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LEAD ARTICLE

Milk, the Complete Food

By Dr. J. S. Pai

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MESSAGE FROM Mr. HERVE LE FAOU

CHAIRMAN AND MANAGING DIRECTOR, HEINZ INDIA PRIVATE LIMITED
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Milk contains large amount of essential nutrients and has rightly been recognised as nature's single most complete food. As a food, milk serves various purposes like growth, supply of energy, maintenance and repair, reproduction and more importantly, appetite satisfaction. The requirements of these purposes may vary with the individual, because not all the functions stated above are required during all ages. For example, adults might not require food for growth, except in some conditions, whereas infants do. It is critical for growing children. The functions of food are served specifically through the various nutritionally important components, comprising of proteins, carbohydrates, lipids, minerals, vitamins and water. Milk proteins in turn are

classified into casein, comprising approximately 76–80% of the total milk proteins, and the whey proteins, comprising roughly 20–24%. In mother's milk the ratio is slightly different.

The whey proteins are in higher nutritional value than casein. Milk proteins are outstanding sources of all essential amino acids. That is why it is said that milk provides first class proteins, like eggs, consisting of all essential amino acids in the recommended ratio. Thus its superiority rested on its nutritive laurels, which was backed by scientific evidence.

According to nutritionists, milk was the perfect food from time immemorial. For instance, NCAES's bulletin had stated way back in the early 20th century, in an article 'Milk for

the whole family' that "The first food a family should have is milk, and the last food to be dispensed with is milk. It is not the only food, but it is the most important food."

Therefore, one can confidently state that "while reviewing the classes of foods, one food stands out beyond all others and that food is milk." Milk not only contains all the elements of food essential to health, it is also a good fuel, providing "energy which enables the body to work."

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Milk, the Complete Food

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Origins

Milk is produced by mammals to provide primary nutrition for their newborn babies or pups. Although cow's milk is most popular in many countries, milk can be obtained from many different animals like water buffalo, sheep, goat, camel etc. which are regularly consumed by people. Milk composition varies with species but contains good amounts of saturated fat, protein and calcium.

Although other mammals stop drinking milk when they grow, milk is consumed by humans beyond infancy as food using milk of other animals. The reason is that milk is one of the most nutritious food available. Milk from cow has been used to make cream, butter, yogurt, ice cream, cheese etc. Many food ingredients, additives and industrial products have also been prepared from milk e.g. casein, whey protein, lactose, condensed and powdered milk etc.

Dairy Industry Globally and in India

In the last three decades, world milk production increased by 50%, from 482 million tonnes in 1982 to 754 million tonnes in 2012. India is the world's largest milk producer with roughly 16% of the total production. Next in line are the USA, China, Pakistan and Brazil. Since 1970s maximum increase in production has occurred in South Asia, which is driving the growth in the developing countries.

In 2012, largest cow milk producers were the USA with 91 million tonnes (MT), India 54 MT, China 37 MT and Brazil 37 MT. In buffalo milk, India led with 66 MT with Pakistan coming distant second with 23 MT. Sheep milk is not produced much in India and the leader is China with 1.5 MT, but India is the leader in goat milk with 4.8 MT production and Bangladesh second with 2.6 MT production. Overall, India led all the countries in total milk production with over 124 million tonnes produced in 2012.

According to NDDB, about 73% of milk is consumed as liquid milk in India. About 8% is converted to milk powder so it could be either converted to liquid milk in lean period or used for other products. About 8% is used for ghee, and 3% for butter. Ice cream is prepared from 4% of milk and other products like curd, cheese, paneer and flavoured milk is prepared with 1% each of the milk. Of the total milk produced, over 75% is sold as liquid milk of which organised industry handles only 18%. Private dudhwalas and other unorganised players sell 36% and about 46% is retained in rural areas.

