Historical Aspects of Milk Consumption in South, Southeast, and East Asia

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Abstract

Man has been using the milk of several animals, such as goat, sheep, cow, buffalo, horse, camel and donkey in different regions of the world since times immemorial. From the South, Southeast and East Asian viewpoint, cow, buffalo and goat milk are the most important. The contents of protein, fat, lactose and minerals differ considerably in milk from different animals. The per capita consumption of milk in Southeast and East Asia is very low and one of the reasons ascribed for this is high lactose intolerance in ethnic groups present in these regions. However, there are indications that continued use of milk and living near dairy farms can lead to lower lactose tolerance. Also milk products, such as, cheese and yogurt can be taken, without concern for lactose. Low consumption of milk has been held to be partly responsible for low male heights in this region. Currently, there is considerable global interest in the use of dairy proteins as supplements to improve metabolic health in humans and this should attract the attention of the people in South, Southeast and East Asia. With the establishment of Asian Dairy Network (DAN) in 2012, a good progress has been made in increasing the consumption of milk in Southeast and East Asia but it is still very low compared to other regions of the world. India has made commendable progress in dairy development and has emerged as the world's largest producer of milk, yet the per capita milk consumption is much lower than the average of the developed countries and it exports only 4% of its total produce. Indians used to be the major milk producers in Southeast Asia during 18th and 19th Century and it is high time that India seriously explores the ways and means of playing the key role in augmenting milk production and consumption in Southeast and East Asia. It has the advantage of being nearest to the region and of ethnic connectivity. Can India make the history repeat itself in its contribution towards milk production and consumption in Southeast and East Asia?

Milk is nature's complete food, with which all humans start their life. Medical research has proved that mother's milk is the best for the infants (Ip *et al.*, 2007; Dietrich *et al.*, 2013). No wonder, World Health Organization (WHO, 2011) recommends that children are breastfed for at least six months after birth and partly breastfed up to 2 years, supplemented with external milk and other soft foods. Thus milk from different animals has a major role in the bringing up of young toddlers and their future health. Each 100g of cow's milk contains about 3-4g high quality protein, 4-5g sugar and 3-5g of fat including 0.1g of Omega-3 fats. About 20-28 % of the protein requirement of humans in the western countries is met by milk and dairy products (Smit *et al*, 1999; Vissers *et al.*, 2011). Milk also supplies vitamins B1(Thiamin) and B2 (Riboflavin) and is a rich source of calcium, which is essentialfor the formation of bones (Hess and Slavin, 2016). Milk has been an important component of Indian diet since Vedic period (1500-500 BC; AAHF-C 8000 BC), since the Indo-Aryans were a pastoral society (O'Conner, 1993; Basham, 2008; Anthony, 2010).

Thanks to the sincere and devoted efforts of World Food Prize Laureate Dr Verghese Kurien, which led to the 'White Revolution' in India and made it the largest producer of the milk in the world by the end of the 20th Century; surpassing even USA (Kurien, 2005). The milk production in India increased from a mere 17 million metric tons (MMT) in 1950-51 (GOI, 2002) to 146 MMT [equivalent to 490,000 metric tons (MT) of NFDM (non- fat dry milk)] in 2014-15 (USDA, 2016). However, bulk of India's milk produce is consumed within the country and only 20,000 MT of NFDM (a mere 4% of the total production) was exported during 2015-16, mostly to neighboring countries, namely, Bangladesh, Nepal, Bhutan, Afghanistan, Pakistan, and United Arab Republic.

Domestication of animals producing milk

It is well known that to begin with man was a hunter and gatherer (McDougall, 2005). In his hunting trips, the early man discovered that some animals, such as sheep, goats, cattle etc. moved in herds and were easy to chase, hunt and raise. He started domesticating and raising them as a pastoral society for meat and skin (Hayden, 2009; Prasad *et al.*, 2016a). Since all such animal females produced milk for their newborns, men also started exploiting them for milk for their own use. Humans have used and are using the milk of cows, buffaloes (generally referred to as water buffaloes), goats, sheep, camels, horses, donkeys, camels, and yaks, depending upon the region, where they were/are abundant. Susruta, the ancient Indian physician, mentioned the use of cow, buffalo, goat, and sheep milk in India (Sarkar *et al.*, 2015). A brief description of domestication of milk producing animals in different regions follows.

