IMPORTANCE OF MILK AND MILK PRODUCTS IN INDIAN DIET

DISSERTATION

SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
MASTER OF SCIENCE
IN
HUMAN NUTRITION & DIETETICS
TO THE KURUKSHETRA UNIVERSITY, KURUKSHETRA

By

NAVTEJ SINGH

DIVISION OF HUMAN NUTRITION & DIETETICS
NATIONAL DAIRY RESEARCH INSTITUTE
KARNAL (Haryana) INDIA

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TO MY

LOVING PARENTS

Dr. A.D. Deodhar, M.Sc., Ph.D.,
Scientist (S-2)

DIVISION OF HUMAN NUTRITION & DIETETICS
NATIONAL DAIRY RESEARCH INSTITUTE
(I.C.A.R.)
KARNAL (HARYANA)

Dated: 20 APRIL , 1982.

I, hereby, certify that the thesis entitled "IMPORTANCE OF MILK AND MILK PRODUCTS IN INDIAN DIET" submitted in partial fulfilment of the requirement for the Degree of MASTER OF SCIENCE (Dairying) in Human Nutrition & Dietetics to the Kurukshetra University, embodies the result of a bonafide research carried out by Mr. NAVTEJ SINGH for two exclusive trimesters under my guidance and supervision.

A D Deodhar
20/4/82
(A.D. DEODHAR)

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Navtej Singh
(NAVTEJ SINGH) 20 April, 1982

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CHAPTER - I

INTRODUCTION

INTRODUCTION

Being endowed with several nutrients essential for growth, milk is recognised as an almost perfect food. While it is virtually indispensable during early stage of infancy, nutritionists all over the world, have unequivocally advocated reasonable allowance for milk in the balanced diet. However, milk is seldom consumed in its sheer natural form. It is subjected to one or more treatments which influence the nutritional value of milk.

Processing has a great effect on the nutrient composition of milk and its products. Different treatments to which milk is subjected during the preparation of various products, include homogenization, pasteurization, sterilization, heat concentration, fermentation, coagulation etc., and in a way, bring about a change in the nutrient content, further affecting the bioavailability of nutrients.

Heat concentration of milk during khoa as well as kalakand preparation results not only in the concentration of the various constituents, but also promotes the interaction between lactose and lysine of milk, forming a complex, thus rendering lysine unavailable during metabolism. Moreover, the severe heat treatment during roller drying destroys much of the lysine of milk (Hansen, 1955). The heat treatment given to milk during the drying process destabilizes milk proteins (casein as well as whey proteins) by first inducing reversible denaturation followed by irreversible coagulation. Losses of B-vitamins during these treatments range between mild to moderate. Such processing, however, does not alter the characteristics of milk as a good source of calcium and phosphorus.

Effect of fermentation is entirely different. Though the nutritional value of cultured dairy products is largely influenced by the quality of milk used, various treatments during preparation, have significant effect on the nutrients in the products. Thus, while making products like cheese and indigenous product-paneer, majority of water soluble nutrients are lost in whey, whereas water insoluble nutrients get concentrated and are retained in the curd; subsequent fermentative changes produce significant chemical alterations, with the result that the end product assumes distinct nutritional characteristics like better and easy digestibility, better absorption of certain nutrients such as calcium and phosphorus, enhanced level of certain water soluble nutrients, particularly B-vitamins, etc. In the case of products like yoghurt, dahi, etc., these score over other cultured products in that, apart from conserving nutrients in its body (otherwise, lost in the whey) starter cultures used in their preparation synthesise certain compounds during fermentation so that these products assume therapeutic value as well as nutritional significance.

The fat-rich product, ice-cream, contains 3-4 times as much fat, four times as much carbohydrates and 12 to 16 per cent more protein than does milk. This imparts ice-cream much higher calorific value than milk. Furthermore, lactose in ice-cream would favour greater assimilation of calcium content in the diet.

Food is consumed primarily to meet the energy requirements. However, apart from meeting energy requirements, it should also include allowances for all other nutrients. Admittedly, requirements and therefore allowances, are not related strictly to energy in some cases, however, expressing dietary allowances in terms of energy permits a number of useful considerations.

Expressing dietary allowances and nutrient content of food on the same basis of caloric content, makes possible a direct comparison between the two parameters from which quality judgements may be easily drawn. The concept of nutrient density has taken several forms over the years. Nutritive ratio was coined by Henry (1904) to express dietary relationship between nutrients and energy in rations for farm animals. Rose (1934) was one of the first individuals to apply this concept to human dietaries. Since then, nutrient density has been used to underscore the importance of food quality.

Hansen et al. (1978) developed a qualitative and quantitative measure of nutrient to calorie density and termed it "Index of Nutritional Quality (INQ)" which was calculated as the ratio of the per cent of the nutrient requirement supplied by a quantity of food to the per cent of energy requirement supplied by the quantity of food. An INQ value above 1.0 for a nutrient indicates that an amount of a particular food that would satisfy the total energy requirement would also supply more than the required amount of the nutrient. Conversely, each nutrient with an INQ lower than 1.0 would need to be supplemented by other foods or by consumption of the food in excess of the calorie needs.

Despite the great nutritional significance and therapeutic value of milk and dairy products in our diet, they still continue to be markedly below the desired consumption levels. The consumption pattern of fluid milk shows a decline in average consumption of 150 g per day per head in 1951 to 122 g in 1979 in India as against the recommended amount of 200 g (Indian Council of Medical Research, 1968). The reason for this decline is not only the nonavailability of milk but the food habits as well. Milk and milk products which are known to be essential in our diet, particularly in infant diet and also in the diet of other vulnerable groups, their consumption needs an augmentation in the diet for their easier digestibility and better availability of their nutrients in the system.

The effect of processing treatment on the protein quality of khoa when it is subjected to further processing treatment for the preparation of kalakand, has been studied in the present investigation to find out the changes, if any, occurring in the protein quality of kalakand made from khoa.

In the present study, the indices of nutritional quality for milk and milk products in respect of certain nutrients have been computed for subjects belonging to different age groups and physiological status. A relative assessment of the nutritional quality of milk, skim milk powder and commonly consumed cereals, millets and pulses forming the staple food of the Indian population, has also been done in the course of the present study.

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CHAPTER - II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

While inclusion of milk in the diet has been universally accepted, the quantum of consumption of milk by population in different parts of the world has been found to vary markedly. Whereas the consumption of milk in western countries such as United States of America, Canada as well as several European countries has been reported to be remarkably high, that in several developing and under-developed countries was alarmingly low (USA - 665 g, United Kingdom - 600 g, Pakistan - 200 g, India - 108 g and Indonesia - 2 g/caput/day; Gopalan et al., 1971), leading to severe incidences of protein malnutrition among vulnerable segments of the population. Surveys conducted in India by different groups show wide variation in the consumption of milk and milk products in population belonging to different states (7 g - 317 g of milk and milk products/person/day; Gopalan et al., 1971).

These observations were further substantiated by the various workers in Karnal district of Haryana (208 - 365 g milk/head/day; Swaran Lata, 1981), Muzaffarnagar district of Uttar Pradesh (453 g milk/head/day; Singh, 1979), Vijayawada district of Andhra Pradesh (233 g/head/day; Rao, 1976) and Madras city of Tamil Nadu (221 - 268 g/head/day; Prabaharan, 1976). It was apparent from these figures that several factors such as socio-economic status of the subjects, availability of milk as well as its cost, were primarily responsible for such variations in the consumption pattern. Keeping in view the nutritional attributes of various items in different food groups, nutrition experts in India recommended the inclusion of 200 g of milk in the balanced vegetarian Indian diet. However, milk is not merely consumed as fluid milk alone, but adopted in the form of any of its products. Observations made during different surveys further revealed that various indigenous products such as, dahi, butter milk and paneer are adopted to varied extent by the population in different states. Although milk has been recognised as a good source of several nutrients, the processing treatment it undergoes during the preparation of products produces pronounced effects on the nutritional quality of milk (Porter and Rolls, 1973).

Milk is subjected to several treatments before it is consumed in the form of various products or even as fluid milk. These treatments include heat treatment by way of pasteurization, boiling, sterilization, ultra high temperature treatment, dehydration with or without the application of heat, fermentation, homogenization and use of additives. Several studies have been reported on the effect of such treatments on the nutritional quality of milk.

1. Heat Treatment

Pasteurization is usually adopted to eliminate pathogenic bacteria from milk in order to make it safer for consumption. Subjecting milk to heat treatment either at 63°C for 30 minutes

(Holding method of pasteurization) or 72°C for 15 seconds, has been reported to produce mild to moderate losses in respect of heat-labile nutrients.

(a) Protein

The protein contents in cow and buffalo milk have been reported to range from 3.1 - 3.6 per cent and 3.7 - 4.5 per cent, respectively (Rangappa and Achaya, 1971; Gopalan et al., 1980).

A small amount (about 14%) of whey proteins was reported to be denatured during holding method of pasteurization at 143°F for 30 minutes whereas a loss of 30 per cent globulin was observed during bulk pasteurization at 155°F for 30 minutes (Shahani and Sommer, 1951). Heating milk at still higher temperatures of 86 - 88°F for 19 seconds was reported by Budny et al. (1964) to cause much higher denaturation of albumin (55 - 57%).

Shahani and Sommer (1951) observed that pasteurization of milk at 143°F for 30 minutes or at 155°F for 30 minutes caused an increase in the ammonia nitrogen, amino acid nitrogen and protease-peptone fraction.

Boiling of milk is adopted in most of the houses in India once milk is procured. Though such treatment is essential to make milk safe for consumption from hygienic standpoint, such treatment too, was reported to result in a significant denaturation to the extent of 80 - 100 per cent of milk proteins when milk was boiled for durations between 3 to 10 minutes (Samuel, 1937 and Budny et al., 1964).

The denaturation of globulin and beta-lactoglobulin was reported by Langsrud (1968) to be remarkably high during the heating of milk at 140°C for 3-4 seconds. Such a treatment was reported to increase both non-protein nitrogen and protease-peptone content in milk and resulted in the browning of milk.

A destruction of 10 per cent lysine was reported to occur during in-bottle sterilization of milk (122° - 124°C for 20 minutes) while heating milk at 139°C for 15 minutes was reported to cause 15.5 per cent lysine unavailable (Payne-Botha and Bigwood, 1959). As regards other essential amino acids, sterilization of milk was found to cause a loss of 12 per cent of tryptophan (Menden and Cremer, 1956) while 20 minutes heating at 100 - 125°C was reported to cause a progressive loss of lysine (Schober and Prinz, 1956). Ultra-high temperature (140°C for 4 seconds) treatment was reported by Tylkin and Tsaberyabaya (1976) to reduce total essential amino acids in milk to 53.1 g/100 g protein as against 58.2 g in untreated milk samples. The losses were observed to be maximum in the case of lysine (16.3%), cystine (16.0%), glutamic acid (14.9%) and methionine (13.1%).

Despite the changes in the content and availability of certain essential amino acids in heat treated milk, the overall protein quality in terms of biological value was found to remain more or less unchanged in ultra-high temperature (135°C for 2 seconds) treated milk (Henry and Toothil, 1960), though a fall of 6 per cent in the biological value was observed for in-bottle sterilized (110°C for 30 minutes) milk.

The values of modified protein efficiency ratio of repeatedly boiled milk was reported to be 3.01 to 3.03 as compared to 3.27 in the case of pasteurized milk (Parvinder Kaur and Deodhar, 1982). The differences observed were found to be nonsignificant. The trend was further confirmed by measuring the protein-dependent xanthine oxidase activity in liver when protein depleted animals were administered proteins from milk subjected to different heat treatments. Similar observations were made by Cook et al. (1961) and Budny et al. (1964) who failed to observe any significant changes in the biological value of milk protein as well as their digestibility coefficient as a result of heat treatment.

(b) Lactose

The lactose contents in cow and buffalo milk have been reported to vary from 4.4 - 4.6 per cent and 4.4 - 5.0 per cent, respectively (Rangappa and Achaya, 1971; Gopalan et al., 1980).

Relatively little information is available on the effect of heat treatment on the lactose content of milk, though a slight decrease of 4.3 per cent in the lactose content has been observed by pasteurizing milk at 64°C for 30 seconds on 74°C for 15 seconds (Cho and Cho, 1970), showing relatively higher heat stability of lactose.

(c) Fat

Cow and buffalo milk fat contents have been found to range from 3.6 - 4.9 per cent and 6.7 - 8.8 per cent, respectively (Rangappa and Achaya, 1971; Gopalan *et al.*, 1980).

As regards the effect of heat treatment on the fat content of milk, little changes are reported to occur. A slight increase in the fat content during different heat treatments could be attributed to the loss of moisture in variously heat treated milk samples (Pol and Groot, 1961).

While the total fat content has been reported to remain more or less unchanged, a decrease in the essential fatty acids contents was reported to occur to the extent of 34 per cent in the case of linoleic acid, 13 per cent linolenic acid and 7 per cent arachidonic acid (Pol and Groot, 1960).

(d) Minerals

The total ash content in cow/buffalo milk has been reported to be 0.73 - 0.82 g/100 g whereas the contents of various minerals (mg/100 g milk) have been observed by Rangappa and Achaya (1971) and Gopalan et al. (1980) to be as follows:

	Calcium	Phosphorus	Iron	Sodium	Potassium
Cow milk	120	90	0.07-0.20	16-57	140-172
Buffalo milk	149-210	123-130	0.07-0.20	19-47	90-158

As for total ash, the heat treatment during pasteurization and boiling has been reported to cause a loss in the total ash content of milk by 4.4 per cent (Anantakrishnan et al., 1943). Sabarwal and Ganguli (1973) reported an increase of calcium content of cow and buffalo milk caused by boiling and sterilization while the phosphorus content in milk was found to be lowered as a result of sterilization (Sandhu et al., 1973).

(e) Vitamins

The contents of various vitamins (mg/100 g) in cow and buffalo milk have been reported (Hartman and Dryden, 1965; Rangappa and Achaya, 1971; Gopalan et al., 1980) to be as follows:

	Cow milk	Buffalo milk
Vitamin A (I.U./100 g)	160-176	119-160
Thiamine	0.05	0.04-0.05
Riboflavin	0.09-0.19	0.10-0.17
Nicotinic acid	0.10-0.26	0.07-0.10
Folic acid (mcg/100g)	5.6	8.5
Vitamin B_{12}	0.27-0.90	0.28-0.40
Ascorbic acid	1.6-2.3	1.0-1.6

Studies conducted on the effect of heat treatment on the vitamin contents of milk show that water soluble vitamins, particularly vitamin C, thiamine and riboflavin are worst affected during boiling and sterilization of milk.

A loss to the extent of 30 - 35 per cent in vitamin C content was reported by Anagama (1955) during boiling of milk whereas heating at 120°C for 20 minutes was reported to cause a loss of 21.5 per cent of vitamin C (Renner, 1971). During inbottle sterilization, 40-60 per cent of vitamin C was reported to be destroyed (Henry and Kon, 1938; Henry et al., 1944; Pol and Groot, 1960). The destruction of vitamin C has been found to be related to the heat treatment in the presence of oxygen (Renner, 1971).

Chapman et al. (1957) and Ford (1959) found that pasteurisation of milk destroyed about 10 per cent of thiamine whereas Kruglova and Gul'ko (1966) reported a loss of 30 per cent of thiamine during the holding method of pasteurization, though pasteurization by high temperature short time method (HTST) could destroy only 5 per cent of thiamine in milk(Burton et al., 1965). Boiling was reported to reduce thiamine to a very small extent, that is, 4 per cent (Escudero et al., 1943). A loss of 25 - 50 per cent of thiamine was reported to occur during prolonged inbottle sterilization (Henry and Kon, 1938; Houston et al., 1940 and Chapman et al., 1957). During ultra-high temperature (135°C - 140°C for 2 seconds) treatment, the losses in thiamine content were found to range from 3-10 per cent in milk (Chapman et al., 1957; Nagaswa et al., 1960; Gregory et al., 1965; Ford et al., 1968).