India's emergence as world's leader in milk production began around 1950's when young Dr. Kurien helped establish dairy cooperative in Gujarat, now famous as Amul. Those efforts became responsible for steady growth of dairy production and Dr. Kurien is called the

India's emergence as world's leader in milk production began around 1950's when young Dr. Kurien helped establish dairy cooperative in Gujarat, now famous as Amul. Those efforts became responsible for steady growth of dairy production and Dr. Kurien is called the Father of the White Revolution in India or also the Milkman of India.



Father of the White Revolution in India or also the Milkman of India. Today, there are tens of thousands of village cooperatives producing milk.

Today, India's largest agricultural crops, rice (92 million tonnes) and wheat (75 MT), are behind milk production (over 100 MT). Although the price it fetches is more than rice and wheat and also farmers realise 60-70% of consumer price as against just 20% or so for fruits and vegetables, there are some problems of networking the procurement properly. Also, the value addition will benefit the industry.

In spite of India being largest producer of milk, per capita consumption is still very low. Following table shows milk consumption in different countries or regions.



Per capita milk consumption (kg/yr) in 2007

Country/Region	Per capita consumption
Developed	213.7
Developing	55.2
China	28.7
Latin America & Caribbean	113.3
Brazil	124.6
South Asia	72.0
India	68.7
World	84.9

Composition of Milk

Milk contains water (over 80 to 85%) in which fat globules are emulsified and kept stable by fat globule membrane made of phospholipids and proteins. Thus, although milk contains significant amount of fat, it does not separate because these tiny fat globules (about 4 to 10 μm diameter) are kept separate from each other by these emulsifiers. However, agitation or churning will disrupt the membrane, allowing fat globules to merge into larger particles that can separate and collect at the surface as cream or butter.

Homogenisation is done by passing milk under pressure through a small orifice, so as it emerges out, the globules experience sudden decompression and break into even tinier globules that will be extremely stable against agitation and this milk will not easily form cream layer.

Major portion of the protein is casein that is present as micelles or spherical aggregates of large number of protein molecules with diameters of about 0.1 μm . Colloidal calcium phosphate acts as a cement to keep the casein micelle intact. Besides Calcium phosphate, there are many interactions like hydrogen and disulphide bonds, hydrophobic and electrostatic interactions and other

forces that keep the stability. The stability of the micelle will be affected by certain other factors like salt content, pH, temperature and moisture that may try to destabilise it under unfavourable conditions.

There is a minor protein fraction called whey proteins that are soluble in water. They consist of globular proteins, mostly β -lactoglobulins and α -lactalbumins. There are also immunoglobulins present that confer immunity against many diseases. Whey proteins are very heat sensitive. Milk proteins are of high biological value providing all the essential amino acids.

Milk contains a unique sugar, lactose. In nature, lactose is found only in milk and very few plants. This, along with fat, provides major source of calories. Besides, there are vitamins and minerals and certain bioactive substances including enzymes. Nutrients present in cow's milk and comparison of milk of other species is given in tables.

Colour of Milk

White colour of milk is due to both tiny fat globules and very small casein micelles that scatter the light. Skimmed milk, having almost no fat, looks slightly bluish as casein micelles scatter shorter wavelengths. Cows (especially Jersey and Guernsey) have good amount of carotene in fat, contributing a yellowish colour to

butter and creamy colour to milk. Buffalo milk fat contains very little carotene so the milk looks whiter and the butter is also white. There are inherent differences in chemical and physical properties of the two milks as seen below.

Composition of Milk from Different Species

There are many differences that will be seen within these, which may be due to breed, time and stage of milking, lactation period, season, feed, nutritional level, environmental conditions, health, age, exercise, medication and hormonal treatments etc.