Cattle (*Bos taurus*). Cattle were domesticated in Turkey about 12,500 BC (Wilson and Reeder, 2005; Bollongino *et al.*, 2012). From there they spread westward to other European countries and eastward to the Indian sub-continent. Why they did not spread further to Southeast and East Asia is not clearly understood. Cows contribute more than 80% of the total milk produced in the world and USA is the

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largest producer of cow milk, producing 91.27 million metric tons (MMT), followed by India producing 60.6 MMT (FAO, 2013).

Buffalo or Water buffalo (*Bubalis* spp). There are two extant types, namely, 'River buffalo' (*Bubalus arnee bublis*) domesticated in India about 5,000 - 3,000 BC and 'Swamp buffalo' (*Bubalis arnee carabenesis*) domesticated in China about 4,000-2,000 BC (Cockrill, 1974; Kumar *et al*., 2007; Yang *et al*., 2008). River buffaloes prefer deep waters, while swamp buffaloes prefer to wallow in mudholes, which they make by their horns. Buffalo has been used in paddy cultivation and for transporting farm produce in Southeast Asian countries since long; why it was not used much for producing milk in those countries is not understood. India is the largest producer of buffalo milk in the world. According to FAO Statistics, in 2013, 102 million metric tons (MMT) of buffalo milk was produced in the world, of which India produced the most 70 MMT [68.6% of world production (WP) i.e. about two-thirds] and was followed by Pakistan (24.1 MMT; 25.2% WP), China (3.0 MMT; 3% WP) Nepal (1.2 MMT; 1.2%WP), Myanmar (0.2 MMT; 0.2%WP) and Vietnam (0.03 MMT; 0.03%WP) (FAO, 2013).

Sheep (*Ovis aries*) . The sheep was domesticated in Mesopotamia (present Iraq and neighbouring countries) during 15,000 to 13,000 BC (Ensminger and Parker, 1986) for meat, skin and milk. Wooly sheep were evolved in Iran about 10,000 BC (Weaver, 2005). Sheep milk is mostly produced in Europe and nearby Mediterranean countries. In 2012, 10.1 million metric tons of sheep milk was produced, which was only 1.3 % of the total milk production in the world (Sheep101.info via internet)

Goat (*Capra aegagrus hircus*). The goat was domesticated in Iran about 12,000 BC (Maisels, 1999; Naderi *et al*., 2008) for meat, milk and skin. In 2013, 17.8 MMT of goat milk was produced, which was 2.4%

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of the total world milk production. India is the largest producer of goat milk; roughly about 22% of the world production (Aziz, 2010). Goat hide has been used since ancient time for transporting water and wine. Persons carrying water in goat hides are known as '*bhistis*' in India.

Camel (*Camelu* spp). There are two kinds of camel. The 'Dromedary camel' (the single hump camel of Arabia) (*Camelus dromedarius*) was domesticated in Somalia and Southern Arabia around 3,000 BC (Bulliet, 1990; Scarre, 1993), while 'Bactrian camel' (the two hump camel of Central Asia *Camelus bacteranus*) was domesticated in Central Asia around 2,500 BC (Mukasa-Mugerwa,1981). Camel milk is a staple food for desert nomadic tribes. In 2013, 2.8 MMT of camel milk was produced in the world. Ethiopia is the largest producer of camel milk at 1.1 MMT (39.3 % of WP), followed by Kenya at 0.94 MMT (33.6 % of WP) (FAO, 2013). India has just made a beginning and the first micro camel milk dairy 'Kumbhalgarh Camel Dairy' was established near Ranakpur in Pali district of Rajasthan in 2015 (via internet). Recently 'Gujarat Co-operative Milk Marketing Federation (GCMMF) has obtained permission of the Food Safety & Standards Authority of India (FSSAI) for collecting camel milk in Kutch area of Gujarat and marketing it.