As regards riboflavin, a very small loss of 5 per cent was reported during the sterilization (120°C for 20 minutes) of milk (Chapman _et al._, 1957; Ford _et al._, 1959) while a loss of 50 per cent was observed in the case of sterilization of milk at 110° - 120°C for 1 hour (Pol and Groot, 1960). Heating of milk at 140°C - 150°C was found to result in 10 - 30 per cent loss of riboflavin (Gregory _et al._, 1965). The destruction of riboflavin could be attributed more to its exposure to light rather than heat treatment.

Sterilization of milk was reported by Pol and Groot (1960) to cause a loss of 17 - 25 per cent in the vitamin B_6 content. The losses in the content of this vitamin were observed to be 96 and 94 per cent in direct and indirect heating during ultra high temperature treatment of milk (Burton, 1972).

During inbottle sterilization of milk at 110°C, 70 per cent of vitamin B_{12} was found to be lost (Ford _et al._, 1957) whereas at 120°C for 30 minutes, 80 per cent and at 115°C for 15 minutes, 90 - 100 per cent of vitamin B_{12} was reported to be destroyed (Chapman _et al._, 1957 and Ford _et al._, 1959). Burton (1972) reported losses of 96 per cent of vitamin B_{12} and 90 per cent of folic acid during direct and indirect ultra high temperature treatment.

Kruglova and Gul'ko (1968) reported a loss of 10 per cent each of biotin and pantothenic acid and 20 per cent of choline during pasteurization at 65°C for 30 minutes.

The effect of heat treatment on fat soluble vitamins has been reported to be relatively less, though certain studies showed mild to moderate effect of such treatment on the vitamin A content of milk.

Sokolov (1959) reported losses upto 5.5, 4.0 and 2.4 per cent of vitamin A in milk pasteurized at 85°C or 95°C or at 74°C for 10 minutes. Boiling of cow milk for 15 minutes has been reported by Agarwal and Singh (1960) to cause losses of 23.5 per cent and 16.7 per cent of carotene and vitamin A, respectively, whereas in the case of buffalo milk, loss of vitamin A was accounted for 15.1 per cent. Small losses in vitamin A were observed when milk was heated to 110°C - 120°C in continuous flow in a closed vessel (Mastakov and Rossikhina, 1966).

EFFECT OF HEAT TREATMENT ON MILK DURING PRODUCT PREPARATION

(i) Skim Milk Powder

Several milk products are prepared by subjecting milk to heat treatment. Such heat treatment mainly results in the decrease in the moisture content and further concentration of total solids in milk. Skim milk powder is one such product prepared from skim milk either by roller drier or spray drier method. Skim milk is subjected to the heat treatment at 130°C for 3 seconds in the roller drier method or 180°C in spray drier method while preparing the skim milk powder.

The moisture content of skim milk powder has been reported to be around 3 to 4 per cent (Flack, 1976 and Gopalan et al., 1980). While the contents of various nutrients were found to be essentially the same as that in milk when expressed on dry matter basis, a decrease in the contents and availability of certain nutrients is known to occur during the heat treatment meted out to milk in the process of skim milk powder preparation.

(a) Protein

The protein content in skim milk powder has been reported to range from 35.0 - 38.0 per cent (Chandana, 1979 and Gopalan et al., 1980).

A slight decrease in the lysine content has been reported to occur during spray drying process and no difference in its availability from skim milk powder as compared to that from milk has been found (Mauron et al., 1955). The lysine availability from roller dried skim milk powder has been observed to be 86 per cent (Bruel et al., 1972). The available lysine from roller and spray dried milk powder has been reported to be 5.2 g and 7.0 g/100 g protein, respectively (Korolczuk et al., 1976).

Despite a decrease in the content and availability of lysine during the drying process, the biological value has been reported to be 83 - 89 (Swaminathan, 1937 and Sumner, 1938). While Pujol and Arteaga (1972) found the digestibility coefficient of 86.7 and

83.6, net protein utilization of 55.4 and 45.0 and biological value of 63.9 and 54.9, respectively, for proteins of skim milk and skim milk powder, Korolezuk et al. (1976) reported the net protein utilization value 73 and 75 for roller and spray processed skim milk powders. The variation in protein quality as evident from differences in biological value and net protein utilization value, could be attributed to several factors such as, the protein, nutritional status of the experimental animals, their weight, age, the level of protein in the diet, etc., besides differences in the available lysine as a result of different drying processes.

(b) Lactose

Relatively little information is available on the lactose content in milk during skim milk powder preparation. The lactose content in dried milk has been reported to be, by and large, the same as in milk when expressed on dry matter basis.

(c) Minerals

As regards minerals, no appreciable change has been reported to occur in the total ash content and the contents of various minerals have been reported to be more or less the same as in milk when expressed on dry matter basis.

(d) Vitamins

The contents of the various vitamins in skim milk powder have been reported to range from 0.22 - 0.45 mg thiamine, 1.3 - 2.5 mg riboflavin, 0.82 - 1.8 mg niacin, 2.3 - 7.7 mg pantothenic acid, 0.28 - 0.68 mg vitamin B_6, 2.9 - 5.9 mcg folic acid, 2.2 - 4.5 mcg vitamin B_{12} and 5 mg vitamin C per 100 g of milk (Hartman and Dryden, 1965; Gopalan et al., 1980).

(ii) Khoa

Depending on the intensity and duration, heat treatment has been reported to produce mild to moderate changes in the nutritional quality of milk during the preparation of the indigenous product, 'Khoa'.

Heat treatment given to milk (100^{o} - 105^{o}C) during khoa preparation has been reported to decrease the moisture level of milk to 26 per cent (Mani et al., 1955) and increase the total solids to a four-fold concentration (De, 1980).

The protein contents in khoa made from whole buffalo milk and whole cow milk have been reported by Gopalan et al. (1980) to be 14.2 per cent and 20.0 per cent, respectively.

The severe heat treatment to which milk is subjected during the preparation of khoa, is likely to cause the interaction between milk sugar, lactose and amino acid, lysine in protein (Maillard reaction), rendering a part of lysine unavailable for metabolism. Such possibility was substantiated by the determination of protein efficiency ratio (2.3) for khoa (Balasubramanian et al., 1955).

The digestibility coefficient (90) of khoa was found to be significantly, though slightly, low in comparison with milk proteins (Digestibility coefficient - 95; Balasubramanian, 1955).

Although vitamin A is known to be heat stable, the losses of this vitamin have been reported to occur to the extent of 25 per cent while the losses in the vitamin C content were observed to be 42 per cent during khoa preparation (Mani, 1955). Heat treatment has been observed to cause a decrease in the thiamine content in khoa to 36 mcg from 55 mcg/100 g in milk, riboflavin to 67 mcg from 167 mcg/100 g, and nicotinic acid to 63 mcg from 96 mcg/100 ml milk (Mani, 1955).

The contents of vitamin A, thiamine, riboflavin, niacin and ascorbic acid in khoa made from whole cow milk have been reported by Gopalan et al. (1980) to be 497 I.U., 0.23 mg, 0.41 mg, 0.4 mg and 6 mg/100 g, respectively.

Khoa forms the base of several products in which it is further subjected to heat treatment in the presence of additives, such as, sucrose. However, little information is available on the extent of the damage, if any, caused to the various nutrients during the preparation of khoa-based sweet products. The effect of heat treatment on the formation of melanoidines (as a result of Maillard reaction) in conditions similar to those during the preparation of khoa-based sweets, has been reported by Shtal'berg (1965) who observed that the formation of melanoidines in sweetened condensed milk was promoted by invert sugar at high temperatures. These findings were further corroborated by Markh et al. (1974) who found that the extent of browning as a result of Maillard reaction in sweetened condensed milk was intensified at higher temperatures by the hydrolysis of sucrose.

2. Fermentation

The nutritive value of cultured milk products depends on several macro- and micro-nutrients derived from milk and the changes resulted during microbial growth and fermentation process.

(a) Protein

Though the protein quality and content in cultured milk products depend on those of milk, microbial cell protein has been known to build up as a result of the growth of starter bacteria and the free amino acids and peptides released by the proteolytic activities of the microorganisms. The total essential amino acid content in dahi has been reported to vary from 1470 to 2433 mg/100 g, though the amount of essential amino acid contents contributed by the microbial cell protein in dahi has been found to be very small, 2.0 to 6.5 mg/100 g (Shanker and Laxminarayana, 1974; Laxminarayana, 1976). *Lactobacillus acidophilus* and mixed cultures of *Streptococcus thermophilus* and *Lactobacillus bulgaricus* have been reported to score highest in respect of essential amino acids released in dahi (Laxminarayana, 1980).

Studies conducted by Chandan *et al.* (1969) showed that the enzymes of lactic cultures degraded the protein, fat and carbohydrate of milk during fermentation. Poznanski *et al.* (1965) reported the breakdown of casein by the enzyme proteinase in *Lactobacillus bulgaricus* and peptidase in *Streptococcus thermophilus*, whereas Chandan *et al.* (1969) observed a slow irreversible aggregation of whey proteins in milk by the action of lactic cultures.

As regards the free amino acids, these were reported to range from 0.2 - 38.0 mg/100 g of dahi. The highest concentrations and number of the free amino acids, among cultured milk products, were found in dahi prepared with mixed cultures containing *Streptococcus cremoris* and *Streptococcus thermophilus* (Laxminarayana, 1976).

Regarding the protein quality, the biological value of dahi proteins has been reported to be 66 in comparison with 74 of milk proteins (Balasubramanian, 1955) whereas the biological value of yoghurt proteins was found to be higher (87.3) than that of milk proteins (81.4). This increase was attributed to the fermentation of milk (Rasic *et al.*, 1971). The lower biological value of dahi proteins has been assigned to the loss of essential amino acids though their amount was not estimated (Balasubramanian, 1955).

(b) Lactose

As for lactose, lactic acid fermentation occurring during the preparation of cultured milk products is known to result in a decrease in its content due to its partial utilization by the culture organisms.

The lactose content in dahi was reported to be 2.9 per cent as against 4.4 per cent in milk (Mani et al., 1955) whereas a decrease of 20 - 30 per cent of lactose was reported to occur during yoghurt preparation.

(c) Minerals

Little changes are reported to occur in the content of minerals in the cultured milk products during fermentation process. The contents of calcium, phosphorus and iron in dahi have been reported to be 149 mg, 93 mg and 0.2 mg/100 g, respectively (Gopalan et al., 1980), whereas their contents in yoghurt have been found to be 120 mg, 94 mg and 0.04 mg/100 g, respectively (Fleck, 1976 and Chaney et al., 1979).

(d) Vitamins

A slight decrease in the vitamin A content has been reported to occur during the fermentation process in dahi (De and Mazumdar, 1938). As for the vitamins of B group, Mani et al. (1955) observed a slight decrease in the contents of thiamine, riboflavin and nicotinic acid during fermentation, while an increase was observed in respect of thiamine (Brochu et al., 1959; Bambha et al., 1973), folic acid activity and riboflavin content (Nambudripad, 1956) and a decrease was found to occur in the case of nicotinic acid (Chitre and Patwardhan, 1945), pantothenic acid and biotin (Laxminarayana, 1956; Nambudripad, 1956) during fermentation. These findings were further standardized by Reddy et al. (1976) who observed an increase in folic acid content to 3.9 mcg in yoghurt from 0.37 mcg/100 g in milk using Streptococcus thermophilus and Lactobacillus bulgaricus and a decrease in pantothenic acid content from 482 mcg to 380 mcg, biotin from 4.087 mcg to 3.98 mcg and vitamin B_{12} from 0.42 mcg to 0.35 mcg per 100 g in yoghurt (Blanc, 1973).

The contents of the various vitamins in dahi and yoghurt have been reported to be 102 I.U. and 69 - 123 I.U. vitamin A, 0.16 mg and 0.08 - 0.18 mg riboflavin, 0.05 mg and 0.04 mg thiamine, 0.10 mg and 0.8 - 1.9 mg niacin, 1.0 mg and 0.44 mg vitamin C/100 g, respectively (Mani et al., 1965; Hartman and Dryden, 1965; Fleck, 1976; Chaney et al., 1979 and Gopalan et al., 1980) whereas the folic acid content in dahi has been found to be 12.5 mcg/100 g (Gopalan et al., 1980).

3. Ripening

(a) Protein

In view of high protein contents in cheese, several studies have been conducted in respect of the nutritional quality of protein. During ripening of cheese, para-casein has been reported to be liberated from mono- and di-calcium para-caseinate complexes by its breaking down into smaller peptides and amino acids (Kosikowski, 1966). The protein content in processed cheese has been found to vary from 30 - 35 per cent (Fleck, 1976 and Chaney et al., 1979).

As regards the protein quality of cheese, Henry and Kon (1946) reported the biological value of 76 and digestibility coefficient of 98 per cent while net protein utilization has been observed to range from 53 - 64 per cent for different varieties of cheese (Posanski and Siudak, 1971).

(b) Fat

The fat content in cheese has been reported to depend on that of milk used for its preparation (Anonymous, 1973 and Eskhofstork, 1976). Ripening of cheese has been reported to cause no effect on the total fat content (Kosikowski, 1966).

(c) Lactose

As regards lactose content, a large portion of it present in milk is lost in the whey during the coagulation of milk. The small amount of lactose entrapped in the curd has been reported to be further utilized by starter culture during ripening.

(d) Minerals

Almost 20 per cent of milk calcium and 70 per cent of milk phosphorus have been observed to be retained in the curd while water soluble salts of potassium, sodium and magnesium have been reported to be removed in whey (Kosikowski, 1966). During ripening, calcium from mono- and di-calcium para-caseinate is known to be solubilised by lactic acid.

The contents of calcium, phosphorus and iron in processed cheese have been reported to vary from 621 - 790 mg, 520 - 753 mg and 0.35 - 2.1 mg, respectively (Fleck, 1976; Chaney et al., 1979 and Gopalan et al., 1980).

(e) Vitamins

Changes in the vitamin contents in cheese occur primarily at the stages of separation of whey and ripening of cheese. During the preparation of cheese, about 22 per cent nicotinic acid, 19 per cent vitamin B_6, 27 per cent pantothenic acid and 10 per cent biotin have been reported to be retained in curd (Nilson et al., 1963), whereas Kon (1972) found that most of vitamin A, 25 per cent of riboflavin and about 16 per cent of thiamine remained in the curd.

The total riboflavin content was observed to decrease from 0.339 mg/100 g to 0.188 mg/100 g during ripening of cheese (Gregory, 1975), while free riboflavin was found to increase during ripening, and vitamin B_1 content was reported to increase from 20 to 80 per cent. Similar increase was found to occur in respect of folic acid during the ripening of cheese (Gregory, 1975). This was attributed to the synthesis of these vitamins during ripening.

The contents of the various vitamins in processed cheddar cheese have been reported to be 1214 - 1705 I.U. vitamin A, 0.02 mg thiamine, 0.35 - 0.46 mg riboflavin, 0.08 - 0.1 mg niacin, 0.43 - 0.79 mg pantothenic acid, 7.8 - 10.0 mcg folic acid and 0.8 mcg vitamin B_6/100 g (Hartman and Dryden, 1965; Fleck, 1976 and Chaney et al., 1979).

4. Coagulation

During coagulation of milk solids with citric acid while preparing paneer, protein and fat are known to be concentrated in the curd. While a part of lactose is removed in whey, the remainder is trapped in the curd.