Milk Composition per 100 grams

Constituents	unit	Cow	Goat	Sheep	Water Buffalo
Water	g	87.8	88.9	83.0	81.1
Protein	g	3.2	3.1	5.4	4.5
Fat	g	3.9	3.5	6.0	8.0
Carbohydrate	g	4.8	4.4	5.1	4.9
Energy	kcal	66	60	95	110
Sugars (Lactose)	g	4.8	4.4	5.1	4.9
Fatty Acids:					
Saturated	g	2.4	2.3	3.8	4.2
Mono-unsaturated	g	1.1	0.8	1.5	1.7
Polyunsaturated	g	0.1	0.1	0.3	0.2
Cholesterol	mg	14	10	11	8
Calcium	IU	120	100	170	195



Processing of Milk

As milk is highly nutritious, most microbes can grow in it and spoil it. Within hours, it starts souring and all kinds of microorganisms, including bacteria, yeast and mould, will spoil and putrefy it unless it is processed and preserved using different processes such as thermal processing including pasteurisation, sterilisation, UHT processing etc., chilling, drying, converting to different products with longer shelf

Although milk in cow's udders is sterile but as it is drawn, it gets immediately mixed with many bacteria commonly present in barn surroundings, especially the lactic acid bacteria. These grow extremely well in milk and produce lactic acid from lactose and cause the pH to drop.

life among other things. Thermal processing involves heating milk at a temperature where spoilage bacteria are killed. Although milk in cow's udders is sterile but as it is drawn, it gets immediately mixed with many bacteria commonly present in barn surroundings, especially the lactic acid bacteria. These grow extremely well in milk and produce lactic acid from lactose and cause the pH to drop. At pH less than 4.6, casein precipitates and milk curdles. When the process is done using desirable bacteria, curd or yogurt is formed, but when uncontrolled then undesirable bacteria and other microbes may grow causing spoilage along with acid production.

When milk is heated these bacteria are destroyed. When heating is done to kill all the bacteria rendering the milk sterile, the process is called sterilisation. This involves very severe heating. Commonly milk is pasteurised to specifically kill pathogens or disease causing microorganisms along with a large proportion of lactic acid bacteria as well. Since this process does not kill all the spoilage organisms, milk can

spoil after cooling and keeping for some time when the surviving bacteria start multiplying and grow to a large number. Hence, pasteurised milk is chilled and kept at refrigerated temperature as colder condition slows down their growth.

Pasteurisation process is named after its discoverer Louis Pasteur and may be carried out by heating milk at 71.7°C for 15 seconds using high temperature short time (HTST) process compared to earlier low temperature holding at longer heating time. As temperature is increased, the process time gets exponentially lower that not only saves time and cost but also there is less destruction of heat sensitive nutrients.

Sterilisation requires severe heating and is mostly carried out in bottles or cans after the product is sealed. Once all microbes are killed, as long as no new bacteria are introduced, the product remains unspoiled for a long time although some chemical change may take place. A new process of sterilisation uses aseptic technology. Here, the product is sterilised at ultra high-temperature (UHT), generally about 130°C, for a second or less, immediately cooled and without allowing microbes getting into the product, milk is packed aseptically into sterile containers and sealed, so the product remains sterile and long lasting. UHT process has even greater benefit of preventing the losses of nutrients and the product can be stored without refrigeration.

Fermented Milks

Original function of fermenting milk was to extend its shelf life. With this came many other advantages like improved taste and digestibility as well as producing a variety of products. Earlier, fermentations occurred spontaneously due to indigenous microflora of milk, namely lactic acid bacteria, that produced lactic acid from lactose and typically suppressed spoilage and pathogenic organisms effectively.

Today, the fermentations are controlled using specific starter cultures and controlled temperature. Examples of fermented milk products are acidophilus milk, kefir, koumiss, buttermilk, sour cream etc.

Common Milk Products

There are a large number of products that are made in many parts of the world. Initial efforts were to preserve the milk in different forms but then innovative variations were made to make different products with different consistencies, texture, colours and flavours using many ingredients and to be consumed at different temperatures. There are many types of milk including whole, skimmed (with different fat %), condensed, dried, evaporated, flavoured and milk shakes. There are many types of yoghurt like plain, fruit, low fat, flavoured, drinking etc. There are many cheeses including cheddar, swiss, cottage, cream, reduced fat, stilton, cheshire, soft (brie), blue, mozzarella, whey cheese etc. There are different types of creams and butters and a large number of dairy desserts and sweets like ice creams, custard, pudding and a long list of Indian sweets including shrikhand, rasogolla, pedha, burfi, kulfi, etc.

