Milk production its commercial aspects, ethical issues, impacts on human health and relation to the widely growing science of biotechnology

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Abstract This paper will discuss the implications of biotechnology in commercial milk production and the concerns and issues that arise with it. Milk as a dietary product has been consumed by humans for ages, with increasing human population the need of milk and milk related products have increased tremendously this has led to the advent of commercial dairy farming. Dairy farming is one of the major areas of animal husbandry in developed countries like New Zealand and Netherlands; it is also one of the most indulged ccupations of a common household in sub-urban and rural parts of India. With the growing need of milk related products and constant decline of available free pastures, there has been a need for the development of cow breeds having genetic potential that provides maximum productivity and has low vulnerability to diseases, this is where animal biotechnology is expertise. But, the increasing demand s and price of milk products have exposed these animals to increased health risk as they have been over-exploited for receiving maximum benefit that has in turn raised a lot of ethical issues and concerns. Moreover poor cattle raising practices and unplanned dairy management system has increased the overall susceptibility of the consumers to contagious diseases and infection.

Index Terms— GM Genetically Modified , SCC somatic cell count

1 Introduction Milk is the most common food available in almost every house hold, people consume it with additives like coffee and tea, it has been a practice that has been flourishing for ages and with the advent of modern biotechnological techniques there has been a lot of modification in the way it's extracted, transported and consumed. Milk is produced by mammals (cows, buffalos, goat etc) for the nourishment of young ones, and is also available in the form of many fermented products like cheese, yogurt, butter which is widely consumed by people of all age group. Commercial dairy farming has been one of the most industrialized areas that include co-operatives comprising of hundreds of farmers that have thousands of milk producing cows in large pastures, many types of purifying plants and several distribution units, Fonterra of New Zealand is an example of one such industrialized company that is leading in milk supplies.

The advent of modern biotechnological methods like Pasteurization has made storage and supply of milk possible as it helps in keeping the milk pure from bacteria and other micro-organisms. Animal Breeding techniques like selective breeding, cross-breeding, embryo transfer, artificial insemination and genetic engineering have further supported the dairy industry by producing high yielding varieties of cows, increasing the annual productivity by several times and decreasing the vulnerability to possible diseases.

Although huge the modern dairy farming practices raise a lot of ethical issues, in order to generate more money the culture of brutal practice have been flourishing in dairy farming. There are farms that claim to be raising their cattle's in free pasture but most of the cows in the dairy industry are grown in concrete floor tied to a place where they have to live for their entire lives. Moreover they are fed un-natural diets compromising of very high protein against their natural instinct for grasses so many of them suffer from stomach ulcers, toxicity and related health problems. They are kept in poor sanitation, almost bathing in their own feces and urine. Milk production is a result of pregnancy in all mammals and all mammals have a certain age of fertility and health period in which the parent lot could support the growth of the offspring by providing proper nourishment without having negative effects on itself. But the misuse of modern medical biotechnology by many commercial dairy farms has menaced the reproductive cycle of these animals by the exploitive uses of female sex hormones like oxytocin to induce the cows heat cycle and withdraw maximum amount of milk which is in-turn causing a lot of health issues to human beings. (Das, 2014)