Relatively little information is available on the changes in the nutrient content of milk during the preparations of paneer. Protein content in buffalo milk paneer and cow milk paneer has been reported to be 18.5 per cent and 15.2 per cent, respectively. While protein efficiency ratio, biological value, digestibility coefficient and net protein utilization of buffalo milk paneer were reported to be 3.4, 86, 96 and 83, respectively, values for these parameters for paneer made from cow milk were found to be 2.5, 81.8, 95.5 and 78.2, respectively (Soni, 1979).

Fat contents of 24 per cent and 10 per cent have been reported to be in the buffalo milk paneer and cow milk paneer, respectively, whereas the total ash contents were found to be 1.6 per cent and 1.0 per cent, respectively for the two types of paneer (Soni, 1979). Little is, however, known about the mineral and vitamin contents of paneer, and warrants further studies.

Nutrient Density and Index of Nutritional Quality

Until recent years, data on the nutrient contents in milk and various milk products are expressed on the basis of total weight or dry matter. However, such information serves only limited purpose while formulating a balanced diet since the calorie contents in these products vastly differ. This could be seen from about 60 Kcal energy content in 100 g of cow milk to over 370 Kcal in respect of 100 g of cheese. It is well conceived that the primary function of the food is to provide energy. However, it also has to meet nutritional needs in respect of several other nutrients. Attempts have been made in the recent years to express these data on the basis of their calorie contents and the concept of nutrient density was tossed by Hansen (1973). On further extrapolating this concept, Hansen et al. (1978) proposed that consideration for nutritional requirements together with that for energy, while assessing the nutritional worth of any product, would be more meaningful and suggested the computation of ratio, "Index of Nutritional Quality" for different food items.

Lofgren and Speckmann (1979) worked out indices of nutritional quality in respect of several animal products popular in an average American diet to stress their importance. They reported these indices in respect of milk, skim milk, plain yoghurt and cheddar cheese with a particular emphasis on nutrients, such as, protein, vitamin A, thiamine, riboflavin, ascorbic acid, nicotinic acid, calcium and iron. It was observed that, by and large, barring ascorbic acid, iron and nicotinic acid, milk products could be recognised as good sources for other nutrients, since their indices were above 1.0. It was further observed that skim milk was, by and large, far better than other products whereas ice cream, a dairy product, was good only in respect of riboflavin and calcium and other products such as plain yoghurt, cheddar cheese and milk falling in between.

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CHAPTER - III

MATERIALS AND METHODS

MATERIALS AND METHODS

Milk and its various indigenous products adopted in Indian dietary habits represent variety of treatments to which milk is subjected before it is consumed. The profile of milk products is fairly large. The products selected in this investigation have been so chosen as to assess the impact of different processing treatments on the contribution of milk towards meeting the nutritional requirements. These products are:

I. Fluid Milk

1. Cow milk
2. Buffalo milk.

II. Heat-treated Milk Products

1. Skim milk powder
2. Khoa
3. Kalakand.

III. Cultured Milk Products

1. Dahi
2. Yoghurt
3. Processed cheese.

IV. Fat-rich Milk Products

1. Ice-cream
2. Paneer.

Cow/Buffalo Milk

Pooled samples of raw cow and buffalo milk were obtained from the cattleyard of National Dairy Research Institute, Karnal at about 6.00 AM. Milk samples were pasteurized by heating at 63°C for 30 minutes. On cooling, these were stored in the refrigerator at 4°C until used for analysis.

Skim Milk Powder

It was prepared by roller drier method from skim milk standardized to 20 per cent solid-not-fat content. The heat treatment given to skim milk was 130°C for 3 seconds during drying.

Khoa

Buffalo milk was standardised with solid-not-fat and fat in the ratio of 1.4:1 for the preparation of khoa. It was prepared in a double jacketed stainless steel kettle, as described by De and Ray (1952). Milk was heated with the help of steam in the kettle at 2 kg/cm^2 steam pressure, stirring and scrapping with a scrapper continuously throughout the boiling process to avoid charring of milk. The heating was controlled by reducing steam pressure when milk attained a pasty consistency. The temperature at this stage was lowered to 82° - 85°C until khoa pat is formed.

Dahi

Buffalo milk containing 5 per cent fat and 9 per cent solid-not-fat was inoculated with the dahi culture "LF-40"

(Streptococcus lactis, Streptococcus cremoris and Streptococcus diacetilactis and incubated at 22°C for 24 hours.

Yoghurt (Sweetened)

It was prepared from the buffalo milk standardized to 5 per cent fat. Total solid content was standardized to 22 per cent with about 6 per cent sugar. The milk was inoculated with the culture of Lactobacillus bulgaricus and Streptococcus thermophilus and incubated at 42°C for 3½ hours.

Processed Cheese

Processed cheese was prepared by mixing and blending 60 per cent of young cheddar cheese (aged 1 - 3 months) and 40 per cent of old cheddar cheese (aged 6 - 9 months) and heated to 70° - 75°C. Emulsifier at the rate of 2.5 per cent was added.

Cheddar cheese was prepared from cow milk with casein and fat standardised in the ratio of 0.7:1. The temperature of the milk was kept at 30°C when lactic acid culture (Streptococcus lactis and Streptococcus cremoris) was added at the rate of 1 per cent. The acidity of the milk increased by 0.02 per cent. One hour after inoculation, calf rennet was added to this at the rate of 2.5 g/100 litres of milk. At this stage, cooking at 39°C was done for half an hour when the acidity further increased by 0.02 per cent. The whey separated during coagulation while cooking, was drained off and cheddaring of curd was done. Acidity increase in this process was 0.4 per cent. This was followed by milling, hooping, pressing and aging of cheese in cold storage at 10°C.

Ice-Cream

Ice cream mix was prepared from cream, skim milk and skim milk powder and was standardized to 12 per cent fat and 12 per cent solid-not-fat. Fifteen per cent sugar was added to it. This mix was preheated to 70°C and stabilizer was added to it at the rate of 0.3 per cent. The mix was homogenized in a double stage homogenizer (first phase 2000 psi, second stage 500 psi), and was pasteurized by heating to 90°C (no holding) and immediately cooling to 8°C. It was kept overnight in cold storage for aging. Next day, the mix was frozen and 100 per cent air was incorporated into it.

Paneer

Buffalo milk with fat and solid-not-fat standardized in the ratio of 1:1.6, was heated to 85°C and cooled to 70°C. Citric acid at the rate of 0.2 per cent was added to milk. The coagulated curd particles were pressed and cooled to 15 - 20°C.

Three samples each of milk (cow/buffalo) and milk products were taken for analysis.

Determination of Moisture Content

Moisture was determined according to the method described in AOAC (1980) by finding the weight of a product before and after drying in an oven maintained at a temperature of 100°C. The difference in weights gave the moisture content in the sample.

Procedure

Five grams of sample in the case of milk and three grams in respect of different milk products, were separately weighed in aluminium metal dishes. These were heated in a hot air oven maintained at a temperature of 100°C for three hours. The metal dishes were, then, transferred to a desiccator, allowed to cool to room temperature, and weighed. The process of drying and cooling was repeated till a constant weight was obtained.

Determination of Proximate Principles

The following constituents, namely protein, fat, total carbohydrates and total ash were determined as described below:

Determination of Protein

Protein content in the samples was determined as per micro-Kjeldahl digestion and distillation method described in AOAC (1980).

Procedure

Five millilitre of milk samples/one gram of products under study, was weighed accurately and digested with the aid of a pinch of catalyst mixture (potassium sulphate, copper sulphate and selenium dioxide in the ratio of 40:8:1) and 10 ml of concentrated sulphuric acid in a digestion flask. The known amount of digest, after appropriate dilution, was transferred to the vacuum-jacketed flask of the micro-kjeldahl apparatus and ammonia was liberated by the addition of 20 ml of sodium hydroxide solution (40%). The liberated ammonia was distilled off and trapped in 20 ml of boric acid (4%) and finally determined by titration against 0.02 N sulphuric acid using mixed indicator (methylene blue and methyl red).

Calculation

The protein content was calculated as under:

$$\text{Protein \%} = \frac{\underset{\text{(titre value)}}{\text{ml of 0.02N } H_2SO_4} \times 0.00028 \times \underset{\text{factor}}{\text{Dilution}} \times 6.38 \times 100}{\text{Wt. of sample (g)}}$$

Determination of Fat

Fat content in milk and milk products was determined according to Gerber's method described in British Standards (1955).

Procedure

Samples of processed cheese and paneer were shredded uniformly and three grams of the shredded sample of the products was taken in the cheese butyrometer cup. Ten ml of Gerber acid (sulphuric acid, sp. gr. 1.815 $\pm$ 0.002 g at 20°C) was added to it followed by the addition of one ml of isoamyl alcohol. On uniformly mixing, it was centrifuged at 1,000 rpm for twenty minutes. The fat content in the products was noted by direct reading the fat level on the butyrometer scale.

In the case of cow and buffalo milk samples, 10.75 ml of milk and the same quantity of diluted samples of skim milk powder, dahi and yoghurt (10 g in 100 ml of water) were subjected to the same treatment as described earlier and the fat content was recorded on the milk butyrometer scale.

Estimation of Ash

It was done as described in ISI Bulletin (1967).

Procedure

Twenty ml sample in the case of buffalo and cow milk and five gram sample in the case of skim milk powder, processed cheese, paneer, dahi, yoghurt and ice-cream were ashed separately in sintered crucibles in muffle furnace maintained at 550°C for three hours. The weight of ash residues were noted to find the total ash content.

Estimation of Total Carbohydrates

Total carbohydrates were estimated according to Lane-Eynon method (1973).

Preparation of Samples

Forty grams of well mixed samples of milk/milk products was dissolved in about 50 ml of hot water (80° - 90°C), mixed it and 5 ml of dilute ammonia solution (10%) was added to it. This was allowed to stand for 15 minutes and exact equivalent of dilute acetic acid (10%) was added to it to neutralize the ammonia added. With gentle mixing, added 12.5 ml of zinc acetate solution (21.9%) and 12.5 ml of potassium ferrocyanide solution (10.6%). The contents were brought to a temperature of 27°C and the volume was made to 200 ml, and filtered through Whatman No. 4 filter paper.

(a) Reducing Sugars

The filtrate obtained above was taken in burette and titrated against 10 ml mixed Fehling solution (Fehling solutions A and B). When reddish tinge colour was obtained, the contents of the flask were boiled and 1 ml of methylene blue indicator (0.2%) was added to it. While the contents of the flask still boiling, more of the sample solution was added from the burette till the colour of the solution in the flask changed from blue to brick red. The volume of the sample solution used in titration was noted.

(b) Sucrose

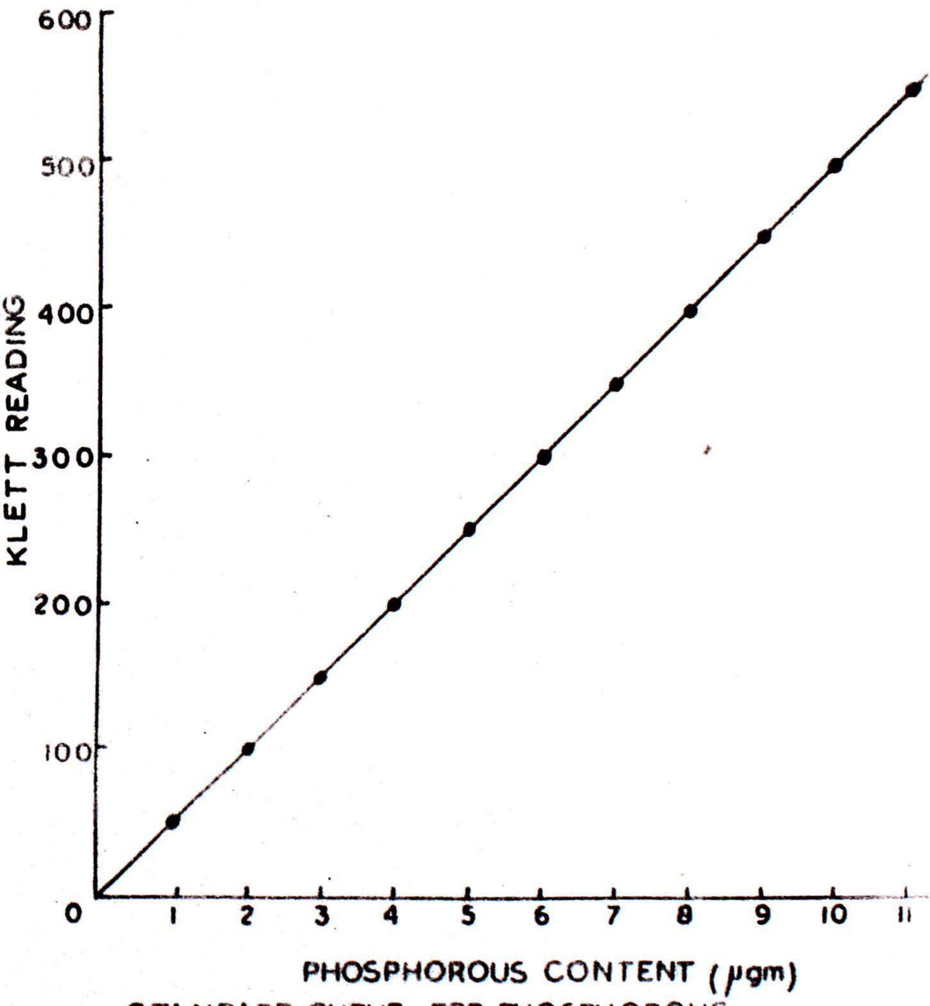
In the case of ice cream, yoghurt and kalakand, 50 ml of the filtrate (obtained above) was pipetted in a 100 ml volumetric flask and 5 ml of hydrochloric acid (sp. gr. 1.16) was added to it. Immersed for 15 minutes the entire bulb of the flask in a water bath maintained at 68°C, mixing by rotary movements. Cooled the contents of the flask to room temperature and neutralized with alkali solution. The solution was diluted sufficiently with water. The well mixed diluted sample solution was titrated against 10 ml of Fehling solution as described in case of reducing sugars estimation.

Estimation of Minerals

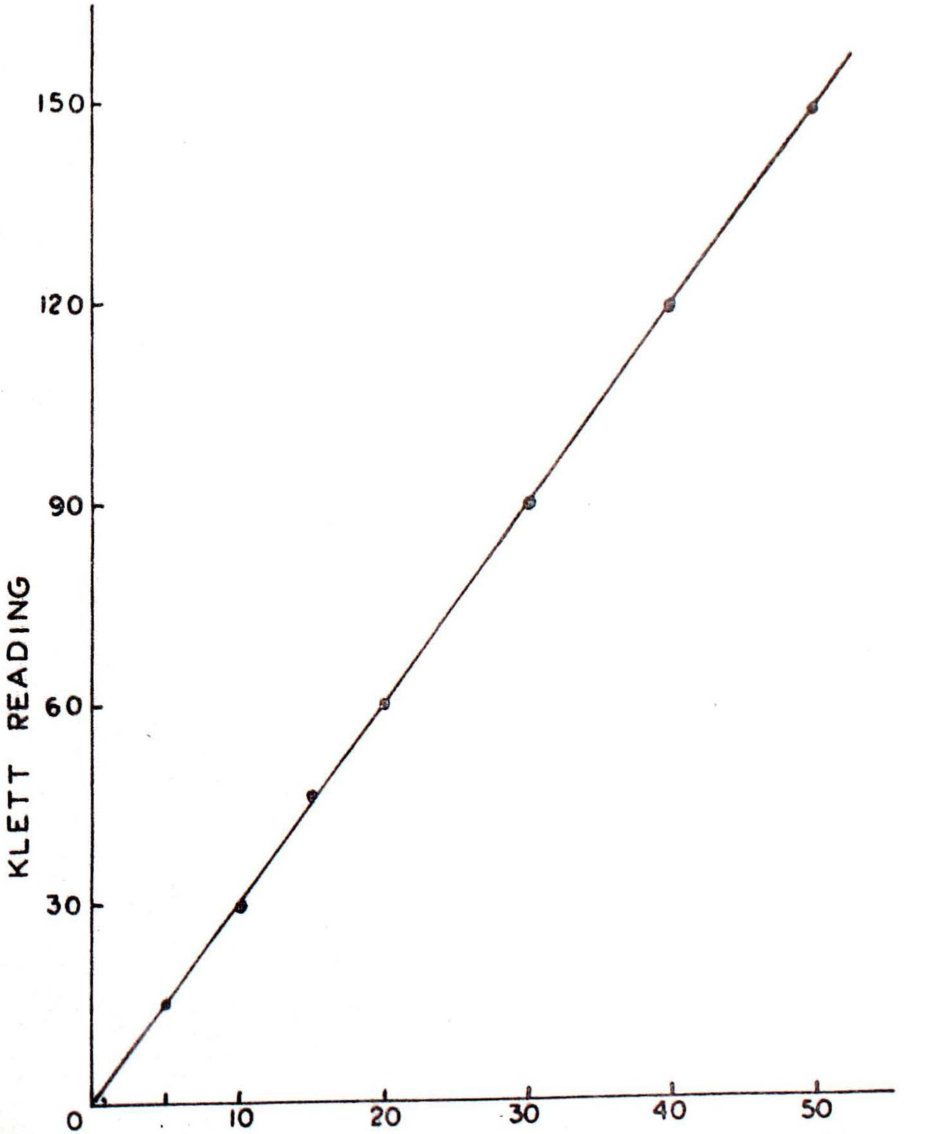
(a) Calcium

Calcium was estimated according to Davis and White method (1962).