Butter & Buttermilk

Butter is prepared by souring the cream that is separated from milk by cream separators. After souring, the separation becomes easier and also there is flavour production; especially the formation of diacetyl that gives characteristic buttery aroma. When the soured cream is churned, butter separates from the buttermilk; which is a very nutritious beverage. It has very little fat as most is removed as butter, but it still has most of the other nutrients including protein, vitamins, minerals etc. Buttermilk can also be prepared directly from whole or partially or fully skimmed milk after fermentation. The resultant yoghurt can then be churned and one gets buttermilk with higher fat. Indian traditional lassi is prepared by adding sugar or salt along with spices to this.



Yoghurt

Yoghurt is prepared by fermenting milk by bacterial cultures that convert some of lactose to lactic acid. This lowers pH, giving it tart flavour and a semi-solid texture due to precipitation of proteins at the lowered pH. This product has been produced in many Asian countries including India for centuries using mixed cultures. In India it is called curd or dahi and usually uses cultures present in previous batch of curd. These cultures were natural flora that have been used over long periods.

Industrially produced yoghurt uses pure cultures specially developed to produce lactic acid and good flavour quite rapidly and with consistency, so that production processes could be standardised. Most commonly *Lactobacillus bulgaricus* strains are used, but others are also used. Fruits and other ingredients including flavour and colour may be used to enhance the appeal. Manufacturers have started using other probiotic cultures including *Bifidobacterium* to add health benefits.

Cheese & Paneer

Difference between cheese and paneer is that milk is fermented and enzyme rennet is added to curdle it for cheese making, while lemon juice is added to heated milk and curdled to make paneer. Also, most cheeses are then ripened while paneer is simply pressed and cut into pieces. Cheeses use fermentation with lactic acid bacteria and also use rennet to hasten coagulation. The curd is then cut to drain the whey. Pressing is also used to hasten draining of whey. The drained curd is then milled to form smaller pieces.

Soft cheeses like cottage or cream cheeses are consumed without ripening. Other cheeses are ripened to make hard cheeses like cheddar, edam, swiss etc. or soft cheeses like camembert, limburger etc. The ripening may be done by microbes and/or enzymes that will hydrolyse protein and fat. During ripening, microbes grow and produce flavour substances. In swiss cheese, *Propionibacterium* grows and

produces CO₂, which forms holes or eyes in the cheese along with the bittersweet flavour, while in blue cheese, mould *Penicillium roqueforti* along with the characteristic blue-green colour also produces sharp flavour.

Ice Cream

This is a frozen dessert prepared using milk and cream along with flavourings and sweeteners. The mixture is stirred while cooling so ice crystals remain very small resulting in a smooth texture. In most ice creams a lot of air is whipped giving 'overrun' making the product lighter and softer. There are many variants with flavours as well as with ingredients like fruits, nuts, other confectionery pieces like chocolate, candies, jellies, as well as coated and multiple variants. Some frozen desserts are made with vegetable fats instead of milk fat. One variation is ice cream with cone in which waffle cone is baked and in this ice cream scoops are put to conveniently eat with no other accessories like plate or spoon. This idea is further extended to ice cream sandwich. Now with all types of variants, there are hundreds of different types of ice creams available including Indian variant kulfi. This product is not aerated so is much denser and harder.

Indian milk-based sweets

Indians use mostly cow and buffalo milk for most sweets and these milks are more suited for certain applications than others. For example, qualities such as high total solids and fat content, superior whiteness and viscosity render buffalo milk suitable for making khoa, dahi, paneer, kheer, payasam, malai, kulfi, ghee and other traditional products. Cow milk yields a soft coagulum, making it suitable for preparation of chhana and its products such as sandesh, rasogolla, chumchum and rasmalai.