2 NUTRITIONAL VALUE

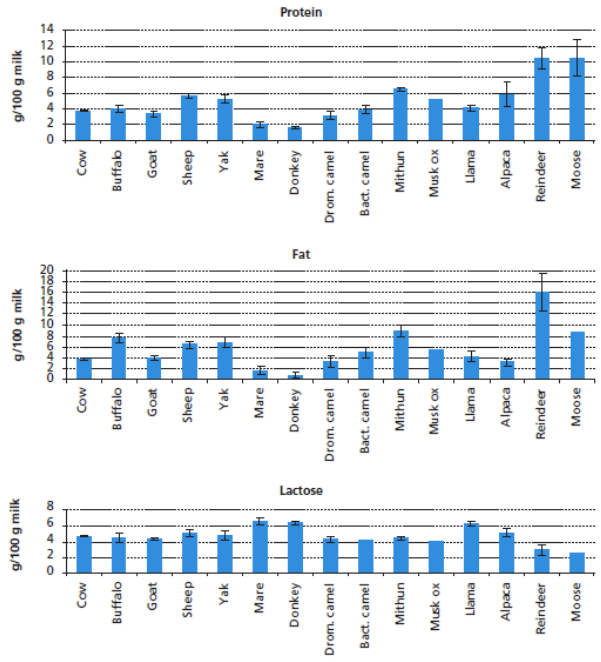
Milk is the primary food for the infants of all mammals hence it is required to contain all the essential vitamins, proteins, fats and energy required for their growth and development. The nutritional content of milk of different animals varies in the amount of contents present which is shown in the table below:-

Proximate composition of human, cow, buffalo, goat and sheep milks (per 100 g of milk)*

Proximates	Human	Cow		Buffalo		Goat		Sheep	
	Average	Average	Range	Average	Range	Average	Range	Average	Range
Energy (kJ)	291	262	247–274	412	296–495	270	243–289	420	388–451
Energy (kcal)	70	62	59–66	99	71–118	66	58–74	100	93–108
Water (g)	87.5	87.8	87.3–88.1	83.2	82.3–84.0	87.7	86.4–89.0	82.1	80.7–83.
Total protein (g)	1.0	3.3	3.2–3.4	4.0	2.7–4.6	3.4	2.9–3.8	5.6	5.4–6.0
Total fat (g)	4.4	3.3	3.1–3.3	7.5	5.3–9.0	3.9	3.3–4.5	6.4	5.8–7.0
Lactose (g)	6.9	4.7	4.5–5.1	4.4	3.2–4.9	4.4	4.2–4.5	5.1	4.5–5.4
Ash	0.2	0.7	0.7–0.7	0.8	0.7–0.8	0.8	0.8–0.8	0.9	0.9–1.0

* Values for human milk (mature, fluid) are from USDA (USDA, 2009), food code 01107. The values for cow, goat and sheep milks were calculated using values where available in the following fo... composition tables: USDA: cow – food code 01211 "Milk, whole, 3.25 percent milk fat, without added vitamin A and vitamin D"; goat – 01106 "Milk, goat, fluid, with added vitamin D"; sheep – fo... code 01109 "Milk, sheep, fluid" (USDA, 2009); FSA (2002): cow – food code 12-316 "Whole milk, pasteurized, average (average of summer and winter milk)"; goat – 12-328 "Goats milk, pasteurize... sheep – food code 12-329 "Sheeps milk, raw" (FSA, 2002); Danish Food Composition Databank: cow – food code 0156 "Milk, whole, conventional (not organic), 3.5 percent fat"; goat – 0516 "G... milk" (NFI, 2009); New Zealand food composition tables: cow – food code F1028 "Whole milk, pasteurized, average (average of summer and winter milk)"; goat – 12-328 "Goats milk, pasteurize... sheep – food code F52 "Sheeps' milk, raw" (Esperance et al., 2009); Columbian food composition table: cow – food code G101 "Milk, whole, crude (leche, entera, cruda)"; goat – G086 "goat m... whole, crude (leche de cabra, entera cruda)" (FAO/LATINFOODS, 2009); Argentinian food composition table: sheep – food code G087 "milk, of sheep, whole, fresh (leche, de oveja, entera, fresc... (FAO/LATINFOODS, 2009). The number of data points varied.
Values for buffalo milk were obtained from Medhammar et al., 2011.