One gram sample of milk products and 5 ml sample of milk was digested with 15 ml of triacid mixture (nitric acid, sulphuric acid and perchloric acid in the ratio of 9:3:1) by heating, and volume was made to 50 ml with water. To 2.5 ml of diluted sample, 1 ml of ammonium oxalate (4%) was added with a drop of methyl red. The solution was made alkaline by adding dropwise NaOH solution (2%) till pale yellow colour appeared. This was followed by the addition of HCl (1 N) till the solution again became pink. The tubes were kept at room temperature for three hours and centrifuged at 1400 rpm for 10 minutes. Precipitates, thus obtained, were dissolved in 0.5 ml of 1N HCl and transferred to a titration flask. One ml of EDTA solution (0.05 M) and 1 ml of NH_4OH-NH_4Cl buffer was added to it and titrated against magnesium acetate solution (0.015 M) using two drops of Eriochrome black T indicator till the colour changed from blue to violet. For blank, 1 ml of EDTA was titrated against magnesium acetate after adding 1 ml of buffer and 2 drops of indicator.



STANDARD CURVE FOR PHOSPHOROUS



STANDARD CURVE FOR IRON

(b) Phosphorus

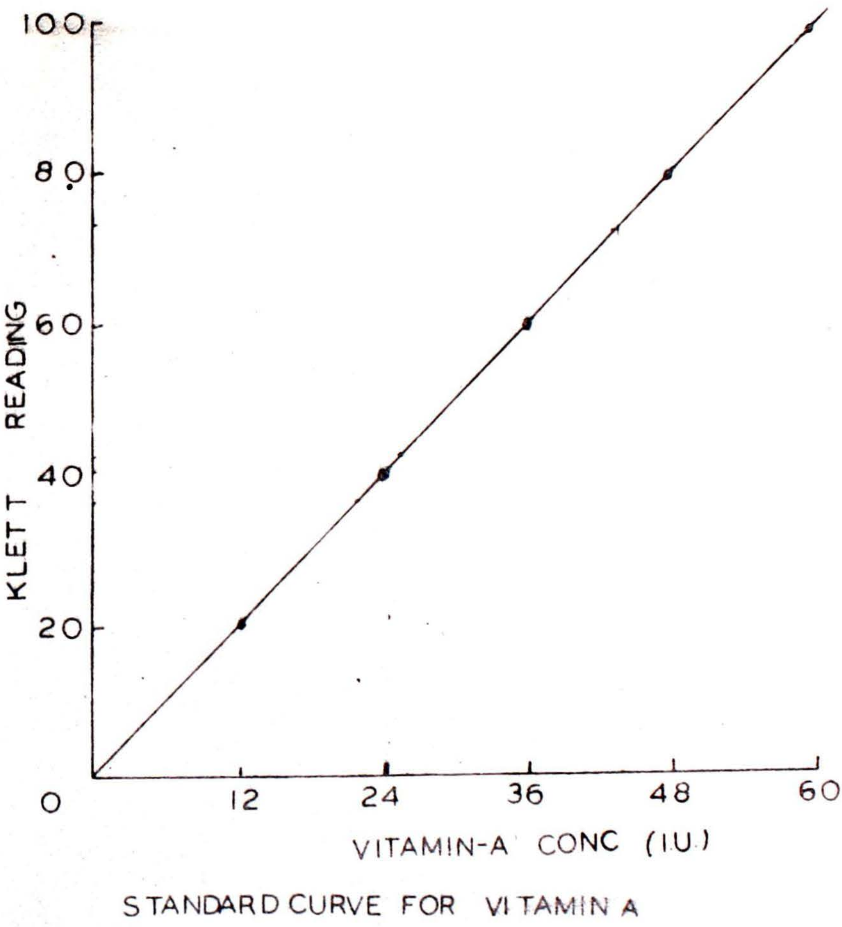
Samples were analysed for phosphorus according to the method described by Ahovocova and Odavic (1969).

Samples of milk and milk products were digested as in the case of calcium estimation and diluted to 50 ml with water. Aliquots of diluted samples containing 1 mcg - 10 mcg phosphorus were taken in different tubes and volume was made to 4.0 ml with water in each of the tubes. One ml of colour reagent (containing 3.5 g sodium molybdate, 200 mg hydrazine sulphate and 50 ml of conc. H_2SO_4 in 500 ml of water) was added to all the tubes. After keeping the tubes in boiling water bath for half an hour, the blue colour of phosphomolybdic acid formed, was measured in Klett Summerson colorimeter at 640 nm with red filter.

(c) Iron

The method described by Vogel (1970) was used for the estimation of iron with slight modifications as described below:

Twenty five ml samples of milk and 5 g samples of milk products was ashed in muffle furnace by heating at 550°C for three hours. The ash was dissolved in 5 ml HCl (1:1). It was boiled for 5 minutes to ensure complete dissolution and volume was adjusted to 50 ml after adding 1 ml of NH_4OH. Different aliquots of diluted samples containing 5 mcg - 35 mcg phosphorus were taken in a series of tubes and volume was made to 10 ml with water. Two ml of Na_2SO_3



STANDARD CURVE FOR VITAMIN A

solution (3%) was added to each tube followed by the addition of acetate buffer (pH 4.0) and 1,10 phenanthraline (0.33%). After incubating the tubes at 60°C for 60 minutes, the orange red colour developed was measured in Klett Summerson colorimeter at 540 nm.

Estimation of Vitamins

(a) Vitamin A

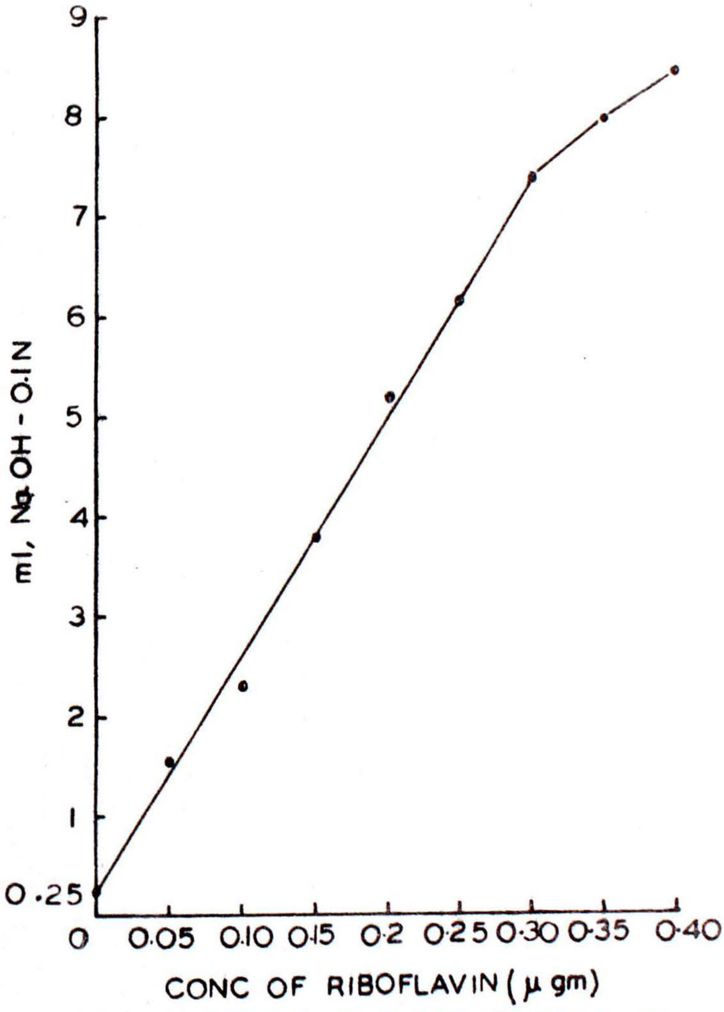
The method described by Carr-Price (1926) was adopted for the estimation of vitamin A in the samples.

Twenty gram samples of milk products and 100 ml milk samples were saponified with 50 ml of ethanol and 7 ml of KOH (50%) for 40 minutes. On cooling, it was extracted with 30 ml water and 50 ml portions of diethyl ether. The aqueous layer was extracted thrice with 50 ml of ether using each time. Ethereal layers were pooled and washed with water till it was alkali free (tested with phenolphthalein as an external indicator). After passing through sodium sulphate, the ethereal layer was evaporated till a residue was obtained. The residue was dissolved in 5 ml of chloroform.

Aliquots containing 12 mcg - 60 mcg of vitamin A were taken and volume was made to 2 ml with chloroform. Four ml of $SbCl_3$ solution was added and colour intensity was instantly measured in Klett Summerson photoelectric colorimeter at 620 nm.

(b) Riboflavin

Riboflavin in samples was estimated microbiologically as described by Snell and Strong (1939) using Lactobacillus casei (ATCC 7469) as a test organism.



STANDARD CURVE FOR RIBOFLAVIN

Preparation of Samples

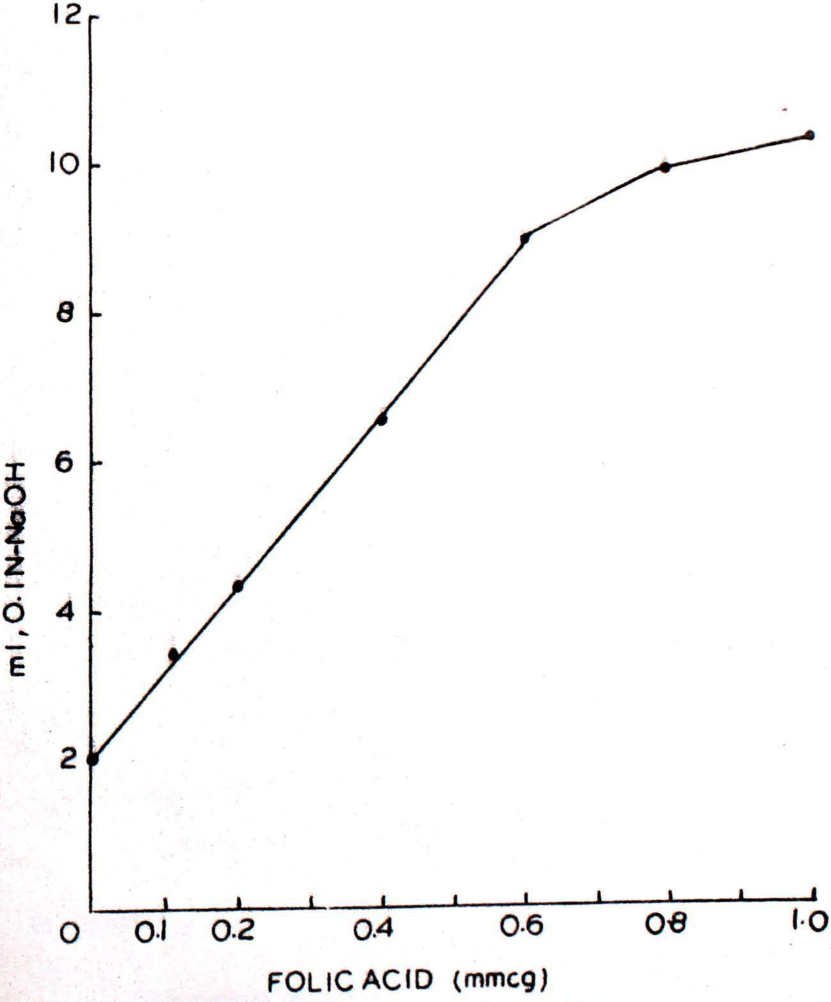
Fat from five ml of milk samples and one gram sample of milk products was extracted according to Rose-Gottlieb method (1959). The samples were treated with 30 ml of a mixture of ethanol and disthyl ether (1:3). The defatted samples were further hydrolysed with 30 ml of HCl (0.1N) and 5 ml of sodium acetate (2.5 M) by autoclaving at 15 lb pressure for 15 minutes. The pH was adjusted to 4.5 after cooling and hydrolysate was filtered. The pH of the filtrate was again adjusted to 6.8 and was suitably diluted so that concentration of riboflavin was 0.1 mcg/ml.

Different aliquots of the sample were pipetted in a series of tubes each containing 5 ml of basal medium. The volume of the solutions in each tube was made to 10 ml with water. The tubes were sterilized and inoculated with the culture of L. casei.

After 72 hours of incubation at 37°C, the growth response was measured titrimetrically with 0.1N NaOH using bromothymol blue as the indicator.

(c) Folic Acid

Folic acid content in the samples was determined microbiologically using Streptococcus faecalis (ATCC 8043) as test organism as described by Freed (1966).



STANDARD CURVE FORFOLIC ACID

Preparation of Samples

Five ml samples of milk and 2 g samples of milk products were defatted according to Rose-Gottlieb method (1959) as described earlier.

Defatted samples were dissolved in 10 ml of HCl (0.1N) and pH was adjusted to 2.0. Folic acid was liberated enzymatically by the action of pepsin and trypsin as described by Ford (1973).

Thirty mg of pepsin (SD's Lab. Chem. Industry, 1:3000) was added to the samples and kept for incubation at 37°C for two hours. Fifty mg of calcium chloride was added and pH was adjusted to 7.2 and 30 ml of water and 32 mg of trypsin (Merck, 2000 units/g) were added. This was followed by another incubation at 37°C for two hours. The pH of the digest was, then, adjusted to 4.6, filtered, and again adjusted to 6.8 pH. This was diluted to 100 ml with water so that the concentration of folic acid was 2 mcg/ml.