Donkey (*Equus africansasium*). The donkey was domesticated in Nubia and Somalia probably much before the domestication of cattle (Kimura *et al.*, 2011) although their organized breeding in Africa started about 3,000 BC and later it shifted to Mesopotamia in 1800 BC (Rossel *et al*., 2008). Donkeys were priced possession in Egypt during 2,675-2,565 BC. China has probably the largest number of donkeys (Kugler *et al.,* 2008).

Horse (*Equus feruscaballus or E. cabalus*). The horse was domesticated in Kazakhstan about 6,000 BC (Outram *et al*., 2009). Russian and many nomads in the European steppes use horse milk. Dry powdered horse milk is available from Germany, France, and Italy (Park and Haenlein, 2008).

Yak (*Bos grunniers*). The yak is of cattle family (*Bos*) and is found throughout the Himalayan region of South-central Asia, the Tibetan Plateau and as far north as Mongolia and Russia. The major yak belt is fairly high in altitude and is referred to as 'Roof of the World'. Yak is reported to have been domesticated by Qiang people, who lived as early as 30,000 years ago in the Qunghai-Tibetan Plateau region. However, most domestication and use of yak milk began 2,800-2,300 BC (Phillips *et al.*, 1946; Yanwen, 1979).

Organic constituents of milk from different animals vis-à-vis human milk

The major organic components (protein, fat, sugar) of milk from different animals vary considerably depending upon breed, region and feeds and forages. Some data including human milk are provided in table1. The comments made here are of a very general nature.

Lactose content is fairly high in human milk, which is mainly responsible for problems such as boating, nausea, and cramps in the stomach in persons not producing enough lactase. Donkey and horse (mare) milks have also high lactose content. This could be one reason, why horse milk is consumed generally after fermentation, and the drink is called 'Kumis' (Zedar, 2006).

In general, buffalo and sheep milk are richest in fat, ash, total dry matter and energy. In India, the general fat content in buffalo milk is 6.17 -7.43 % (Misra *et al.,* 2008) as compared to 3.6-5.5% in cow milk (Abraham and Gayathri, 2015). The protein content in buffalo milk could be 3.87-4.03 % as compared to 3.1-3.3 % in cow milk. Thus in general buffalo milk has more nutrients than cow milk. The fat in buffalo milk has, however, slightly higher levels of saturated fatty acids, but the casein in it has larger micelles and is richer in minerals (Abd El-Salam and El-Shibiny, 2011).

Goat milk has the lowest lactose content and is fairly rich in protein and has been traditionally used as the first milk during weaning period of children. Goat milk is claimed to have anti-inflammatory and metabolism and immune boosting properties. Nevertheless, a number of reports have described a host of morbidities associated with the use of goat milk for young children, including severe electrolyte abnormalities, metabolic acidosis, megaloblastic anemia, allergic reactions including life-threatening anaphylactic shock, hemolytic uremic syndrome, and infections (Basnet *et al.*, 2010).

Horse milk is rich in whey proteins, poly-unsaturated fatty acids and vitamin C (Park and Haenlein, 2008). Donkey milk (also known as *equid* or *jenny* milk) has been used for overcoming some of the children's ailments and for skin care and making the cosmetics (Salimei and Fantz, 2012; Cosentino *et al.*, 2013, 2015). Also in many African countries donkey's milk is the only

Table 1. Organic constituents (mg/100g) and energy (kJ/100g) of different milks.

Species	TDM	Fat	Protein	Lactose	Ash	Energy
Human[1]	10-13	2.1-4.0	0.9-1.9	6.3-7.0	0.2-0.3	270-209
Horse[1]	9-12	0.4-7.2	1.3-2.0	6.0-7.2	0.3-0.5	109-210
Donkey[1]	8-12	0.3-1.8	1.4-2.0	5.8-7.4	0.3-0.5	160-180
Buffalo[1]	16-17	5.3-15.0	2.7-4.7	3.2-4.9	0.8-0.9	420-480
Cow[1]	12-13	3.3-6.4	3.0-4.0	4.4-5.6	0.7-0.8	270-280
Goat[1]	12-16	3.0-7.2	3.0-5.2	3.2-4.5	0.7-0.9	280-290
Sheep[1]	18-20	4.9-9.0	4.5-7.0	4.1-5.9	0.8-1.0	410-440
Camel[2]	11-14	3.6-4.9	3.0-3.7	4.4-5.1	0.7-0.8	na
Yak[3]	17.8	4.3	3.4	4.7	0.8	na

Sources : 1. Gantner *et al* (2015); 2, Sawaya *et al* (1984); Indra (1997); na = not available

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milk available for human consumption and is considered good and safe (Ianco *et al.*, 1992; Guo *et al.*, 2007).