Protein, fat and lactose contents of milks from different species



Vitamin and mineral composition of human, cow, buffalo, goat and sheep milks (per 100 g of milk)*

	Human	Cow		Buffalo		Goat		Sheep		Daily RNI[1] for children, 1–3 yr
	Average	Average	Range	Average	Range	Average	Range	Average	Range	
Minerals										
Calcium (mg)	32	112	91–120	191	147–220	118	100–134	190	170–207	500 mg
Iron (mg)	Tr	0.1	Tr–0.2	0.2		0.3	Tr–0.6	0.1	Tr–0.1	5 mg (12% bioavailability)
Magnesium (mg)	3	11	10–11	12	2–16	14	13–14	18		60 mg
Phosphorus (mg)	14	91	84–95	185	102–293	100.4	90–111	144	123–158	
Potassium (mg)	51	145	132–155	112		202	170–228	148	120–187	
Sodium (mg)	17	42	38–45	47		44	32–50	39	30–44	
Zinc (mg)	0.2	0.4	0.3–0.4	0.5		0.3	0.1–0.5	0.6	0.5–0.7	4.1 mg (Moderate bioavailability)
Copper (mg)	0.1	Tr	Tr–Tr			Tr	Tr–0.1	0.1	0.1–0.1	
Selenium (µg)	1.8	1.8	1.0–3.7			1.1	0.7–1.4	1.7		17 µg
Manganese (µg)		8	4–10			18	Tr–18	18	Tr–18	
Vitamins										
Retinol (µg)	60	35	29–45	69		45	35–56	64	44–83	
Carotene (µg)	7	16	7–23			13	Tr–18[2]	Tr		
Vitamin A (µg RE)	61	37	30–46	69		48	30–74	64		Mean requirement: 400 µg RE
Vitamin E (mg)	0.08	0.08	0.07–0.08	0.19	0.19–2.0	0.05	0.03–0.07	0.11	0.11–0.11	
Thiamin (mg)	0.01	0.04	0.02–0.04	0.05		0.06	0.03–0.09	0.07	0.07–0.08	0.5 mg
Riboflavin (mg) (vit B_2)	0.04	0.20	0.17–0.20	0.11		0.13	0.04–0.18	0.34	0.32–0.36	0.5 mg
Niacin (mg)	0.18	0.13	0.09–0.20	0.17		0.24	0.10–0.30	0.41	0.40–0.42	6* mg
Niacin equivalent (mg)		0.79	0.70–0.80			1.00	1.00–1.00			
Pantothenic acid (mg)	0.22	0.43	0.34–0.58	0.15		0.30	0.31–0.41	0.43	0.41–0.45	2.0 mg
Vitamin B_6 (mg)		0.04	0.03–0.06	0.33		0.05	0.05–0.06	0.07	0.06–0.08	0.5 mg
Folate (µg)	5.0	8.5	5.0–8.0	0.6		1.0	Tr–1.0	6.0	5.0–7.0	150 µg
Biotin (µg)		2.0	1.4–2.5	13.0		2.5	2.0–3.0	2.5	2.5–2.5	8.0 µg
Vitamin B_{12} (µg)	0.05	0.51	0.25–0.90	0.40		0.07	0.04–0.10	0.66	0.60–0.71	0.9 µg
Vitamin C (mg)	5.0	1.0	0.0–2.0	2.5		1.1	1.0–1.3	4.6	4.2–5.0	30 mg
Vitamin D (µg)	0.1	0.2	0.1–0.3			0.1	0.1–0.1	0.2	0.2–0.2	5 µg

(source: Food and Agricultur 2013)

The above mentioned data shows details about the nutritional value present in different milk sources. Even though there are varying sources of milk the first thing that hits our mind when we hear the word milk is cow milk. So it is of primary importance to consider facts relevant to cow farming and cow milking mostly. "The demand for milk in developing countries is expected to increase by 25 percent by 2025'' (FAO, 2009). Small-scale livestock holders supply the vast majority of this milk, and dairy animals provide household food security and a means of fast returns for them.(Degen, 2007).Countries like New

Zealand, Netherlands and America are the largest producers and suppliers of milk. India is also amongst the global leaders in milk production but milk is not included in the list of goods exported from here.