Buffalo milk also has more protein and fat. The coagulable proteins, caseins are much more in buffalo milk, so when milk is coagulated by heat and acid, there is firmer and denser coagulum produced which is suitable for products like paneer, peda, burfi etc. Cow's milk produces softer coagulum and gives a springy texture, which is more suitable for products like rasogolla, sandesh and rasmalai.

Indian milk sweets have been developed to preserve the nutritional goodness of milk and to extend its shelf life under high ambient temperature. Sweets are mainly prepared from three intermediate product bases: khoa (partially heat-desiccated milk), chhana (coagulated milk after draining of whey) and chakka (concentrated curd).

Khoa is a major intermediate product base for a variety of sweets. It is obtained by rapidly evaporating milk in shallow pans to a total solid content of about 70%. The product could be preserved for several days and is also used as a base for different kinds of sweets like peda, burfi, gulab jamun, etc. Another important base is chhana. It is obtained by acid coagulation of hot milk and draining out the whey. This product is used as an ingredient in different kinds of sweets, especially in the eastern region of India. Chhana based sweets are popularly called Bengali sweets e.g. rasogolla, rasmalai, rajbhog, khirmohan, sandesh, pantua etc. The third major intermediate base is chakka, popular in western India. It is a fermented product obtained from dahi (curd) and is used in a variety of Gujarati and Maharashtrian desserts. Whey is drained using cloth which removes most of the unfermented lactose. Sweets like shrikhand, mishti doi etc. are prepared by adding sweeteners like sugar and jaggery along with flavourants and colours.



Milk: An Excellent Source of Nutrients

Bovine milk has been consumed by humans ever since domestication of cattle and is considered one of the most nutritious foods even for children. Milk has an excellent nutrient profile and provides various macro and micro-nutrients that are essential for them. It provides significant amounts of high quality protein, calcium, riboflavin, magnesium, phosphorus, niacin, vitamin B12, vitamin B6, vitamin A as well as several other essential nutrients.

Comparing the calories provided by milk with the high levels of nutrient contents that are delivered, milk is a very nutrient dense food. When some of the products like skim milk, low fat milk and buttermilk are considered, these have much lower calorie contents, so their nutrient density is even higher.

One of the important nutrients in milk is the high quality protein. Bovine milk is an excellent source of protein, and provides various amounts of all of the essential amino acids that humans cannot synthesise. In proportion, the amino acid composition resembles amino acid requirements of humans. Cow's milk protein is rich in lysine. Lysine is limiting in most plant proteins and so cow's milk complements these plant proteins, elevating the nutritive value of these proteins.

Cow's milk proteins have one of the highest PER (Protein Efficiency Ratio) among all food proteins, with a value of 3.1. Another measure of protein value is PDCAAS (Protein Digestibility Corrected Amino Acid Score). Cow's milk PDCAAS is 1.21, next only to casein, the major milk protein (1.23). Thus, milk proteins are quite nutritious and are used as ingredients in many products to make them more nutritious.

Cow's milk has 13% solids, of which about 27% are proteins. These are made up of two major protein groups, caseins, which account for 80% of milk proteins and whey proteins, which account for about 20%. Much of the studies were done earlier on milk proteins. However, because of technological advancements, it is now possible to prepare commercially various fractions of milk proteins. Lately many new studies have been conducted on whey proteins and their different fractions.

Milk proteins also include whey proteins. When milk is fermented or acidified, casein coagulates and separates from whey. Whey contains soluble milk proteins globulins and albumins together called whey proteins. These have been recognised to be very healthy ingredients in growth, muscle building and maintaining body proteins, so are important ingredients in infant and sports nutrition as well as geriatric products.

Milk is an excellent source of calcium. Its bioavailability from milk is high compared with that in other foods as milk does not contain substances like phytates and oxalates that lower bioavailability. It is also a rich source of B vitamins especially B12 and B2.

Some studies have shown that consumption of low-fat milk reduces risk of hypertension, coronary heart disease, colorectal cancer and obesity. Overweight individuals consuming milk may have reduced risk of insulin resistance and diabetes type 2. Milk is a source of conjugated linoleic acid that has been shown beneficial against cancer and also in lowering cholesterol.