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Yak milk is the only milk available in the mountain regions of Tibet and Central Asia, while camel milk is the staple in desert areas (Sawaya *et al.*, 1984).

Mineral composition of milk from different animals vis-à-vis human milk

Minerals are generally reported as ash in milk. The ash content in milk varies only from 0.2 to 0.8%, but is an important component from the viewpoint of human nutrition and health. It has not received the attention it deserves, because bulk of the attention is focused on protein, fat and sugar content as discussed earlier. Data on the content of seven, most important minerals, from the human nutrition and health viewpoint are presented in table 2 (Soliman, 2005). Calcium (Ca) and phosphorus (P) are involved in the bone formation. Low intake of calcium leads to osteoporosis, which is characterized by

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low bone density. Osteoporosis increases the chances of hip fracture, especially in post-menopausal women (Alami *et al.*, 2016). Sodium (Na) and potassium (K) are involved in the body's electrolyte functions. K^+ is the principal cation inside the cell, while Na^+ is the principal ion in the extra-cellular fluid. K^+ concentration inside the cell is about 30 times higher, while Na^+ concentration is about 10 times lower than outside the cell. These concentration differences create membrane potential, which is maintained by Na and K-ATPase pumps and is important for nerve pulse transmission, muscle contraction, and cardiac function (Hall and Guyton, 2006). Potassium also helps in maintaining a healthy blood pressure (Sacks *et al.,* 1998). Magnesium helps in regulating K^+ fluxes and is also involved in Ca metabolism (Al-Ghamdi *et al*., 1994). Iron's role as a component of hemoglobin in transferring oxygen from lungs to all other parts of human body is well known and iron deficiency anemia is rampant in Asia including India (Clark, 2009; Rangrajan and D'Souza, 2007; Prasad *et al*., 2014). Zinc deficiency leads to dwarfism in humans and it is also rampant in Asia (Prasad *et al.*, 2014). For more information on the role of minerals in human nutrition reference may be made to Prasad *et al* (2016b).

As per the data in table 2, human milk has the lowest amounts of minerals. Buffalo milk has the highest Ca and P content, much higher than cow's milk. Thus for growing children buffalo milk is better than cow's milk from the viewpoint of bone health and development. Muelhoff *et al* (2013) reported following values for Ca (mg/100g) for different milks: buffalo 147-220 (average 191), sheep 170-207 (average 190), goat 100-134 (average 118), and cow 91-120 (average 112), indicating the superiority of buffalo milk in supplying Ca. Goat's milk has the highest K. Calcium content in the goat milk is higher than the cow milk. Camel milk has the highest Na, Fe and Zn content.

Milk consumption in South, Southeast and East Asia

Despite being the largest milk producer, the per capita consumption of milk in India in 2000 AD was only 79kg/year as compared to the European Union average of 496 kg/year and United States of America's average of 287kg/year (Box 6) (Table 3). In Asia, Pakistan had the largest per capita milk consumption of 180kg/year, while Vietnam had the lowest consumption of 8kg/year; up to 1990 milk consumption in Vietnam was dismal at 1kg/year. Even China was not good at 11 kg/year. In general, the milk consumption in developing countries of the world in 2000 was only 23.8% of that in developing countries.

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Table 2. Mineral content (mg/100g) in milk from different species.

Species (Samples)	Calcium	Phosphorus	Sodium	Potassium	Magnesium	Iron	Zinc
Human (70)	32.4	14.0	16.0	51.8	3.4	0.05	0.16
Buffalo (40)	163.2	111.4	51.6	167.2	29.6	0.13	0.24
Cow (44)	119.9	95.0	49.7	147.0	13.4	0.07	0.38
Goat (40)	130.3	110.2	50.3	201.4	13.9	0.06	0.32
Camel (108)	111.4	81.2	57.8	156.3	6.7	0.23	0.51

Source: Soliman (2005).