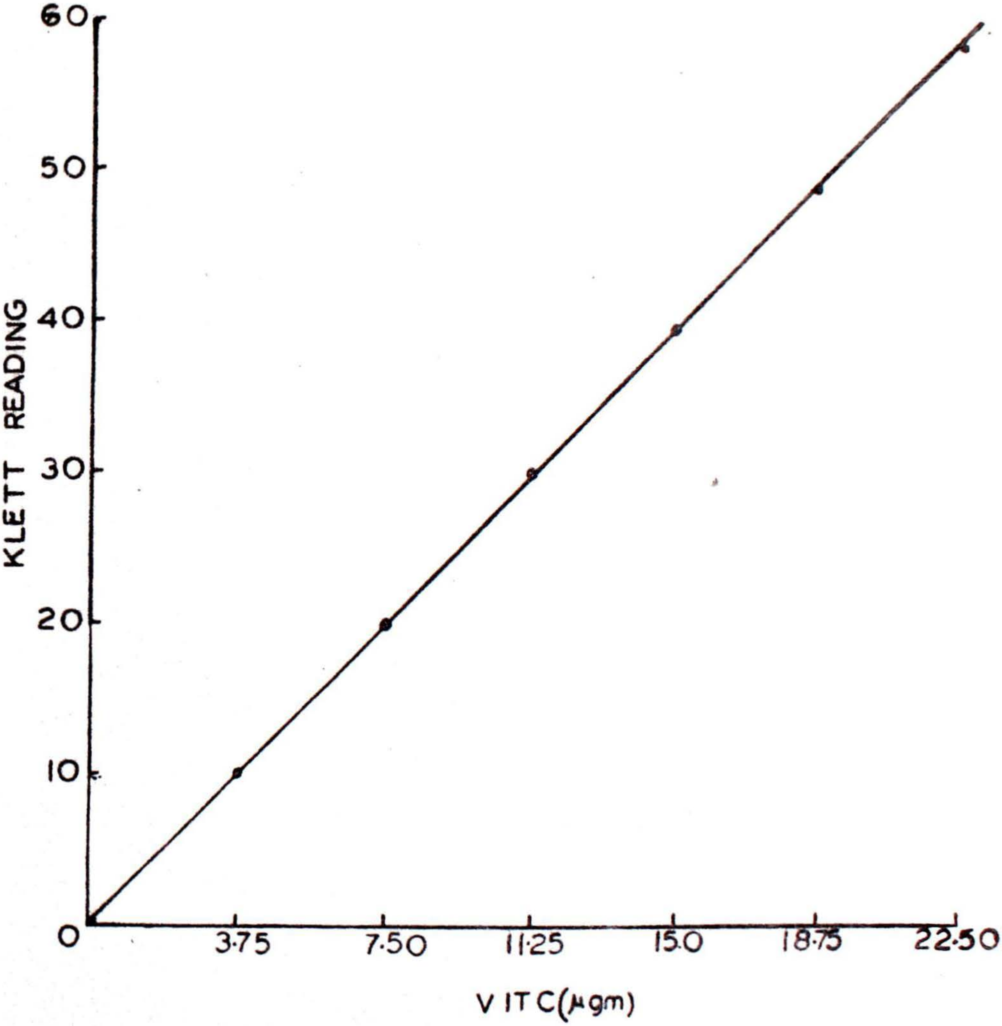
The growth response was measured titrimetrically with NaOH (0.1N) using bromothymol blue as the indicator.

(d) Vitamin C

The method described by Roe and Kuether (1943) was adopted for vitamin C estimation.

Preparation of Samples

Ten ml samples of milk and 2 g samples each of skim milk powder and ice cream, 5 g of paneer and 10 g each of dahi and



STANDARD CURVE FOR VITAMIN'C'

yoghurt were suspended in trichloroacetic acid (6%) and volume was made to 25 ml. After allowing to stand for about 30 minutes, 0.5 g of activated charcoal was added to it to convert reduced form of ascorbic acid to its oxidized (dehydro) form. The sample size taken for different products differed, depending on the extent of retention in these products.

Aliquots of the samples containing 3 mcg to 22 mcg vitamin C were taken in a series of tubes and volume made to 4.0 ml. One drop of thiourea (10%) was added to each tube followed by the addition of 2,4 dinitrophenyl hydrazine (2%). The tubes were incubated at 37°C in water bath for three hours and 5 ml conc. H_2SO_4 (85%) was added to each tube. The colour intensity developed was measured in colorimeter at 540 nm.

<u>Determination of Protein Efficiency Ratio and Net Protein Ratio</u>

The protein efficiency ratio for khoa and kalakand was determined according to the procedure described in AOAC (1980).

Weanling albino rats of either sex weighing 35 - 45 g were obtained from the animal house of the Institute and divided in three groups, each having equal number of male and female rats. The average body weight of rats in a group was 40.3 g.

The animals were housed individually in anodised aluminium cages and fed <u>ad libitum</u> test protein diets providing 10 per cent protein (Table 1) for a period of 28 days. The animals had free access to water. The daily intake of food was recorded individually and the rats were weighed once a week. In order to calculate net protein ratio (Bender and Doell, 1957), a group of eight animals, identical in body weight with the test group, was maintained on a protein-free diet (Eggum and Jacobson, 1976).

Table 1: Composition of Test Protein and Protein Free Diets.

Ingredients (g)	Test protein (Khoa/Kalakand) diet	Control (casein) diet	Protein free diet
Protein	10.0	10.0	-
Sucrose	-	-	9.0
Fat (oil)	-	12.0	12.0
Cellulose	1.0	1.0	1.0
Vitamin mixture*	1.0	1.0	1.0
Salt mixture*	4.0	4.0	4.0
Starch	Rest to make 100	Rest to make 100	Rest to make 100

* AOAC (1980).

Protein efficiency ratio and net protein ratio were calculated from the formulae:

$$PER = \frac{\text{Gain in body wt. (g)}}{\text{Protein intake (g)}} = \text{Gain in wt. per g protein intake.}$$

$$NPR = \frac{\text{Gain in wt. (g) of the test group + Loss in wt. (g) for the non-protein group}}{\text{Protein intake (g)}}$$

Statistical Analysis

The data obtained on protein efficiency ratio and net protein ratio were subjected to statistical analysis to verify the trends that were observed from the results and to ascertain if the difference between the khoa and kalakand proteins was significant. This was done according to randomised block design as suggested by Cochran and Cox (1957).

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CHAPTER - IV

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

1. Changes in the Protein Quality of Khoa During the Preparation of Kalakand

As mentioned time and again, milk contains abundant quantities of several nutrients. However, various processing treatments, particularly those involving heating of milk, influence its nutritional value. The important one among such changes is the interaction between milk sugar, lactose and epsilon amino group of lysine in proteins, generally known as Maillard reaction. Little is known, however, about the extent of such damage in respect of several indigenous milk products. Quite a few of these products constitute major ingredients of many other products. Khoa is one such product which is further subjected to heat treatment in the presence of additives, such as sugar during the preparation of kalakand. Changes in the nutritional characteristics of such products are little understood. Such changes would appear possible in the light of observations by Hurrell and Carpenter (1974) that heating of albumin with sucrose in the presence of 15 per cent moisture content at 121°C for 1 and 2 hours, markedly lowered the levels of reactive lysine.

An experiment was, therefore, conducted to study the nutritional quality of proteins in khoa and sweet product, 'kalakand' made from it, in respect of their growth promoting abilities in weanling albino rats. Data obtained on the protein efficiency ratio (PER) and net protein ratio (NPR) are presented in Tables 2 and 3.

It was observed that PER for khoa (average PER = 2.38) was significantly less than ($P < 0.01$) that for control diet containing casein (Average PER = 2.8). The PER for kalakand (Average PER = 2.19) was also found to be slightly, but significantly, lower than that for khoa (Table 2A). Protein efficiency ratio of the group receiving khoa based diet in the present study was found to compare well with the ratio 2.3 reported by Balasubramanian et al. (1955). A very small, though statistically significant, decrease in the PER value for kalakand, in comparison with khoa, suggested that the other processing conditions like temperature and duration for the preparation were not conducive to produce the inversion of the added sugar to reducing sugars, though the moisture levels were considerably higher in khoa (about 33%), with the result that PER values failed to decrease. This was evident from data on the sugar concentration in khoa and kalakand (Table 1). It was apparent that there was practically no conversion of added sugar.

Apart from this consideration, the optimal conditions of duration and intensity of the heat applied for optimal Maillard reaction were not attained so as to render significant portion of lysine from milk proteins unavailable.

A comparison of PER for khoa and casein showed that the values for khoa (as well as kalakand) were significantly lower than

Table 1: Proximate Principles in Khoa and Kalakand.

Product	Moisture g/100g	Protein g/100 g	Fat g/100 g	Total carbohydrates			Food energy calories/ 100 g	Total ash g/100 g
				Reducing sugars g/100 g	Reducing sugars g/100 g dry matter	Sucrose g/100 g		
Khoa	33.6	13.6	26.3	24.2	36.4	-	361	3.5
Kalakand	24.2	10.8	20.4	19.2	25.3	22.5	394	2.8

The values are average of three samples.

Table 2: Protein Efficiency Ratio (PER) for Diets Based on Khoa and Kalakand.

Type of diet	Average initial body weight (g)	Average final body weight after 28 days (g)	Gain in body wt. in 28 days (g)	Average protein intake in 28 days (g)	Mean protein efficiency ratio PER ± S.E.
Casein diet	40.3	194.5	151.1	54.9	2.807 ± 0.017
Khoa diet	40.4	170.7	130.3	54.6	2.382 ± 0.007
Kalakand diet	40.3	142.1	101.8	46.4	2.192 ± 0.019

The values are average for 8 rats in each group.

Table 2A: Analysis of Variance - Protein Efficiency Ratio.

Source of variation	Degree of freedom	Total sum of squares	Mean sum of squares	Calculated 'F' value	Tabulated 'F' value	Critical difference
Between treatment	2	1.5829	0.7914	483.0249*	6.51	0.0330
Within treatment	7	0.0177	0.0025	1.5437 NS	4.30	
Error	14	0.0229	0.0016			
Total	23	1.6236				

* Significant at 1 per cent level of significance.

NS Non-significant.

those obtained for casein. Regarding the nutritional value of khoa in comparison with casein, though the protein originates from milk in both the cases, the former had undergone heat treatment in the presence of lactose and possibly resulted in the decrease of available lysine from khoa proteins. However, the overall magnitude of PER for khoa proteins was considerably high (Average PER = 2.3) and the apparent decrease in the protein value was not as alarming. This could be explained on the basis that milk proteins have fairly high lysine content and possibly only small fraction of the total lysine was unavailable as a result of heat treatment of milk during khoa preparation. The extent of unavailable lysine could also be much smaller in view of the observations by Finot (1973) who showed that significant portion of the bound lysine (epsilon-N-deoxyketosyl lysine derivative) becomes biologically available during hydrolysis. In addition to this, the adaptability of albino rats to lysine deficient diets had also to be taken into consideration.

The general criticism of protein quality evaluation using PER as the criterion is, that it takes into account only the nitrogen requirement for growth rather than the one for maintenance. A group of rats was, therefore, maintained on protein free diet in the earlier experiment to account for the nitrogen requirement for maintenance. The net protein ratio (NPR) was computed according to Bender and Doell (1957) and presented in Table 3. It was found that the trend observed in respect to this parameter, too, was identical to that reported earlier (Table 3A).

Table 3: Net Protein Ratio (NPR) for Diets Based on Khoa and Kalakand.

Type of diet	Average initial body weight (g)	Average final body weight after 10 days (g)	Average gain in body weight in 10 days (g)	Average loss in body weight in 10 days (g)	Average protein intake in 10 days (g)	Mean Net Protein Ratio NPR ± S.E.
Casein diet	40.3	77.5	37.1	7.7	16.1	2.786 ± 0.041
Khoa diet	40.4	72.1	31.7	7.7	16.3	2.412 ± 0.040
Kalakand diet	40.3	64.2	23.9	7.7	13.2	2.420 ± 0.033

The values are average for 8 rats in each group.

Table 3A: Analysis of Variance - Net Protein Ratio.

Source of variation	Degree of freedom	Total sum of squares	Mean sum of squares	Calculated 'F' value	Tabulated 'F' value	Critical difference
Between treatment	2	0.7329	0.3664	38.6409*	6.51	0.07951
Within treatment	7	0.1211	0.0173	1.8242 NS	4.30	
Error	14	0.1327	0.0094			
Total	23	0.9868				

* Significant at 1 per cent level of significance.

NS Non-significant.

2. Nutritional Evaluation of Milk and Milk Products

In view of its characteristic nutritional attributes, milk has universally found a place in the balanced diet. While per capita consumption of milk or its products far exceeds the required quantum in several developed countries, it falls awfully short of the desired level in most of the developing and populous countries like India (ICMR, 1968). Apart from the shortfall in the production of milk, another consideration that constrains the adequate intake of milk is the cost of milk processing during product preparation which further complicates the situation. As mentioned time and again, milk becomes essential in an average Indian diet, being the only source of good quality proteins. It, therefore, becomes necessary to reassess the nutritional merits of milk through proper perspectives so that such limited resource could be judiciously and meaningfully utilized to meet the nutritional needs of vast segments of Indian population.

Keeping in mind the range of milk products consumed in different parts of the country, an attempt has been made to reassess the nutritional value of milk in respect of several nutrients it would furnish in the Indian diet. Milk is subjected to either heat or fermentation treatment before it is consumed. Products representing these categories have, therefore, been selected in this study.

Milk products obtained by various processing treatments undergo changes in their nutrient contents. Thus, the nutrient contents in milk products may be higher or lower than those in milk. Data on the nutrient constituents in milk and its products are presented in Tables 4 and 5.

(a) Protein

It was observed from the data presented that the protein content ranged between 3.04 per cent in the case of dahi (curd) to 35.1 per cent in roller dried skim milk powder. A close similarity between the protein content in milk with those in fermented milk products such as dahi and yoghurt, was understandable in the light of the known observation (Balasubramanian *et al.*, 1955; Shanker and Laxminarayana, 1976) that the nutrient contents in these fermented milk products depend on the nutrient contents of the starting material, viz., milk. Values observed in the case of paneer, processed cheese and skim milk powder were distinctly high due to substantial decrease in moisture content during preparation of these products. The increases were progressively larger as the extent of moisture loss increased. As regards protein content in ice-cream, the values were comparable to those present in milk, despite the fact that the high fat and high sucrose content were maintained in the milk during the preparation.

The values of protein content obtained for different preparations in the present investigation compared well with those reported by several workers in respect of milk, skim milk powder, dahi (Gopalan *et al.*, 1980), yoghurt, processed cheese and [illegible] ice-cream (Fleck, 1976 and Chaney *et al.*, 1979) and paneer (Soni,

Table 4: Proximate Principles in Milk and Milk Products.

Product	Moisture g/100 g	Protein g/100 g	Fat g/100 g	Total ash g/100 g	Total carbohydrates		Food energy	
					Reducing sugars g/100 g	Sucrose g/100 g	Calories/ 100 g product	Calories/ 100 g dry matter
Milk, cow's	87.7	3.37	3.66	0.83	3.75	-	61.4	500
Milk, buffalo's	81.2	4.24	7.03	0.83	4.67	-	98.9	526
Skim milk powder	3.03	35.1	0.25	6.41	54.4	-	369	381
Dahi	85.9	3.03	5.03	0.83	3.80	-	72.6	517
Yoghurt	79.6	3.99	5.96	0.82	3.96	5.55	108	495
Processed cheese	38.4	26.4	29.3	4.22	0.51	-	372	604
Paneer	48.8	18.9	27.7	2.87	2.87	-	337	660
Ice cream	63.0	4.01	11.2	2.15	4.54	14.8	195	527

The values are average of three samples.

1979). Certain differences observed could be attributed to the genetic, physiological and managemental factors influencing the milk composition.

The values reported in the present study although did not, in any manner, indicate the biological value of these proteins, several studies conducted earlier showed that neither the boiling of milk before consumption (Parvinder Kaur and Deodhar, 1982) nor pasteurization or fermentation influenced the nutritional quality of milk proteins significantly. Such considerations in terms of effect of processing on protein quality while working out the nutritional needs, would be meaningful.