4 BIOTECHNOLOGY OF MILK AND MILK PRODUCTS

The development of modern biotechnology serves as one of the major tools in the commercialization of milk and milk fermented products. Today we have hundreds of different milk fermented products that is available in the market, the most popular once being curd, yogurt, cottage-cheese, cheese. The fermentation caused by the cellular activities of the micro-organisms involved also causes a variation in the nutritional composition of milk due to cellular action, which then makes milk of more additional benefits to human. 'Yakult' is an example of one such fermented milk product containing live strain of bacterium *Lactobacillus casei* shirota which was originally invented in Japan which claims to have a lot of health benefit and is known as a probiotic product.(Yakult,2014)

6 HEALTH BENEFITS OF DRINKING MILK

Fortification of milk with iron and other micronutrients has helped in solving problems like iron deficiency and anemia in children in India. Many micro-organisms present in milk are known to have direct and indirect health benefits to human. "In addition, milk is thought to contain constituents that enhance mineral absorption, such as lactose and certain amino acids, but absorption of minerals from cow milk has not been demonstrated to be greater than that from mineral salts."(Weaver and Heaney, 2006).Cow milk is also known to have the following health benefits as discussed below:-

Bone Health: The phosphorus, magnesium, calcium and protein of milk are considered very advantageous for bone health; long term consumption of milk is known to prevent risk of osteoporosis.

Teeth: Milk contains calcium, phosphorus that is very beneficial for maintaining the tooth strong and also contains casein protein that prevents it from acid decay due to the formation of enamel coating.

Blood pressure: Studies show that eating 3 portions of dairy product each day helps to lower down the blood pressure.

Cardiovascular disease: Research has shown that high amount of milk calcium is useful in lowering blood cholesterol which makes cardiovascular disease less prone to people who drink milk.

Obesity: Studies have also shown that consumption of milk and dairy foods as part of a calorie controlled diet is associated with increased weight loss, particularly from the abdomen.

Diabetes: Studies suggest that regular consumption of low fat dairy products can help to reduce the risk of type 2 diabetes, which has been a longstanding problem in adults, and is becoming increasingly common in children and adolescents.

Cancer: There is considerable evidence to suggest that milk has a protective effect on risk of both colorectal and breast cancer with increased intakes. A study conducted in Norway revealed that those who drank milk as children and continued to do so as adults had a lower risk of developing breast cancer.

Calcium and a naturally occurring fat in dairy prod-

ucts known as Conjugated Linoleic Acid (CLA) have been suggested as protective components in colon cancer.

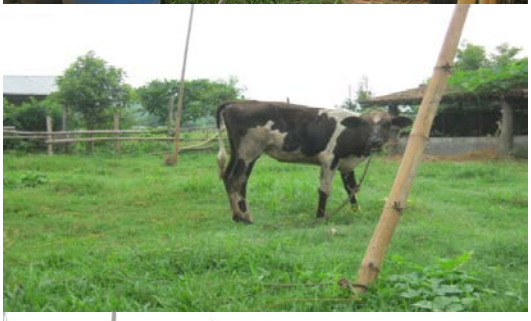
COMMERCIALIZATION OF MILK

In the Ancient times, people used to in-house one or two cattle for their own for milk benefits, buying milk from a distant place looked impossible as the milk would ferment on the way during transportation and would not be of any use, so large scale production and supply of milk was never imagined. Louis Pasteur's technique of milk Pasteurization is the vital finding to biotechnology as well as to the commercialization of milk, this technique effectively eliminates bacteria and other harmful micro-organisms that could contaminate the milk. This has made the storage of milk possible for days, weeks and now even for months (microfiltration).Because of the lack of risk of spoilage during the transportation period demand of milk seemed to increase tremendously at a very alarming rate this gave rise to the instigation of commercial milk production.