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Table 3. Per capita milk (milk equivalents) consumption (kg) in South, Southeast and East Asian Countries vis-à-vis USA and European Union (EU).

Region/country	1981	1990	2000
Asia	33	39	50
China	3	6	11
Mongolia	141	144	176
SE Asia	6	10	16
Thailand	8	14	26
Philippines	14	19	22
Malaysia	48	41	52
Viet Nam	1	1	8
South Asia	543	66	84
India	50	63	79
Pakistan	113	134	180
Bangladesh	16	17	18
Sri Lanka	24	28	33
Nepal	49	50	50
World	86	80	104
Developed	222	180	235
Developing	35	40	56
USA	271	274	287
EU	na	363	496

Source: FAO (2008).

Causes for low milk consumption in Southeast and East Asia

Historical. Presence or absence of milk as a dietary constituent separates South Asia, especially the Indian sub-continent (India, Pakistan, and Bangladesh) from Southeast and East Asia. The historical 'milk line' roughly runs between the geopolitical borders of Bangladesh, Northeast India, and Myanmar (Simoons, 1970). When Myanmar (Burma) was a part of the British Empire, the colonial officers had difficulty in getting good quality milk even in Yangon (Rangoon formerly), the capital of Myanmar and the Indian dairymen were among the first and most active suppliers of milk in the region, especially in the urban areas. Milk consumption by locals was nil to very low. According to Saha (2006), as per the then Imperial imagination,there were three factors responsible for nil to low consumption of milk in Myanmar: i. Characteristic customs and conventions of Burmese people; ii. Introduction of Indian dairy animals was considered to be associated with the encroachment of Indians into Burmese life and colonial officials viewed it as an alien and potentially damaging intrusion; and iii. Material obstacles in the introduction of large-scale dairy production. As a consequence milk production in Myanmar never caught up. Even today, in Myanmar, milk is mainly used in the form of hot tea with condensed or evaporated milk, while consumption of fresh milk for drinking purposes is limited to infants and elderly persons (Hinrichs, 2014).

As regards the then French Indochina (now independent countries of Cambodia, Laos, Vietnam), from the mid-nineteenth century, the listing for 'merchants of milk' consisted entirely of Tamil names (Pairaudau, 2015). By the turn of the century, some thirty Tamil businesses supplied milk to the Saigon (Ho Chi Min City) and neighborhood. Yet in 1913, the scores of Indian milkmen listed in the colonial commercial pages abruptly disappeared, replaced by a single listing: 'Nestlé and Anglo-Swiss Condensed Milk Co'. The rise and subsequent decline of Indochina's Indian dairymen traces a pattern which repeated itself across Southeast Asia and as a consequence milk consumption in Southeast Asia remained very low in the 20th Century. Nevertheless, the success in Thailand of FAO's school milk program, wherein each child is given 200 ml of milk everyday free of cost, has improved the overall wellbeing of the children and its linkage to the smallholder dairy development has led to the increased livelihood of the farmers and increased production of milk in the country. This model is now being copied in other

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Southeast and East Asian countries, such as, Myanmar, Vietnam etc. (FAO Regional Office for Asia and the Pacific, via internet). A similar report is available from Malaysia (Chen, 1989). It is hoped that over years, such programmes will increase the component of milk in Southeast and East Asian diet and will improve the health of the people. From children's viewpoint the availability of chocolate or other flavored milks are a big attraction, although these are a little costlier.

Furthermore, recently with the establishment of Asian Dairy Network (DAN) in 2012 by the Animal Products and

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Health Commission for Asia and the Pacific (APHCA) as a part of the Smallholder Dairy Development Program support of the Food and Agriculture Organization of the United Nations (FAO) and the Common Fund Committee (CFC), good progress has been made in the development of dairy industry in Southeast Asia (Hinrichs, 2014) and milk consumption has gradually increased. This has received further fillip due to the interests of the international dairy industry (Duteurtre**,** 2015). Bulk of the milk consumed in Southeast Asia at present is imported from abroad. Vietnam has made serious attempts, including importing *Murrah* buffaloes (some from India), for increasing milk production (Su *et al*., 1989). No wonder that 'Vina Milk' an Vietnamese dairy producer is setting up a milk processing plant in Cambodia and Cambodia's own Angkor Dairy Products is going to set up a large-scale dairy farm to supply adequate milk for processing at the Vietnamese processing plant (Igor, 2015).