(b) Fat

The fat content in cow and buffalo milk was found to differ considerably, and could be due to the genetic reasons. As the milk with standardised fat was processed for the preparation of dahi and yoghurt, relatively very small difference was found to occur in the fat content in these products. As regards fat content in processed cheese and paneer, the minor differences observed could be due to the extent of removal of whey and consequently the decrease in the moisture content in these products. While during the preparation of ice-cream, fat content of the ice-cream mix was standardized to 12 per cent, roller and dried milk powder was prepared from skim milk having fat content less than 0.5 per cent.

It would appear that, by and large, the fat content in the initial material used chiefly influences the fat content in the product. The data presented did not indicate changes, if any, in the nature of fats occurred during different treatments. It was observed that the fat content in milk and its products compared well with those reported by several workers in respect of milk, dahi (Gopalan et al., 1980), yoghurt, processed cheese, ice-cream (Fleck, 1976 and Chaney et al, 1979) and paneer (Soni, 1979).

Though milk fats have been shown to be comprised of low chain saturated fatty acids and these have often been identified as the dietary risk factor in several affluent countries (Vergroesen, 1975), such considerations would have limited relevance in the context of dietary situations in this country. The inclusion of about 200 g of milk or equivalent amount in terms of products, would hardly yield more than 12 to 14 g of fat, the amount still much below the quantum of fat permissible under the dietary allowances for an Indian adult (Gopalan et al., 1980).

(c) Carbohydrates

Lactose is the major reducing sugar in milk and its products. Its content was found to range from 0.51 per cent in the processed cheese to 54.4 per cent in the skim milk powder. The reducing sugar content was observed to be larger in the case of products like skim milk powder than in milk, due to the moisture removal. Though the lactose content in milk and its products like dahi and yoghurt was found to be virtually same despite the fermentation treatment, the

Table 5: Mineral and Vitamin Contents in Milk and Milk Products.

Product	Calcium mg/100 g	Phosphorus mg/100 g	Iron mg/100 g	Vitamin A I.U./100 g	Riboflavin mg/100 g	Folic acid mcg/100 g	Ascorbic acid mg/100 g
Milk, cow's	134	93.3	0.24	169	0.23	8.21	1.73
Milk, buffalo's	204	129	0.23	152	0.19	5.15	0.88
Skim milk powder	1191	1015	1.36	-	1.66	4.25	5.11
Dahi	154	116	0.27	143	0.18	12.7	0.84
Yoghurt	205	165	0.29	146	0.18	11.1	0.81
Processed cheese	813	521	2.04	1331	0.43	17.6	1.28
Paneer	705	425	1.67	1123	0.22	7.36	1.21
Ice cream	163	194	0.21	425	0.41	5.26	1.15

The values are average of three samples.

recommended allowance of 300 g of milk or equivalent products would not provide more than 10 g of lactose which is well below the threshold value of 50 g lactose for lactose intolerants.

The lower level of lactose in processed cheese could primarily be due to the removal of lactose in whey and the subsequent utilization of the remaining lactose, by conversion into lactic acid by the culture organisms during the ripening of the cheese. The higher lactose content in paneer than that in processed cheese could be attributed to the incomplete removal of lactose during whey separation.

The values of total reducing sugars were found to be in close agreement with the values reported in respect of milk, skim milk powder and dahi (Gopalan et al., 1980), yoghurt, processed cheese and ice-cream (Fleck, 1976 and Chaney et al, 1979).

The only major sugar other than lactose found to be present in the case of yoghurt and ice-cream, was sucrose and was 5.55 per cent and 14.8 per cent, respectively, as this was used as additive to milk to improve the palatability of products.

(d) Minerals

Though the total mineral content in various milk products was found to vary (Table 5) the differences were observed to be significantly narrow when the results were expressed on dry matter basis, except in the case of paneer and processed cheese, where a sizeable amount of minerals were lost in whey. The high contents of calcium, phosphorus and iron in the case of skim milk powder, processed cheese and paneer in comparison with milk samples could be due to the higher total solids in these products as a result of partial decrease in the moisture content of these products. However, the content of these minerals expressed on dry matter basis showed that the differences in their contents were not significant further indicating that the contents of these minerals were not altered significantly during the product preparation by various processing treatments.

The values obtained for calcium, phosphorus and iron in different preparations were observed to compare well with those reported by several workers in respect of milk, skim milk powder, dahi (Gopalan et al., 1980), yoghurt, processed cheese and ice-cream(Fleck, 1976 and Chaney et al., 1979).

(e) Vitamins

Milk and its products except skim milk powder, were found to be rich in fat soluble vitamin A (Table 5). The content of this vitamin was observed to be the highest in processed cheese followed by that in paneer and ice cream. The higher vitamin A content in these products than milk, could be due to their high fat content. Skim milk powder was found to have negligible amount of vitamin A because of very low fat content.

Milk and milk products are considered to be quite good sources of water soluble vitamin, riboflavin and its content was found to be more or less the same in all the products chosen in the present study. Though a large proportion of this vitamin is drained off in the whey during the preparation of processed cheese, its content in this product was observed to be almost the same as in milk. This could be due to the synthesis of riboflavin, by the microflora during the ripening of processed cheese (Gregory, 1975). Similar increase was observed in the folic acid content in the case of dahi, yoghurt and processed cheese wherein the synthesis of folic acid could have occurred during the preparation of these products as reported by Gregory (1975). Folic acid content in other products of milk was almost the same as in milk.

As regards ascorbic acid, it has been observed to occur in quite low levels in milk and milk products except in the case of skim milk powder where its content was found to be 5.1 mg/100 g in comparison with 0.88 mg/100 g in milk.

The values obtained for different vitamins in the various milk products were fairly close to those reported in respect of milk, skim milk powder, dahi (Hartman and Dryden, 1965; Gopalan et al., 1980), yoghurt, processed cheese and ice cream (Fleck, 1976 and Chaney et al., 1979).

Food is consumed primarily to meet energy requirements of the body. However, it ought to simultaneously fulfill body needs for other nutrients as well. In the light of the recent concern over energy consumption, formulation of a right diet providing all essential nutrients within the stipulated frame of permissible calorie intake, becomes imperative. To achieve this, it becomes essential to assess various food items for several nutrients on the basis of their calorie contents, and express as nutrient density (Hansen et al., 1978). Attempts have been made further on these lines by advancing the concept of index of nutritional quality by taking into account the nutrient allowance together with the energy allowance. However, nutrient allowance as well as energy allowance for any subject is determined by several factors, such as age, weight and sex of the subjects, apart from the physiological status. Thus, the index of nutritional quality for any food item is bound to vary from subject to subject in the light of the aforesaid.

In order to have a meaningful assessment of milk as well as several milk products in the Indian diet, data on various nutrient contents have been expressed on the basis of their calorie contents (Table 6), and indices of nutritional quality were calculated, keeping in mind different physiological and growth status of subjects to study the extent of variation. Data are presented in Tables 7 to 14.

Protein

From the data on indices of nutritional quality for protein (Table 7), it was seen that values differ markedly for different milk products as well as for different physiological stages for the same product. This clearly suggested differences in the potential of various milk products in meeting the body requirements.

Table 6: Nutrient Contents in Milk and Milk Products per 1000 Calories.

Product	Protein (g)	Calcium (mg)	Phosphorus (mg)	Iron (mg)	Vitamin A (I.U.)	Riboflavin (mg)	Folic acid (mcg)	Ascorbic acid (mg)
Milk, cow's	54.8	2173	1519	3.9	2745	3.7	134	28.2
Milk, buffalo's	42.9	2064	1308	2.3	1535	2.0	52.1	8.9
Skim milk powder	95.1	3225	2748	3.7	-	4.5	11.5	13.9
Dahi	41.8	2125	1589	3.7	1965	2.5	176	11.5
Yoghurt	37.1	1903	1529	2.7	1351	1.7	103	7.5
Processed cheese	71.1	2185	1401	5.5	3579	1.2	47.4	3.4
Paneer	56.3	2090	1261	5.0	3330	0.6	21.8	3.6
Ice cream	20.6	833	997	1.1	2181	2.1	27.0	5.9

Table 7: Indices of Nutritional Quality in Milk and Milk Products for Protein.

Groups	Particulars	Cow milk	Buffalo milk	Skim milk powder	Dahi	Yoghurt	Processed cheese	Paneer	Ice-cream
Infants	0-6 months wt. 3 kg	3.29	2.57	5.70	2.51	2.23	4.27	3.38	1.24
Infants	7-12 months wt. 9 kg	3.23	2.52	5.59	2.46	2.18	4.18	3.31	1.21
Pre-school children	1-3 years	3.56	2.78	6.17	2.71	2.41	4.61	3.65	1.34
School going children	7-9 years	2.99	2.34	5.19	2.28	2.02	3.88	3.07	1.13
Adolescent boys	16-18 years	2.74	2.14	4.75	2.09	1.86	3.55	2.82	1.03
Adolescent girls	16-18 years	2.41	1.88	4.18	1.84	1.63	3.13	2.48	0.91
Adult man	Sedentary worker	2.36	1.88	4.14	1.83	1.62	3.10	2.46	0.90
Adult woman	Sedentary worker	2.34	1.81	4.02	1.77	1.57	3.00	2.38	0.87
Woman	Pregnancy (2nd half)	2.20	1.71	3.80	1.67	1.48	2.84	2.25	0.82
Woman	Lactation (upto 1 year)	2.19	1.71	3.80	1.67	1.48	2.84	2.25	0.83

Of all the milk products chosen in the present investigation, skim milk powder was found to be superior to others. It was followed by processed cheese. Surprisingly, despite of being member of food items in the "milk group", ice cream showed the lowest index of nutritional quality. Values for buffalo milk, dahi and yoghurt compared well primarily due to proximity in respect of fat contents in these products, although the value for buffalo milk was little higher. Despite the differences in respect of fat and protein content (Table 4), the indices for paneer and cow milk compared well primarily due to marked differences in respect of moisture content. It would appear from the table that so far as protein is concerned, the skim milk powder scores over rest products in meeting efficiently protein requirements for subjects in all age groups. Although the value for processed cheese, as mentioned earlier, comes closer to that of skim milk powder, marked differences in the protein quality reported in different studies need also to be kept in view. While the biological value for milk proteins from skim milk powder was around 83 (Sumner, 1938), for cheese proteins, it was 72 (Dearden et al., 1945). Likewise, levels of lactic acid in preparations, such as dahi and yoghurt, could as well constrain its application in infant nutrition, though their INQ values were very close to that for milk.

The uniformly high INQ values for skim milk powder for subjects of all the age groups together with reported superiority of skim milk powder proteins, strongly suggest this to be a good source of protein in the Indian diet. The data would indicate that milk and its products, except ice cream, are good sources of protein in the light of the findings of Hansen et al. (1978), in that, all of them had INQ for protein above 1.0.

Calcium

As regards calcium content (Table 5), in view of the hypothesis proposed by Hansen and coworkers (1978), all the milk products studied could be considered as good source of calcium in the diet since the values were invariably above 1.0 in all the cases (Table 8). Relative ranking, however, showed skim milk powder with the values ranging between 5.3 and 17.5 for different age groups, to be a superior source of calcium. Interestingly, indices for different products, except skim milk powder and ice cream, were identical in all the age groups.

The values obtained in the present study were somewhat higher than those reported by Lofgren and Speckmann (1979) for several milk products, chiefly due to relatively lower recommended allowances for Indian population by ICMR (1968) in contrast to an allowance of 0.8 g in the case of population in United States of America and Canada (National Research Council, 1974).

Phosphorus

In the absence of recommended allowance for phosphorus for Indian subjects, data were computed on the basis of recommendations by NRC (1974). The skim milk powder was observed to have

Table 8: Indices of Nutritional Quality in Milk and Milk Products for Calcium.

Groups	Particulars	Cow milk	Buffalo milk	Skim milk powder	Dahi	Yoghurt	Processed cheese	Paneer	Ice-cream
Infants	0-6 months wt. 3 kg	-	-	-	-	-	-	-	-
Infants	7-12 months wt. 9 kg	3.56	3.38	5.28	3.48	3.12	3.58	3.42	1.36
Pre-school children	1-3 years	5.80	5.51	8.60	5.67	5.08	5.83	5.57	2.22
School going children	7-9 years	8.70	8.25	12.90	8.50	7.61	8.74	8.36	3.33
Adolescent boys	16-18 years	11.85	11.25	17.59	11.59	10.38	11.92	11.40	4.55
Adolescent girls	16-18 years	8.68	8.25	12.89	8.50	7.61	8.75	8.36	3.33
Adult man	Sedentary worker	11.42	11.07	17.19	11.34	10.15	11.66	11.15	4.45
Adult woman	Sedentary worker	9.28	8.73	13.64	8.97	8.04	9.22	8.83	3.52
Woman	Pregnancy (2nd half)	4.79	4.54	7.09	4.68	4.19	4.81	4.60	1.83
Woman	Lactation (upto 1 year)	5.65	5.37	8.39	5.53	4.95	5.68	5.44	2.17

Table 9: Indices of Nutritional Quality in Milk and Milk Products for Phosphorus.

Groups	Particulars	Cow milk	Buffalo milk	Skim milk powder	Dahi	Yoghurt	Processed cheese	Paneer	Ice-cream
Infants	0-6 months wt. 3 kg	2.28	1.96	4.12	2.39	2.29	2.10	1.89	1.49
Infants	7-12 months wt. 9 kg	3.42	2.94	6.18	3.58	3.44	3.15	2.84	2.24
Pre-school children	1-3 years	2.28	1.96	4.12	2.38	2.29	2.10	1.89	1.50
School going children	7-9 years	3.42	2.94	6.19	3.58	3.44	3.15	2.84	2.24
Adolescent boys	16-18 years	3.80	3.27	6.87	3.97	3.82	3.50	3.15	2.49
Adolescent girls	16-18 years	2.78	2.40	5.04	2.91	2.80	2.57	2.31	1.83
Adult man	Sedentary worker	4.49	3.95	8.24	4.77	4.59	4.20	3.78	2.99
Adult woman	Sedentary worker	3.65	3.11	6.54	3.78	3.63	3.32	3.00	2.37
Woman	Pregnancy (2nd half)	2.79	2.40	5.04	2.91	2.80	2.57	2.31	1.83
Woman	Lactation (upto 1 year)	3.29	2.83	5.96	3.44	3.31	3.04	2.73	2.16

highest index for all age groups, indicating that skim milk powder could be a better source of phosphorus than any other milk product chosen in the present study (Table 9). The INQ values for other milk products were found to compare well except in the case of ice cream where the values were observed to be relatively lower than those for other products. Though the utilization of phosphorus in the body from milk and milk products has been reported to be upto a considerable extent, the consideration of the form in which phosphorus occurs in products becomes essential while concluding milk and milk products to be better source of this mineral than other foodstuffs.

Iron

Milk and its products have been reported to be poor sources of iron and this is further evident from the data on the indices of nutritional quality of iron presented in Table 10. Iron was found to have INQ value below 1.0 for all products and for subjects of all age groups, indicating that these products of milk could hardly be considered as a good source of iron. The data were in agreement with that reported by Lofgren and Speckmann (1979).

Vitamin A

From the data(Table 11), milk and milk products were found to be good dietary sources of vitamin A for all age groups, except infants between 0 and 6 months of age and this could primarily be ascribed to the relatively higher vitamin A requirement at this

Table 10: Indices of Nutritional Quality in Milk and Milk Products for Iron.