Cows are the most widely used animal for milk production, although they are better milk producers than any other consumable milk producing species, primitive cows were only facilitated with the caliber to produce milk as that would be required to raise her calf i.e. (4-5L per day).One such example of the native indigenous species of cows is Vechur of Kerala,India which produces maximum amount of milk for the amount of feed consumed it also hold's the Guinness World Record for smallest cattle breed it has an average length of 124cm and height of 87 cm and weighs about 120kgs. The growing need of milk for human consumption has forced the need of more milk production this is where selective breeding of highly productive cow breeds come into play. The French Holstein and Jerseys of USA are the most abundant milk producing cows, they produce about (25-40 L of milk per day).This earns them the name of MILKING MACHINES. Today we have many genetically designed animals with the capacity to produce milk with desirable fat content, milk resembling that to the human milk and maximum productivity.

Traditional and modern ways of raising dairy cattles

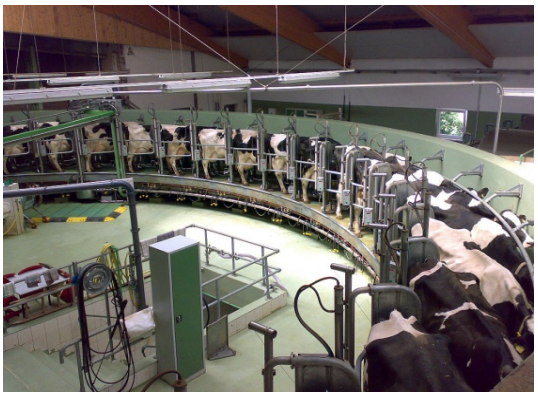
Dairy farming has changed a lot in its structural functional and dimensional aspects, in antiquity dairy farming meant raising animals in large pastures with abundance of free grazing space and access to natural herbs, grasses and shrubs that formed the part of their natural diet. But the growing need of commercialization of the dairy industry and the decrease in the availability of free pastures has enforced the system of raising farm animals in customized sheds under artificial diet plans with least or no access to free ground. Moreover their diet plans have been changed to a completely artificially formulated one with high amount of protein for a better productivity, they are raised in captive environment from the time when they are calves and they are fed high calorie diet to achieve maturity at a very early sometimes as early as 8 months in which they acquire their first heat, these cows are then artificially inseminated with the desired sample of semen from a very healthy stud with maximum genetic potential for milk producing traits.



Picture taken in a local Dairy Farm that raises cattle following traditional practices with organic diet and free access to pasture with animals getting ample of exercise, in Nawalparasi,Nepal.

Picture taken from another dairy farm whereby the animals are being raised commercially and are being fed an artificially formulated diet with virtually no space to move.

Traditional method of Hand milking the cow



Picture shows modern day milking practices with the use of self operating milking machines.

Ethical Issues

7 End Sections Cows lactate for 10 months and are then inseminated again, continuing the cycle, they do not get any resting phase or gap after one birth. Some spend their entire lives standing on concrete floors; others are confined to massive, crowded lots, where they are forced to live amid their own waste. Cows have a natural lifespan of about 20 years and can produce milk for eight or nine years. However, the stress caused by the conditions on factory farms leads to disease, lameness, and reproductive problems that render cows worthless to the dairy industry by the time that they're 4 or 5 years old, at which time they are sent to be slaughtered.(For meat in the Western World and for their Skin to make leather products in Asia).The calves produced by the milk producing cows are taken away from day one and are raised in a diet in which they are forced to grow at the rate of 1pound/day to reach a slaughter age in less than 2 months.The use of oxytocin a sex hormone secreted by the posterior pituitary gland which causes the womb to contract has recently made highlights for its exploitive use by dairy farmers to extract more milk.Greedy dairymen inject cattle with veterinary Oxytocin in the mistaken belief that this produces more milk when all it does is make the milk come faster. It is used to force the cow to give milk even after severe beatings and stress. However it destroys the cow's reproductive system and she goes dry in just 3 years. She is then abandoned.