Nutritional. Human milk is fairly high in lactose content and although infants in all ethnic groups have lactase production capacity and thus can tolerate high lactose content in mother's milk, this capability tends to decrease by the time the infants are weaned from the mothers. This is true for most mammals, who tend to cease to produce lactose after weaning and tend to develop lactose intolerance (Swallow, 2003).

Lactose intolerance (LI) is ascribed as one of the reasons for low milk consumption in Asia. It is generally viewed that LI is primarily due to genetic factors (Simoons, 1969; Flatz and Rothauwe , 1971). Yuval *et al* (2010) reported that LI was the most in East Asians (90-100%), followed by Central Asians (80%) and was the least (5-15%) in British (UK); the LI values for some other ethnic and geographic regions were: North Indians (30%), South Indians (70%), Germans (15%), French from Northern France (17%), French from Southern France (65%), Anglo-Americans (21%), Latin-Hispanic Americans (51%), and African Americans (75%). Some of the low LI values in European countries could be due to the fact that a large part of milk is consumed as dairy products, such as, cheese and yogurt, which have no lactose.

In China, the concept of LI was recognized quite early and led to their departure from classical health benefits about the importance of milk and dairy products (Smith, 2015). As early as the 1^{st} Century BC, Chinese medical writers pronounced that foods appropriate for people from one

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region might prove inedible to people from another region and later (13th Century onwards), they specified that dairy products suited northern steppe nomads with pastoral agriculture and hardy constitutions, but were not suitable to most Chinese in other regions. This agrees to the European experience, such as in Britain, where dairying has been an important component of country's agriculture. Deng *et al* (2015) opined that LI can be reduced if the persons continue to drink milk and live in the vicinity of dairy farms. As already pointed out that some of the milk products, such as, curd or yogurt can be easily taken without any adverse effects, because they do not contain lactose, which is changed to lactic acid by *Lacto bacillus* during fermentation.

Most individuals with lactose intolerance can tolerate up to 12g of lactose (about 250ml of cow milk, that will also supply 300mg of calcium, which is 30% of the recommended calcium intake for adults) without suffering gastrointestinal symptoms; symptoms become prominent at doses above 12g and are appreciable above 24g of lactose (Savaiano *et al*., 2006; Wilt *et al*., 2010). Thus people in Southeast and East Asia can easily consume at least small quantities milk and milk products without any health problem (McBean and Miller, 1998). For those, who still have problems with the direct consumption of milk, lactase pills/tablets are available and can be used, preferably under medical advice.

Milk Consumption and Human Health

Human body has two main components, namely, the muscles and bones. Muscles are made up of proteins, while bones are mostly hydroxyapatite [$Ca_{10}(PO_4)_6(OH)_2$]. Milk supplies proteins for the formation of body muscles, and Ca and P for the formation of bones. In addition, it also supplies fat and sugar to provide the energy for the functioning of human body. This is why milk is considered a complete food. Milk has two kinds of proteins, namely, caseins and whey proteins. In cow milk, approximately 82% of milk protein is casein and the remaining 18% is serum or whey protein. The casein family of protein consists of several types of caseins (α-s1, α-s2, β, and κ) and each has its own amino acid composition, genetic variations, and functional properties (Kunz and Lonnerdal,1990). The major whey proteins in cow milk are β-lactoglobulin and α-lactalbumin. Milk proteins are high quality proteins and are easily absorbed and utilized. The protein ranking standard PDCAAS (Protein digestibility Corrected Amino Acid Score) value for milk proteins (both casein and whey) is 1.0 as against, 0.91 for soybean, 0.7 for pea and 0.5 for rice (Schaafsma, 2000). Thus rice consumers in Southeast Asia are at disadvantage and this could be a factor for their lower male height. Evidence from epidemiological studies suggest that greater consumption of dairy products is associated with lower risk of metabolic health disorders, including hyperglycemia (high blood sugar or glucose), dyslipidemia (elevation of plasma cholesterol, triglycerides or both), abdominal obesity, hypertension and cardiovascular diseases (CVD) (Rice *et al*., 2011; Crichton*et al.,* 2011; Ralston *et al*., 2012; Soedamah-Muthu *et al*., 2012; McGregor and Poppitt, 2013; Qin *et al.*, 2015; Rosenberg *et al*., 2016). Sodhi *et al* (2012) reported that populations that consume high levels of β-casein A_2 variant have lower incidence of cardiovascular disease and Type1 diabetes. Milk whey protein are especially reported to lessen several risk factors for metabolic diseases (Graf *et al.*, 2011; Pal and Radavelli-Bagatini, 2013; Sousa *et al.*, 2012; Jakubowicz and Froy, 2013). Milk whey proteins are also reported to promote bone formation (Aoe *et al.*, 2001).