Milk has an excellent nutrient profile and provides various macro and micro-nutrients that are essential for them. It provides significant amounts of high quality protein, calcium, riboflavin, magnesium, phosphorus, niacin, vitamin B12, vitamin B6, vitamin A as well as several other essential nutrients.

Problems with Milk

Some people from ethnic groups in South America, Africa and Asia have lactose intolerance. These individuals have less or no lactase; an enzyme that digests lactose in small intestine. When lactose is not digested, it goes into large intestine where microbes feed on it and produce gas which causes symptoms like bloating, cramps or diarrhoea when a glass or two of milk is consumed. These individuals can have smaller amounts of milk without reaction or they can consume fermented products like cheese, buttermilk, yoghurt or fermented milks in which part of lactose is predigested and also may contain bacteria that help digest remaining

lactose. In the US and some European countries, milk treated with lactase is available. Such milk contains very little lactose and is safe for lactose intolerants.

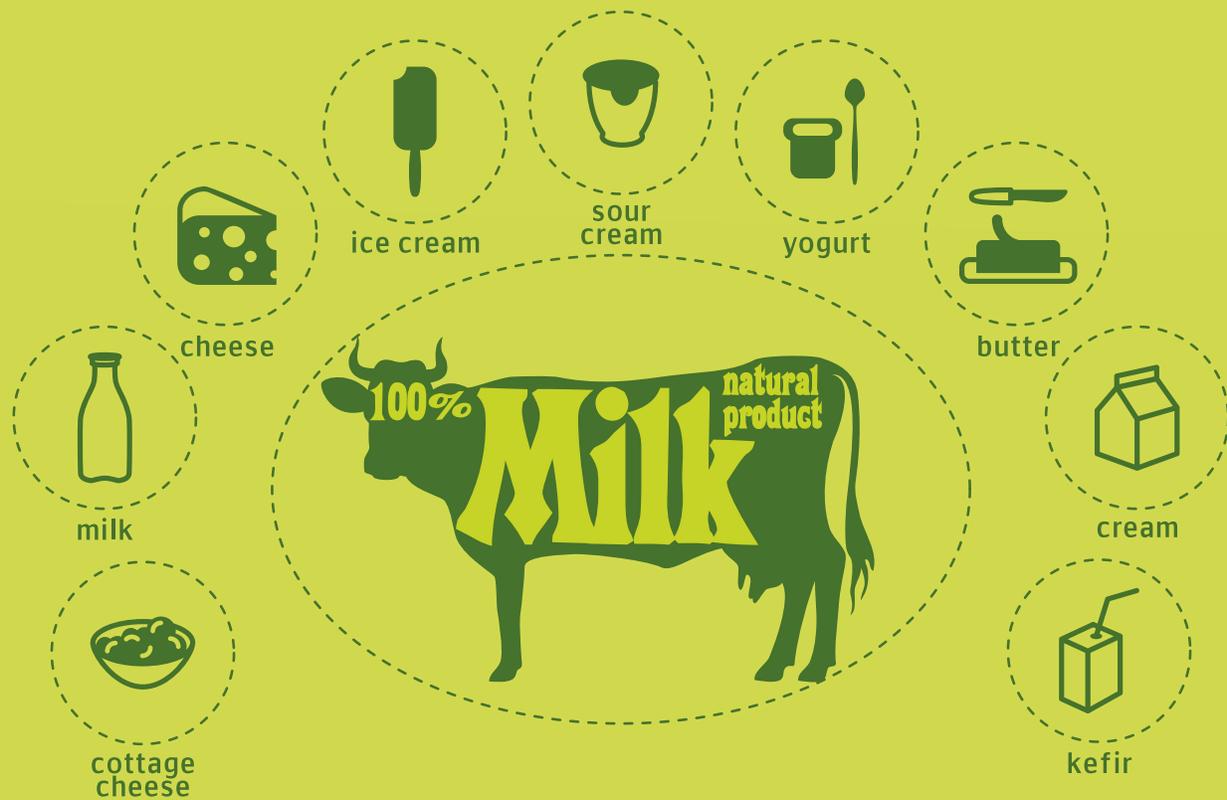
Milk allergy is due to proteins present in milk which may cause allergic reactions in some children that may show skin rash, itching, diarrhoea, wheezing etc. Usually these children outgrow this problem. There are some hypoallergenic milk based formulas available for sensitive children where proteins are hydrolysed to very small peptides; so they won't trigger allergic reaction.