Left :Photo of an Abandoned Cow in the streets of Kathmandu Nepal,in a very miserable condition. Right :People come for rescue.

Major Impacts on Cattle

Painful inflammation of the mammary glands, or mastitis, is common among cows raised for their milk. There are about 150 bacteria that can cause the disease, one of which is E. coli. Symptoms are not always visible, so milk's somatic cell count (SCC) is checked to determine whether the milk is infected. Somatic cells include white blood cells and skin cells that are normally shed from the lining of the udder. As in humans, white blood cells—also known as "pus"—are produced as a means of combating infection. The SCC of healthy milk is below 100,000 cells per milliliter; however, the dairy industry is allowed to combine milk from all the cows in a herd in order to arrive at a "bulk tank" somatic cell count (BTSCC).Milk with a maximum BTSCC of 750,000 cells per milliliter can be sold. A BTSCC of 700,000 or more generally indicates that two-thirds of the cows in the herd are suffering from udder infections.

Studies have shown that providing cows with cleaner housing, more space, and better diets, bedding, and care lowers their milk's SCC as well as their incidence of mastitis. A Danish study of cows subjected to automated milking systems found acutely elevated cell counts during the first year compared with the previous year with conventional milking. The increase came suddenly and was synchronized with the onset of automatic milking. Instead of improving conditions in factory farms or easing cows' production burden, the dairy industry is exploring the use of cattle which have been genetically manipulated to be resistant to mastitis.

Health impacts on human

Studies show that on an average the consumption of milk and milk related products in India by a person is more than 10ounce per day which relates to increasing susceptibility of the person to several health issues. Milk is mostly delivered to a commercial household in two forms either the one that is available in packed bottles or in packets. They might come as a refined form from the milk selling companies or fresh form that is directly made available from the farms. Whichever might be the case, the purity of milk is always something that might not ought to be relied every time because of the modern adulteration practices in the milk business. Contaminated Milk might contain many adulterated contaminants like caustic soda, urea, soap, detergents, formalin, table sugar, ammonium sulphate etc which are used for increasing the profit margins in the following ways:

Soap and Detergents- causes the foaming of milk and makes the milk thick

Urea- Is added to increase the fat value of milk

Formalin- Is added to increase the shelf life of milk

Table Sugar-Is added to increase the carbohydrate content of milk which increases the density of milk and facilitates for the addition of water without getting detected in the lactometer test.

Ammonium Sulphate: Is added to increase the lactometer reading by maintain the density of milk

Caustic Soda-This is also added to tweak the lactometer reading

Starch-Flour from wheat, rice, corn etc is used in the milk to increase the conc. Of carbohydrate over the fat thus increasing the total solid content of milk.

The addition of these contaminants to milk thereby adulterating the purity of milk not only decreases its

nutritional value but also raises a lot of health concerns to consumer health. When these contaminants enter the body they might lead to severe effects on the functionality of our body systems. The major organs to be affected are stomach, kidneys and liver which are very crucial to the well being of the body.

The exploitive use of anti-biotics in the feed of farm animals have been found to cause vital secondary effects to the health of human who consume food products obtained from these animals either in the form of milk or meat. The bio-accumulation of various spectrum of anti-biotics obtained from these dairy sources in the human body has led to increased resistance of the pathogenic microbes that enter our body which due the genetic modification in the presence of low dosage of these anti-biotics are now completely resistant to these anti-biotics which has made humans prone to so many susceptible health risks. Also the bioaccumulations of these anti-biotics have several hazardous effects on the overall health of humans some of the major ones are

Immuno Pathological Effect
Autoimmunity
Carcinogenecity
Mutagenecity
Nephropathy
Hepatotoxicity
Reproductive Disorders
Bone Marrow Toxity
Allergy