Human body has two main components, namely, the muscles and bones. Muscles are made up of proteins, while bones are mostly hydroxyapatite [$Ca_{10}(PO_4)_6(OH)_2$]. Milk supplies proteins for the formation of body muscles, and Ca and P for the formation of bones. In addition, it also supplies fat and sugar to provide the energy for the functioning of human body. This is why milk is considered a complete food.

One valuable index of the human health of a country is its male height. Male height is preferred, because the males are considered to stick to their ethnic groups. Male height is considered to be affected by a number of factors including, genetic, overall prosperity, general health and nutrition. Robinson *et al* (2015) from a European study covering 14 countries suggested that genetic factors explained about 24% variation in male height. However, Grasburger *et al* (2016) based on a global study covering 105 countries suggested a much larger contribution of genetic factors in determining the difference in male height; in their study a correlation efficient value of r=0.75 (P<0.001) was obtained. Male height was the highest (> 175 cm) in Europe, followed by highly developed countries in Asia (Japan, Singapore, South Korea, Taiwan), China and North African countries (170-175 cm) and was the lowest in the South and Southeast Asia (<170 cm). Grasburger *et al* (2016) also studied the effect of a number of other factors on male height;

these included protein nutrition (FAO Stat), GDP [Gross Development Product determined by Purchasing Power Parity (PPP) in US $], level of heath expectancy as affected by PPP, children mortality under 5 years and total fertility (World Bank data), Gini index of social inequality (CIA World Facebook data), and HDI (Human Development Index) of UN. Their study showed that HDI and protein nutrition had more bearing on male human height than other factors. The intake of protein from milk and milk products emerged as the most significant factor affecting male human height ($r=0.79$, $p<0.001$); this was most significant for India. In India, milk consumption as well as the male height was most in the Northwest and the lowest in Northeast. Available data indicate that as the milk consumption decreased from 1032g/day in Punjab to 219g/day in Bihar, the male human height decreased from 168.6cm in Punjab to 163.8 cm in Bihar (Manidi *et al*, 2011). Grasburger *et al* (2016) also pointed out that male human height correlated most negatively with the consumption of rice proteins ($r= -0.74$, $P<0.001$). In addition to the proteins, milk is also a rich source of calcium, which is the key element in the formation of bones, which are chemically hydroxyapatite. A number of researchers have reported the importance of increased calcium intake through milk in increasing human height (Takahashi, 1984; Black *et al*, 2002; Okada, 2004). Up to about two-thirds of Ca intake in humans in western countries is from milk and milk products (Gueguen and Pointillart, 2000). Calcium content (mg/1000g) in cow milk and its products is reported to be: milk (3.7% fat) 119, skimmed milk 122, yogurt (plain low fat) 183, cheddar cheese 721, cottage cheese 86, and ice cream (vanilla) 128 (USDA, 2013). Calcium content (mg/100g) in milk from other animals is as follows: goat 100, sheep 170, and buffalo 195 (USDA, 2011). Ca content (mg/100g) in some green vegetables is: kale 72, broccoli 49, spinach 135, red beans 24, and rhubarb 145 (Weaver *et al*., 1999). As a contrast grains, such as, rice, wheat, pigeon pea, and soybean, supply only 1, 3, 13 and 28 mg Ca/100g, respectively. Thus in addition to being a poor supplier of complete proteins, rice is also the poorest supplier of calcium. This could further be responsible for the lowest human height in Southeast Asia, where rice is the staple food. As already pointed out calcium deficiency can lead to osteoporosis, while calcium and vitamin D supplements can prevent osteoporosis (Tang *et al*., 2007; Nowson, 2010). Adequate intake of milk and milk products can be of great help in preventing osteoporosis.