Conclusions

India is the largest producer of milk and Indian food industry is showing rapid growth of many value added food products. Milk is a unique material that is both healthy and has many applications as ingredients in many different food products. Its industrial products like casein, whey protein isolate, caseinates etc. have further enhanced the possibility and usefulness. Indian consumers are showing keen interest in new products, not just western food products like hamburger, pizza etc. that uses cheese and other dairy products, but also variants of traditional products. The future is quite promising for milk and milk products in India.

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“The first food a family should have is milk, and the last food to be dispensed with is milk. It is not the only food, but it is the most important food.”





MESSAGE FROM
Dr. Y. K. AMDEKAR

Milk – the missing component of Indian diet

It is well accepted that milk is the main source of energy for infants and continues to be so to some extent even in toddlers. But as age advances, older children and adults in India do not drink milk and at best consume small amount through tea, coffee or other food items. They certainly are missing many advantages of milk, because milk is a complete nutrition. So, with an exception of infants in first year of life due to possible development of allergy, every child and adult must drink milk, more so as India is the largest producer of milk. Primary lactase deficiency is extremely rare. However, poor intake of milk over years results in decrease in intestinal lactase production that leads to diarrhoea if milk is consumed. "In Touch" brings you an article by Dr. Pai that emphasises importance of milk in our daily diet.

At 82, this duo continues to inspire medicos

On the occasion of World Doctors' Day, young medical practitioners fondly talk about Dr YK Amdekar and Dr OP Kapoor, who are not only revered for being among the fittest in the fraternity, but also for their spirit and enthusiasm in terms of teaching and guiding others in the profession

dna correspondent @dna

Dr YK Amdekar and Dr OP Kapoor have a lot in common. At 82, Amdekar and Kapoor are perhaps the fittest doctors who continue to teach and inspire young medics. Both have been doctors and teachers at JJ group of hospitals. While Amdekar is now a medical director at Wadia hospital and still teaches, Kapoor practises in Fort and gives lectures on Sundays.

According to their students, both are among the greatest teachers in medicine in Mumbai. Dr

Samir Dalwai, developmental paediatrician, said, "Both are gods who have inspired and taught many doctors like me. To begin with Dr Kapoor, he is the original rock star in medicine who has never turned away any student hungry for knowledge."

He added that Kapoor started the concept of night clinic, where he taught medical students for free. "His class was open for everyone. He used to get food for his students too. At this age too, he not only continues practising, but also shares his knowledge with students. It is



Dr OP Kapoor and Dr YK Amdekar

his love for fitness and sports that keeps him going," said Dalwai.

Talking about Amdekar, Dalwai said simple living and high think-

ing has been his motto. "He is extraordinarily intelligent and a sharp clinician. He is actually the Sherlock Homes of paediatrics. He has also helped his students financially," he added.

Dalwai said Amdekar has taught students to be honest with patients about diagnosis.

Dr Suhas Pingle, secretary of Indian Medical Association and a student of both Amdekar and Kapoor, said, "Both are excellent clinicians and teachers.

They are gifted with the talent of being

good teachers as well as good doctors."

Pingle narrated an incident involving Kapoor, when a Dubai citizen had pain in abdomen and had visited many doctors. "No one was able to diagnose the cause. Dr Kapoor asked him only one question, whether he had the habit of biting nails. We all, including the patient, were shocked. He had observed the patient from head to toe and seen his nail-biting habit, which was related to his stomach pain," he said.

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