1950; Dean, 1951; Hytten, 1954), the age at primary parity being generally believed to influence the establishment and maintenance of lactation (Strom, 1948; Walker, 1950).

Regarding the composition of milk, while total nitrogen (Nimbs et al., 1932; Brown et al., 1932, Devis and Talbot, 1919) and ascorbic acid (Sadevsky, 1939; Simorin and Markov, 1955) have been reported to decrease with the age of the mother, milk fat, vitamin A and carotenoids (Kon and Mawson, 1950) have been reported to increase. ~~Diurnal~~

Diurnal variations in the composition as well as yield of milk have also been reported. The considerable amount of variation in this dimension underlines the need for controlling this factor in any study undertaken on milk composition. The most striking variations have been with regard to fat content which has been found to be about 3 g percent early in the morning and to rise steeply by about 10 a.m. to about 5.5 g percent and to decline steadily thereafter (Denis and Talbot, 1919; Gunther and Stanier, 1951; Hytten, 1954). Slight variations have been reported with regard to vitamin A, thiamine, and ascorbic acid contents of milk (Kon and Mawson, 1950). Similar variations have been reported with regard to milk yield which is found to be a maximum early in the morning and to decrease towards the evenings.

The role of hormones in the induction and maintenance of lactation in both animals and human subjects have engaged the interest of several investigators. Beneficial effects of administering pituitary extracts on milk yield have been reported in the case of human subjects (Kenney and King, 1939; Winson, 1943), and cows (Gruter and Stricker, 1929). Similar beneficial effects of administering thyroid hormones and certain iodinated proteins to cows on milk yield, fat content, and to^acertain extent, on solid

not-fat, have been reported (Graham, 1934; Bartlet et al., 1954; Folley and White, 1936). However, adverse effects on milk yield have been reported in cows as a result of prolonged treatment with pituitary extracts, administration of adrenocorticotropin (Shaw et al., 1955; Flux et al., 1954), and higher doses of estrogens (Folley et al., 1941; Hutton, 1958; Spielman et al., 1941), although this has been found to be associated with a percentage increase in fat content (Sykes et al., 1942; Reece, 1937; Reineke, 1942; Rowland and Thompson, 1949).

The diet of the lactating mother and the nursing and weaning of the infant are influenced to a considerable extent by cultural factors. Belavady et al. (1959) reported the successful maintenance of lactation by poor class women from the Nilgiri Hill tribes subsisting on an inadequate diet as compared to the relative difficulty experienced by upper class women. The former observation underscores the question as to whether, with lactation maintained on a grossly inadequate diet, the quality of milk suffers and a harmful depletion of body reserves takes place.

It will be seen from the foregoing that lactation is influenced by a variety of factors ranging from the cultural and psychological to the hormonal. However, while factors other than diet may influence the utilization of available

X nutrients for the purpose of lactation, the availability of nutrients itself either from diet or body reserves is an essential prerequisite. The problem is of a particular importance in a country such as India where malnutrition is widely prevalent, particularly with regard to protein. The question therefore arises as to whether on an inadequate diet the quality and quantity of milk suffers. If it does, we have the problem of infant malnutrition, whereas if it does not, we shall have to consider the implications for maternal health. Studies were therefore carried out on the quality of milk with regard to proximate principles and essential amino-acids in subjects in and around Barāda. Investigations were made of the relation between dietary intake and milk content of these constituents and the effect of dietary supplementation on the latter. Additional studies were made of variations in milk composition with the progress of lactation. The presence in milk of certain enzymes was also investigated and one of them partially purified and characterised.

This thesis incorporates the studies just outlined.