Epilogue

Famines and food shortages frequently occurred in India in the 18th and 19th Century (Prasad, 2013) and even in the 20th Century, the 1942-43 Bengal famine provided the backdrop to India's Independence. After gaining the freedom from the British Empire in 1947, the Government of India's first priority was to provide enough food grains for its people. During 1960s, India depended heavily on wheat imports from USA under Public Law 480, which was well known as 'Ship to Mouth' situation in the country. This encouraged Paddock and Paddock (1967) to prophesize a food famine in India in 1975. However, the Indian Agricultural Scientists with the technical guidance and support of the Nobel Laureate Norman E. Borlaug from CYMMIT, Mexico, developed dwarf high yielding wheat varieties that led to 'Wheat Revolution' in 1967-68 (Swaminathan, 2013) that falsified the prophecy of Paddock brothers.

India's agricultural research has always focused on crop husbandry and grain production although a large number of farmers always depended on small scale milk production for supplementing their income. However, the 'White revolution' has now drawn the attention of the Government of India and serious efforts are underway to develop dairy industry in India. Gujarat, Punjab, Haryana, and Rajasthan have already taken a lead in this direction. Eternal drought prone areas, such as Bundelkhand region of Uttar Pradesh and Madhya Pradesh and similar regions in other states should seriously consider developing dairy farming. In these regions, there is an urgent need for developing the silvopastoral and agroforestry systems (Rai,1999; Saha, 2001; Cheng and Meade, 2003; Kallenbach *et al.*, 2006) in place of traditional crop husbandry resulting in frequent crop failures.

The latest figures indicate that per capita milk availability in 2015-16 was 123kg in India as compared to world average of 83.6kg.

Being the largest producer of milk in the world should not lead us to the complacency, although the latest figures indicate that per capita milk availability in 2015-16 was 123kg in India as compared to world average of 83.6kg (Business Standard 13th January, 2017), however, it is still only 43.3% of the value of 284kg in USA. So to catch up with the developed world, India has a long way to go. Further, we are way back in producing internationally marketable milk products, such as, different kinds of cheese (Mozzarella, Cheddar etc.), the market for which is increasing in the metros of India and big cities of other countries due to increasing popularity of fast foods, such as, pizzas, burgers, and sandwiches among the young ones. India does not have adequate know how and experience in making these products and need to learn these real fast, if they have to internationally compete in dairy industry. In the India, the milk products made are curd, country cheese (*paneer* or *chhena*), *khoya* or *mawa* (a pan evaporated semi-dry product used for making Indian sweets), butter, ice cream and *ghee* (clarified butter). But for the butter and ice cream there is no international market for other Indian milk products even in the Southeast and East Asia. It is hoped that the authorities of recently announced Government scheme 'SAMPDA' (Scheme for agro-Marine

Processing and Development of Agro-processing Clusters) by Shri Narendra Modi Ji, Honourable Prime Minister of India (Times of India.Com 26 May, 2017, via internet) look seriously into this matter, especially because presently dairy industry in India is on the top of the world in milk production. Also there is an urgent need of food quality testing laboratories, because for international marketing, each package must specify the nutritional components and stand guarantee for it. Indian dairy industry itself will have to keep this in mind, while establishing milk processing and product manufacturing plants.

It is hoped that the authorities of recently announced Government scheme 'SAMPDA' (Scheme for agro-Marine Processing and Development of Agro-processing Clusters) by Prime Minister of India look seriously into this matter, especially because presently dairy industry in India is on the top of the world in milk production.

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