Groups	Particulars	Cow milk	Buffalo milk	Skim milk powder	Dahi	Yoghurt	Processed cheese	Paneer	Ice-cream
Infants	0-6 months wt. 3 kg	0.47	0.28	0.45	0.45	0.32	0.66	0.60	0.13
Infants	7-12 months wt. 9 kg	-	-	-	-	-	-	-	-
Pre-school children	1-3 years	0.27	0.16	0.25	0.26	0.18	0.38	0.34	0.07
School going children	7-9 years	0.40	0.24	0.38	0.39	0.28	0.57	0.51	0.11
Adolescent boys	16-18 years	0.47	0.28	0.45	0.45	0.23	0.66	0.60	0.13
Adolescent girls	16-18 years	0.25	0.15	0.23	0.24	0.17	0.35	0.31	0.07
Adult man	Sedentary worker	0.46	0.28	0.44	0.45	0.33	0.60	0.60	0.13
Adult woman	Sedentary worker	0.25	0.15	0.24	0.24	0.17	0.35	0.32	0.07
Woman	Pregnancy (2nd half)	0.22	0.13	0.20	0.21	0.15	0.30	0.27	0.06
Woman	Lactation (upto 1 year)	0.34	0.20	0.32	0.32	0.23	0.48	0.43	0.09

Table 11: Indices of Nutritional Quality in Milk and Milk Products for Vitamin A.

Groups	Particulars	Cow milk	Buffalo milk	Skim milk powder	Dahi	Yoghurt	Processed cheese	Paneer	Ice-cream
Infants	0-6 months wt. 3 kg	0.74	0.42	-	0.53	0.37	0.97	0.90	0.59
Infants	7-12 months wt. 9 kg	2.47	1.38	-	1.77	1.22	3.22	3.00	1.96
Pre-school children	1-3 years	3.96	2.21	-	2.83	1.95	5.15	4.80	3.14
School going children	7-9 years	3.71	2.14	-	2.66	1.82	4.83	4.50	2.95
Adolescent boys	16-18 years	3.29	1.84	-	2.36	1.62	4.29	4.00	2.62
Adolescent girls	16-18 years	2.41	1.35	-	1.76	1.19	3.15	2.93	1.92
Adult man	Sedentary worker	2.60	1.48	-	1.89	1.30	3.44	3.20	2.10
Adult woman	Sedentary worker	2.11	1.17	-	1.50	1.03	2.72	2.53	1.65
Woman	Pregnancy (2nd half)	2.42	1.35	-	1.73	1.19	3.15	2.93	1.92
Woman	Lactation (upto 1 year)	1.87	1.04	-	1.33	0.92	2.43	2.26	1.48

stage. It was observed that processed cheese and paneer had higher indices than milk, dahi, yoghurt or ice-cream because of the higher concentration of vitamin A in these products.

Milk and its products are considered to be better source of vitamin A than vegetables in which vitamin A is known to be present in the form of its precursor, carotene. Vitamin A is further known to be better assimilated in the body while carotenes are not. The ability of milk and milk products in meeting the vitamin A requirement could be attributed primarily to the presence of this vitamin in the fat of these products which facilitates utilization of this vitamin from milk and milk products.

The values obtained in the present study were higher than those reported by Lofgren and Speckmann (1979) for various milk products. This could be due to the relatively higher recommended allowances for vitamin A (NRC, 1974) for American diet in comparison with those by ICMR (1968).

Riboflavin

Milk and its products are considered as excellent sources of water soluble vitamin, riboflavin. The indices of nutritional quality for riboflavin (Table 12) for all the products studied was observed to be above 1.0 for almost all age groups (except in the case of pregnant and nursing mothers) underscoring their importance in the diet as a source of this vitamin. It was further seen that

Table 12: Indices of Nutritional Quality in Milk and Milk Products for Riboflavin.

Groups	Particulars	Cow milk	Buffalo milk	Skim milk powder	Dahi	Yoghurt	Processed cheese	Paneer	Ice-cream
Infants	0-6 months wt. 3 kg	-	-	-	-	-	-	-	-
Infants	7-12 months wt. 9 kg	-	-	-	-	-	-	-	-
Pre-school children	1-3 years	6.30	3.36	7.71	4.34	2.80	1.96	1.10	3.59
School going children	7-9 years	6.61	3.53	8.09	4.56	2.97	2.06	1.15	3.78
Adolescent boys	16-18 years	6.47	3.46	7.93	4.47	4.13	2.02	1.13	3.70
Adolescent girls	16-18 years	6.72	3.59	8.23	4.49	3.03	2.10	1.17	3.84
Adult man	Sedentary worker	6.20	3.38	7.70	4.34	2.83	1.96	1.10	3.60
Adult woman	Sedentary worker	7.05	3.73	8.56	4.81	3.14	2.17	1.22	3.97
Woman	Pregnancy (2nd half)	4.26	2.27	5.20	2.93	1.91	1.33	0.74	2.43
Woman	Lactation (upto 1 year)	4.55	2.43	5.57	3.14	2.05	1.42	0.79	2.60

the values for different products varied considerably, with skim milk powder having highest and paneer having the lowest value. Despite higher contents of riboflavin in processed cheese (Table 5), indices in the case of processed cheese and paneer were found to be lower than those for milk. This could be partly due to the retention of fat in the curd, though the losses of vitamin in the whey were partially compensated by the increases occurring during the ripening of cheese. Besides their richness in respect of riboflavin, recent studies (Saroj Kumar, 1979, Mehta, 1981) showed superiority of milk and its products over synthetic vitamin regarding the bioavailability. Such factors which do not figure in the index proposed by Hansen et al. (1978), however, need to be taken into account while ascertaining allowances for milk and its products in the diet. Thus, the vitamin requirement could be effectively met even by much smaller quantity of milk than that anticipated on the basis of nutrient density.

Folic Acid

As evident from the data given in Table 13, not all the products of milk could be considered as good sources of folic acid. The loss of vitamin during roller drying process in the preparation of skim milk powder or whey in the case of paneer and cheese preparation are understandable, although some amount of the vitamin is known to be synthesized during cheese ripening (Gregory, 1975). Dahi, yoghurt and cow milk, on the other hand, appeared to be good source of this vitamin. Increment in the index for dahi, over that found

Table 13: Indices of Nutritional Quality in Milk and Milk Products for Folic Acid.

Groups	Particulars	Cow milk	Buffalo milk	Skim milk powder	Dahi	Yoghurt	Processed cheese	Paneer	Ice-cream
Infants	0-6 months wt. 3 kg	1.92	0.75	0.16	2.53	1.49	0.68	0.31	0.38
Infants	7-12 months wt. 9 kg	4.81	1.88	0.41	6.32	3.72	1.71	0.79	0.97
Pre-school children	1-3 years	2.14	1.14	0.18	2.81	1.65	0.76	0.35	0.43
School going children	7-9 years	3.21	1.25	0.28	4.22	2.48	1.14	0.52	0.65
Adolescent boys	16-18 years	5.35	2.08	0.46	7.03	4.13	1.90	0.87	1.08
Adolescent girls	16-18 years	3.92	1.53	0.34	5.15	3.03	1.39	0.64	0.79
Adult man	Sedentary worker	3.21	1.25	0.28	4.22	2.48	1.14	0.52	0.65
Adult woman	Sedentary worker	2.54	0.99	0.22	3.34	1.96	0.90	0.42	0.51
Woman	Pregnancy (2nd half)	1.31	0.51	0.11	1.72	1.01	0.46	0.21	0.26
Woman	Lactation (upto 1 year)	2.32	0.90	0.20	3.04	1.79	0.82	0.38	0.47

either for cow or buffalo milk, is compatible with the fact that the starter culture used in dahi preparation has distinguished folic acid synthesizing capacity (Laxminarayana, 1980).

Ascorbic Acid

As regards ascorbic acid, observations that milk or its products being poor source, were further substantiated by the data on nutrient density as well as the indices (Table 14) for different age groups which was less than 1.0 in almost all the cases.

The relative assessment of the nutritional quality of milk and milk products can be made by comparing their indices of nutritional quality for various nutrients. Such a comparison would show the potentialities of milk and milk products in meeting the nutrient requirements besides meeting the energy needs. Thus, milk and its products have been found to be good dietary sources of protein, calcium, phosphorus, riboflavin and, to some extent, of folic acid, for subjects of all age groups and physiological status whereas these food items have been found to be poor sources of iron and ascorbic acid as their indices in respect of these nutrients have been observed to be less than 1.0.

Though the inferences on the nutritional quality of milk and the products obtained from milk, could be drawn from their INQ values, the computation of these indices does not take into account the bioavailability of the various nutrients. Relatively greater

Table 14: Indices of Nutritional Quality in Milk and Milk Products for Ascorbic Acid.

Groups	Particulars	Cow milk	Buffalo milk	Skim milk powder	Dahi	Yoghurt	Processed cheese	Paneer	Ice-cream
Infants	0-6 months wt. 3 kg	0.34	0.11	0.17	0.14	0.09	0.04	0.04	0.07
Infants	7-12 months wt. 9 kg	0.85	0.27	0.42	0.34	0.23	0.10	0.11	0.18
Pre-school children	1-3 years	0.85	0.27	0.42	0.35	0.23	0.10	0.11	0.18
School going children	7-9 years	1.27	0.40	0.62	0.52	0.34	0.16	0.16	0.27
Adolescent boys	16-18 years	2.12	0.67	1.04	0.86	0.57	0.26	0.27	0.45
Adolescent girls	16-18 years	1.55	0.49	0.76	0.63	0.42	0.19	0.20	0.33
Adult man	Sedentary worker	1.33	0.43	0.67	0.55	0.36	0.17	0.43	0.29
Adult woman	Sedentary worker	1.08	0.34	0.53	0.44	0.29	0.13	0.14	0.23
Woman	Pregnancy (2nd half)	1.25	0.39	0.61	0.51	0.33	0.15	0.16	0.26
Woman	Lactation (upto 1 year)	0.92	0.29	0.45	0.37	0.25	0.11	0.12	0.19

availability of the nutrients from milk and its products, in comparison with that from other food items, would hardly be accounted in the computation of the INQ values for the nutrients present in milk and milk products.

The recommended allowance of 200 g of milk in the balanced vegetarian Indian adult diet (ICMR, 1968) would provide 5.0 per cent of the recommended energy allowance for an adult subject. Consuming 200 g of milk per day would meet 12.3 per cent protein, 60 per cent calcium, 23.3 per cent phosphorus, 2.4 per cent iron, 13.3 per cent vitamin A, 3.3 per cent riboflavin, 16.4 per cent folic acid and 7 per cent ascorbic acid requirements of an adult subject (Fig. 1). But the average consumption of 122 g of milk per head per day in our country provides only 60 per cent of the nutrients which could be provided by consuming 200 g of milk per day (Fig. 2).

Comparing the indices of nutritional quality of milk and skim milk powder with those of commonly consumed cereals, millets and pulses which form the staple food of Indian population, it has been found that milk and skim milk powder have indices higher than those for milk in respect of protein, calcium, phosphorus and riboflavin (Table 15).

Owing to the higher INQ values for protein, calcium, phosphorus and vitamin A, skim milk powder can unquestionably be considered a better source of these nutrients than other foodstuffs

	INQ	PERCENT STANDARD
Energy	1.00	5.13
Protien	2.36	12.10
Calcium	11.42	58.58
Phosphorus	4.50	23.10
Iron	0.46	2.36
Vitamin A	2.60	13.34
Riboflavin	6.20	31.81
Folic acid	3.21	16.96
Ascorbic acid	1.33	6.82

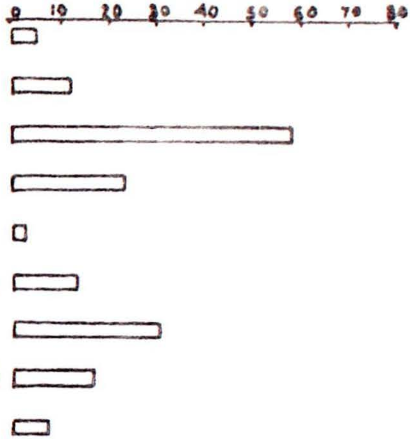

Fig. No. 1 - Nutrient Requirements met by Consuming 200 gms milk per day.

Energy	1.00	3.13
Protein	2.36	7.39
Calcium	11.42	35.75
Phosphorus	4.50	14.10
Iron	0.46	1.44
Vitamin A	2.60	8.14
Riboflavin	6.20	19.14
Folic acid	3.21	10.10
Ascorbic acid	1.33	4.16

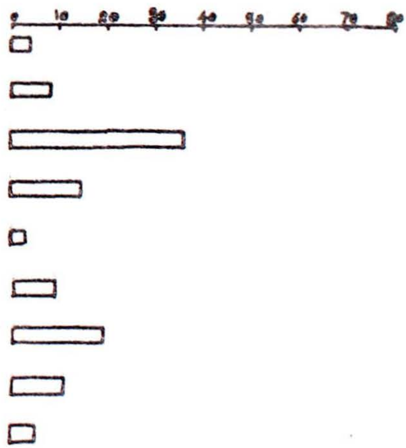

Fig. No. 2 - Nutrient Requirements met by Consuming 122 gms of milk per day.

Table 15: Index of Nutritional Quality for Certain Commonly Consumed Foods.

Name of foodstuff	Protein	Calcium	Phosphorus	Iron	Riboflavin
Wheat	1.5	0.6	2.7	1.7	0.8
Rice	0.9	0.2	1.4	1.1	0.3
Bajra	1.4	0.6	2.5	1.7	1.2
Barley	1.5	0.4	1.9	1.1	1.0
Arhar	2.9	1.2	2.7	2.1	1.0
Milk	2.4	11.6	4.5	0.5	6.4
Skim milk powder	4.2	17.2	8.3	0.5	7.7

and even milk. Consumption of 20 g of skim milk powder has been found to provide equivalent amount of nutrients as could be provided by the recommended allowance of 200 g of milk per day. Greater digestibility and complete utilisation of calcium and phosphorus in the body from skim milk powder further add a plus point to the nutritive value of this product. Moreover, the versatility of skim milk powder lies in its incorporation in different foods and in the diet of the subjects belonging to all age groups. Due to low fat content, skim milk powder can be safely recommended for the formulation of low energy diet.

Fluid milk, however, is more susceptible to bacterial growth and may, therefore, have relatively poor keeping quality as compared to that of skim milk powder whose preparation involves heating of milk at higher temperatures, destroying most of the viable microorganisms present in milk and, thereby, increasing the shelf life of skim milk powder. This would further ease the bulk transportation of skim milk powder to the remote areas where perishable food item, milk, could be provided safe only with difficulty.

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CHAPTER - V

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

Keeping in mind the variety of processing treatments given to milk, products representing these treatments and commonly consumed by various segments of the population of this country, were evaluated to assess their importance in the Indian diet. Milk, cow's and buffalo's, skim milk powder, dahi, yoghurt, processed cheese, paneer and ice cream were assessed for their relative nutritional merits in the Indian dietary habits.

A study conducted on the nutrient contents of milk and milk products to compare the nutrient composition of variously processed milk preparations, showed skim milk powder to have higher contents of protein, calcium, phosphorus, riboflavin and ascorbic acid than milk while it had lower contents of vitamin A and folic acid than milk. Similar increase in the contents of certain vitamins in the cultured milk products showed the relative superiority of these products despite the losses of certain nutrients in whey during the preparation of processed cheese.

A study carried out on the effect of heat treatment on the protein quality of indigenous milk product khoa and khoa based sweet product, kalakand, indicated that the protein quality of both the milk products remained unaltered despite the further processing of khoa in the presence of sugar.

Owing to the limited application of the nutrient contents expressed on product weight basis, the contents of the various nutrients in the products were computed per 1000 calories of energy indicating the nutrient density of these products. Skim milk powder was found to have highest nutrient density in respect of protein, calcium, phosphorus and riboflavin followed by processed cheese and paneer.

Studies conducted on the potentialities of milk and milk products in terms of meeting nutrient requirements besides meeting the energy needs (Index of Nutritional Quality) for subjects of different age groups and physiological status showed the relative superiority among different milk products for different age groups in respect of various nutrients. Skim milk powder and processed cheese were found to have highest indices followed by paneer, milk, dahi and yoghurt, and ice cream having the least INQ value for various nutrients.