Safety measures that can help us detect adulteration

Modern Biotechnological techniques enable us to detect the adulteration of milk that can lead to possible health hazards with the use of different chemical reagents and bioanalytical techniques. There are many prescribed tests and techniques that can be used at household and laboratory level to check for contaminants in milk. Over here only those techniques that can be implemented at home are discussed here;

S. no.	Food article	Adulterant	Method of detection	Remarks
1	**Milk**	Water	The presence of water can be detected by putting a drop of milk on a polished slanting surface. The drop of pure milk flows slowly leaving a white trail behind it, whereas milk adulterated with water will flow immediately without leaving a mark.	
2		Starch	Add a few drops of tincture of Iodine or Iodine solution. Formation of blue colour indicates the presence of starch.	Iodine solution is easily available in the medical stores.
3		Urea	Take a teaspoon of milk in a test tube. Add ½ teaspoon of soybean or arhar powder. Mix up the contents thoroughly by shaking the test tube. After 5 minutes, dip a red litmus paper in it. Remove the paper after ½ a minute. A change in colour from red to blue indicates the presence of urea in the milk.	
4		Detergent	Shake 5-10 ml of sample with an equal amount of water. Lather indicates the presence of detergent.	
5		Synthetic milk	Synthetic milk has a bitter after taste, gives a soapy feeling on rubbing between the fingers and turns yellowish on heating.	Synthetic milk is made by adding white colour water paint, oils, alkali, urea and detergent, etc.
6.		Synthetic milk- test for protein	The milk can easily be tested by Urease Strips (available in the Medical stores. Colour chart of the Urease Strip test given below will show the quantity of urea present in milk :	Urease Strip is a biostrip based on enzymatic assay.

S.No.	Urea in Milk (g/L)	Colour of the strip
1	0-0.2	Yellow
2	0.2-0.7	Peach
3	0.7-1.20	Reddish

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LATEST WORK ON DAIRY AND MILK

Genetic engineering particularly gene cloning is gaining a lot of popularity these days. China is the leading producers of transgenic animals and transgenic food products. After several years of research on studying the genomes of various creatures' scientists have been able to track down the genes that are responsible for contribution towards a particular trait the phenomenon which is popularly known as quantitative-trait mapping. Over the years milk producing companies only focused on successfully identifying, collecting and preserving the blood line of highly yielding varieties of cows through selective breeding and artificial insemination and embryo transplant. It is now due the study of the animal genome scientists have been able to manipulate the genes of these dairy animals to inculcate different diversities to their milk producing abilities. Scientists have already been successful in producing transgenic cows that produce milk for lactose intolerant patients, milk like human milk for human infants, milk with 20 percent low fat for cardio-vascular patients.

The date of commercialization of this transgenic product and their legalization is cannot be forth claimed as there are many different issues to be dealt with and many trials to be conducted to see if it is safe to feed on products that are derived from creatures with genes of two different species. At present, Britain and some Countries in Europe have legalized the production and sale of GM(genetically modified) foods while others are still conducting trials.

CONCLUSION

Milk is a white/yellow colored beneficial dietary liquid which has become very popular for its wide array of fermented products. The increasing demand of milk has lead to its commercialization gaining interest on the way it's produced the health of the animals and the additional health benefits that it tends to provide. The adulteration of milk and mis-management of the farm animals used in dairy farming has increased a lot of ethical issues concerning the well-being of both the animals and the humans who depend upon these animals for their nutrition. Detrimental practices of adulteration of milk and use of hormones and antibiotics in the live-stock have major effect in the physical and mental well being of the people. It's very important to make sure that the milk we consume is free of all kinds of adulteration. Milk free from all kind of impurities derived from properly reared animals when consumed in proper quantity is of tremendous heath benefits. Milk can be tested at a home for its purity and in the future milk with varied nutrition might be obtained commercially from transgenic species producing GM milk.

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