Relative assessment of the nutritional quality of milk and skim milk powder and certain commonly consumed cereals, millets and pulses forming the staple food of the Indian population, showed the better nutritional quality of milk and skim milk powder in respect of protein, calcium, phosphorus and riboflavin.

Further, it was found that the nutritional requirements met by consuming 200 g of milk could also be judiciously met (except for vitamin A) with 20 g of skim milk powder which would be beneficial both from the hygienic and nutritional standpoint.

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CHAPTER - VI

BIBLIOGRAPHY

BIBLIOGRAPHY

Agarwal, J.P. and Singh, S.M. (1960).
J. Agric. Sci. Res. 2: 26. Cited: Dairy Sci. Abstr. 26: 2067 (1964).

Ahovocova, J.K. and Odavic, R. (1969).
J. Chromat. 40: 90.

Anagama, Y.J. (1955).
Fac. Fish. Anim. Husb. Hiroshima Univ. 1: 49.
Cited: Dairy Sci. Abstr. 18: 603C (1956).

Anantakrishnan, C.P., Dastur, N.N. and Kothavalla, Z.R. (1943).
Ind. J. Vet. Sci. 13: 297.

Anonymous (1973).
Cultured Dairy Prod. J. 8: 16.

AOAC (1980).
Methods of Analysis. Association of Official Analytical Chemists of America, Washington.

Balasubramanian, S.C., Lily, G., Mani, G.S. and Basu, K.P.(1955).
Ind. J. Med. Res. 43: 264.

Bambha, P.P., Shankara, P.A., Nambudripad, V.K.N. and Laxminarayana, H. (1973).
Ind. J. Anim. Sci. 43: 210.

Bender, A.E. and Doell, B.N. (1957).
Br. J. Nutr. 11: 140.

Blanc, B. (1973).
Schweizerscha Milchseilung 99: 463.
Cited: Dairy Sci. Abstr. 36: 2639 (1974).

Brochu, E., Riet, R. and Vezine, C. (1959).
Researches in Agronomy, Monograph No. 3.
Cited: Dairy Sci. Abstr. 22: (1969).

Bruel, Vanden, A.M.R., Jenneskens, P.J. and Mol, J.J. (1972).
Neth. Milk Dairy J. 26: 19.

BS (1955).
British Standards, 696. Part 2.

Budny, J., Chodkowska, B. and Rutkowski, A. (1964).
Przem. Spozyw. 18: 153. Cited: Dairy Sci. Abstr. 27: 3899. (1965)

Burton, H., Pien, J. and Thieulin, G. (1965).
Milk Sterilization. 37 (FAO).

Burton, H. (1972).
Dairy Industry, 37: 197.

Carr and Price (1926).
Biochem. J. 20: 497.

Chandan, R.C., Argyle, P.J. and Jones, N. (1969).
Cited: Dairy Sci. Abstr. 52: 894.

Chaney, M.S., Ross, M.L. and Witschi, J.C. (1959).
Nutrition. 9th Ed. Houghton Mifflin Company, Boston.

Chapman, Helen R., Ford, J.E., Kon, S.K., Thompson, S.Y., Rowland, S.J., Crossley, E.L. and Rothwell, J.J. (1957).
J. Dairy Res. 24: 191.

Chitre, R.G. and Patwardhan, V.N. (1945).
Curr. Sci. 11: 320.

Cho, J.H. and Cho, T.H. (1970).
Res. Rep. Off. rur. Dev. Kores. 13: 89. Cited: Dairy Sci. Abstr. 33: 5987 (1971).

Cochran, W.G. and Cox, G.M. (1957).
Experimental Designs. 1st Ed. Asia Publishing House, Bombay.

Cook (1961).
Cited: Research Paper (in press), Parvinder Kaur and Deodhar, A.D., Ind. J. Dairy Sci. (1982).

Davis, D.T. and White, J.C.D. (1962).
J. Dairy Res. 29: 285.

Dearden, D.V., Henry, K.M., Houston, J., Kon, S.K. and Thompson, S.Y. (1945).
J. Dairy Res. 14: 100.

De, N.K. and Mazumdar, B.N. (1938).
Ind. J. Med. Res. 25: 857.

De, S. and Ray, S.C. (1952).
Ind. J. Dairy Sci. 5: 147.

De, S. (1980).
Outlines of Dairy Technology, Oxford Univ. Press, Delhi.

Eggum, B.O. and Jacobsen, I. (1976).
J. Sci. Fd. Agric. 27: 1190.

Escudero, A., Herraiz, M.L., DeAlvarez and Herrero, H.G. (1943).
Rev. Assoc. Argent. Dietologia 1: 119. Cited: Nutr. Abstr. and Rev. 14: 2214 (1944-45).

EskhofStork (1976).
World Atlas of Cheese. Ed. by Adrian Balley.
Peddington Press, USA.

Finot,PA(1973).
Proteins in Human Nutrition, 501 (1973). Ed. by Porter, J.W.G. and Rolls, B.A., Academic Press, London.

Fleck, Henrietta.(1976).
Introduction to Nutrition, 3rd Ed. Macmillan Publishing Co., Inc. New York.

Ford, J.E., Kon, S.K. and Thompson, S.Y. (1959).
Int. Dairy Congr. 429.

Ford, J.E., Porter, J.W.G., Thompson, S.Y., Toothill, J. and Edwards-Webb, J. (1968).
Proc. Nutr. Soc. 27: 60A.

Ford,J.E(1973).
Cited: Methods of Vitamin Assay. Verleg Chemic. Weinheim.

Freed, M. (1966).
Methods of Vitamin Assay. Verleg Chemic. Weinheim.

Gopalan, C., Balasubramanian, S.C., Shastri, B.V.R. and Rao, K.V. (1971).
Diet Atlas of India, Indian Council of Med. Res., Natl. Inst. of Nutr., Hyderabad.

Gopalan, C., Shastri, B.V.R. and Balasubramanian, S.C. (1980).
Nutritive Value of Indian Foods. Indian Council of Med. Res., Natl. Inst. of Nutr., Hyderabad.

Gregory, Margaret E. and Burton, H. (1965).
J. Dairy Res. 32: 13.

Hansen (1955).
Cited: Drying of Milk and Milk Products (1971). Ed. by Hall, C.W. and Hedrick, T.I. AVI Publishing Co., Inc.

Hansen, R.G. (1973).
Nutr. Rev. 31: 1.

Hansen, R.G., Wyse, B.W. and Brown, G. (1978)
Food Tech. 32: 44.

Hartman, A.M. and Dryden, L.P. (1965).
Vitamins in Milk and Milk Products. American Dairy Sci. Assoc., USA.

Henry, (1904).
Cited: Food Tech. 30: 22 (1976).

Henry, K.M. and Kon, S.K. (1938).
J. Dairy Res. 9: 6.

Henry, K.M. and Kon, S.K. (1938).
J. Dairy Res. 9: 22.

Henry, K.M. and Kon, S.K. (1938).
J. Dairy Res. 9: 185.

Henry, K.M., Houston, J., Kon, S.K. and Thompson, B.Y. (1944).
J. Dairy Res. 13: 329.

Henry, K.M. and Toothill, J. (1960).
J. Dairy Res. 9: 188.

Houston, J., Kon, S.K. and Thompson, S.Y. (1940).
J. Dairy Res. 11: 67.

Hurrell, R.F. and Carpenter, K.J. (1974).
Food Tech. 32: 589.

ISI (1967).
IS: 1664. Indian Standards Institution, New Delhi.

ISI Methods (1973).
IS: 1166. Specification for Condensed Milk.

Kon, S.K. (1972).
Milk and Milk Products in Human Nutrition. FAO, Rome.

Korolezuk, I., Kwasniowska, I. and Szki Ilactziowan (1976).
Przemyslu-mlcazar Skiego 18: 29. Cited: Dairy Sci. Abstr. (1978).

Kosikowski, F. (1966).
Cheese and Fermented Milk Foods. Edwards Brothers Inc. Ann. Artor, Michigan.

Kruglova, A. and Gul'ko, L.E. (1966).
Dokl. II. Mezhdunarod. Kongr. Vop. Nauki Tekhnol., Pishch, Prom. (Tekhnol pisch Prod. Zhivot Proiskhozhdeniza) 2: 32. Cited: Dairy Sci. Abstr. 29: 3685 (1967).

Langsrud, T. (1968).
Meieriteknikk, 33: Cited: Dairy Sci. Abstr. 32:4377 (1970).

Laxminarayana, H. (1976).
Final Report, Indian Council of Agric. Res., New Delhi.

Laxminarayana, H. and Shanker, P.A. (1980).
Indian Dairyman, XXXII No. 2: 121.

Lofgren, P.A. and Speckmann, E.W. (1979).
J. Dairy Sci. 62:1019.

Mani, G.S., Lily, G. and Balasubramanian, S.C. (1955).
Ind. J. Med. Res. 43: 239.

Markh, A.T., Shcherbakova, E.V., Paulina, Ya B. and Bogdel, O.A.(1974).
Izvestiya Vysshikh Uchebnykh Pishchevaya Tekhnologiya 3: 17. Cited: Dairy Sci. Abstr. 37: 4476 (1975).

Mastakov, N. and Rossikhina, G. (1966).
Moloch. Prom. 27: 25. Cited: Dairy Sci. Abstr. 29: 1188(1967).

Mauron, J., Mottu, F., Bujard, E. and Egli, R.H. (1955).
Arch. Biochem. Biophys. 59: 433.

Mehta, A.K. (1981).
Ph.D. Thesis. Kurukshetra University.

Menden, E. and Cremer, H.D.Z. (1956).
Lebensmitt Unter. such. 104: 150. Cited: Dairy Sci. Abstr. 19: 250 (1956).

Nagaswa, T., Tanahashi, T., Kuzuya, Y. and Shigeta, N. (1960).
Jap. J. Zootech. Sci. 31: 200. Cited: Dairy Sci. Abstr. 23: 1158 (1961).

Nambudripad, V.K.N. (1956).
Ph.D. Thesis, Bombay University.

NRC (1974).
Food and Nutrition Board, National Research Council. Recommended Dietary Allowances. Cited: Essentials of Foods and Nutrition, Swaminathan, M. 1st Ed., Ganesh and Co., Madras.

Nilson, K.N., Vekil, T.H. and Shahani, K.M. (1963).
J. Nutr. 86: 602.

Parvinder Kaur and Deodhar, A.D. (1982).
Ind. J. Dairy Sci. (In press).

Payne-Botha and Bigwood, E.J. (1959).
Brit. J. Nutr. 13: 385.

Pol, G. and Groot, E.H. (1960).
Neth. Milk Dairy J. 14: 158. Cited: Dairy Sci. Abstr. 23: 1776 (1961).

Pol, G. and Groot, E.H. (1961).
Nutr. Abstr. Rev. 31: 3580.

Porter, J.W.G. and Rolls, B.A. (1973).
Proteins in Human Nutrition, Academic Press, London.

Poznanski, S., Lenoir, J. and Mocquot, G. (1965).
Le Lait, 45: 3. Cited: Paper No. 5969, Journal Series, Nebraska Agric. Expt. Stn., Lincoln.

Poznanski, S. and Siudak-folike (1971).
Ind. J. Nutr. Dietet. 8: 189.

Prabaharan, R. (1978).
M.Sc. Dissertation, Kurukshetra University.

Pujol, A. and Arteaga, E. (1972).
Analesde Bromatologia, 24: 143. Cited: Dairy Sci.Abstr.(1973).

Rangappa, K.S. and Achaya, K.T. (1974).
Indian Dairy Products, Asia Publishing House, Bombay.

Rao, N. Jagan Mohana (1976).
M.Sc. Dissertation, B.N. Chakraborty University.

Rasic, J., Stojsavljevic, T. and Curcic, R. (1971).
Milchwissenschaft, 26: 219.

Rasic, J., Curcic, R., Stojsavljevic, T. and Obradovic, B. (1971).
Milchwissenschaft, 26: 496.

Reddy, K.P., Shahani, K.M. and Kulkarni, S.M. (1976).
J. Dairy Sci. 59: 191.

Renner, E. and Baier, O. (1971).
Dte. Molk. Ztg. 92: 75. Cited: Dairy Sci. Abstr. 33: 3729 (1971).

Roe and Kuether (1943).
J. Biol. Chem. 147: 399.

Rose, M.S. (1934).
Cited: Food Tech. 30: 22 (1976).

Rose and Gottlieb (1959).
Lab. Manual of Milk Products, 624.

Sabarwal, P.K. and Ganguli, N.C. (1973).
Ind. J. Dairy Sci. 26: 211.

Sameul, J.R. (1937).
J. Dairy Res. 8: 1.

Sandhu, R.A., Siel, M.A. and Sial, M.B. (1973).
Pakistan J. Sci. 25: 246. Cited: Dairy Sci. Abstr. 39: 3362 (1977).

Saroj Kumari (1979).
M.Sc. Dissertation, Kurukshetra University.

Schober, R. and Prinz, I. (1956).
Milchwissenschaft. 11: 209. Cited: Dairy Sci. Abstr. 19:156. (1957).

Shahani, K.M. and Sommer, H.H. (1951).
J. Dairy Sci. 34: 1010.

Shanker, P.A. and Laxminarayana, H. (1974).
Proc. Int. Dairy Congr., New Delhi.

Shtal'berg, S.M., Radaeva, I.A. and Shul'kina, S.P. (1965).
Trudy veses. nauchno-issled. Inst. molach. Prom. 23: 16.
Cited: Dairy Sci. Abstr. 28: 2088.

Singh, Bhupal (1979).
Ph.D. Thesis, Panjab University.

Snell, E.E. and Strong, F.M. (1939).
Microbiological Assay of Vitamin B Complex. Pitman and Sons,Ltd.

Sokolov, F.S. (1959).
Nauch. Trud. Poltavsk Sel'Skokhoz Inst. 146. Cited: Dairy Sci. Abstr. 23: 3323 (1961).

Soni, Neelam (1979).
M.Sc. Dissertation, Kurukshetra University.

Sumner, E.E. (1938).
J. Nutr. 16: 129.

Swaminathan, M. (1937).
Ind. J. Med. Res. 25: 57.

Swaran Lata (1981).
M.Sc. Dissertation, Kurukshetra University.

Tylkin, V.B. and Tsaberyabaya, N.I. (1976).
Tavarovedenic, 9: 47. Cited: Dairy Sci. Abstr. 40: (1978).

Vergroesen, A.J. (1975).
The Role of Fats in Human Nutrition, Academic Press, London.

Vogel, A.I. (1970).
A Text Book of Quantitative Inorganic Analysis, 4th Ed. 741.

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Appendix: Daily Allowances of Nutrients for Indians (Recommended by the Nutrition Expert Group, 1968).

Group	Particulars	Calories	Protein (g)	Calcium (mg)	Phosphorus* (mg)	Iron (mg)	Vit. A (I.U.)	Riboflavin (mg)	Folic acid (mcg)	Ascorbic acid (mg)
Infants	0-6 months	120/kg	2.0/kg	-	240	1.0/kg	1333	-	25	30
	7-12 months	100/kg	1.7/kg	550	400	-	1000	-	25	30
Children	1-3 years	1200	18.5	450	800	17.5	833	0.7	75	40
	7-9 years	1800	33	450	800	17.5	1333	1.0	75	40
Adolescent boys	16-18 years	3000	60	550	1200	25	2550	1.7	75	40
Adolescent girls	16-18 years	2200	50	550	1200	35	2550	1.2	75	40
Man	Sedentary worker	2400	55	450	800	20	2550	1.4	100	50
Woman	Sedentary worker	1900	45	450	800	30	2550	1.0	100	50
	Pregnancy (2nd half)	2200	55	1000	1200	40	2550	1.9	225	50
	Lactation (upto 1 year)	2600	65	1000	1200	30	3833	2.1	150	80

* Recommended by the National Research Council (NRC), 1974.