ISSN 2475-5451

Review Article

International Journal of Diabetes & Metabolic Disorders

Effect of Adulterants on Quality and Safety of Cow Milk: A Review

Tolcha Techane[1]*

[1]*Alemu Department of Post-harvest Management, Jimma University College of Agriculture and veterinary medicine, Jimma, Ethiopia.*

***Corresponding Author:**
Tolcha Techane, Alemu Department of Post-harvest Management, Jimma University College of Agriculture and veterinary medicine, Jimma, Ethiopia.

Submitted: 29 Dec 2022; **Accepted**: 07 Jan 2023; **Published**: 20 Jan 2023

Citation: Tolcha Techane. (2023). Effect of Adulterants on Quality and Safety of Cow Milk: A Review. *Int J Diabetes MetabDisord*, 8(1), 277-287.

Abstract

Cow milk adulteration is the act of intentionally decreasing the quality of milk offered for sale either the admixture or substitution of substance or removing of some valuable ingredient. Milk has a high food value, since it comprised of a variety of nutrients. Scientific evidence supports, the consumption of cow's milk and dairy products as part of a balanced diet and it is perfect and complete food. Therefore, milk and its derivatives contribute essential micro and macronutrients to the diet, when consumed according to appropriate national guidelines. However, different adulterants are added, to increase its quantity and done for financial gain. The common adulterants used in cow milk adulteration are water, starch, flour, urea, formalin, sodium hydro oxide and cane sugar. Water is the most common adulterant. These adulterants have effect on the nutritional quality of cow milk by decreasing the concentration of ingredients found and wholesomeness of the milk. To dilute milk, cheaper materials will be added. Almost all commercially available milk comes from cow and major milk adulteration occurs with cow's milk and its products. These, adulteration of milk can pose serious risk to human health. The composition of milk varies with the breed of cow, stage of lactation; feed, season of the year. Therefore, both intentional and incidental milk adulterations affect nutritional quality and safety of milk. This review aims to review the effect of adulterants on safety and quality of cow milk. Even while financial gain is one of the main drivers of cow milk adulteration.

Keywords: Adulterants, Cow Milk, Quality and Safety

Introduction

Back Ground Information

Milk is one of the food needs for human being consumption particular for children and is composed of carbohydrates, water, fats and proteins, different minerals and vitamins which can be drunk by animals for nutrition or pleasure [1]. Cow milk is a lacteal secretion obtained by the complete milking of cow used as sources for milk. It is a complex biological fluid, perishable commodity, and an important source of food for consumption [2]. According to definition, Milk is the normal mammary secretion derived from complete milking of healthy milk animal without either addition there to or extraction there from [3]. Also, nutritionally, milk has been defined as the most nearly perfect food. In recent decades, there has been an upsurge in milk consumption worldwide, especially in developing countries, and it is now forming a significant part of the diet for a high proportion of the global population. As a result of the increased demand, in addition to the growth in competition in the dairy market and the increasing complexity of the supply chain, some unscrupulous producers are indulging in milk fraud. One of these activities is adulteration of milk. Milk adulteration is the process by which the quality or the nature of a given food is reduced through addition of adulterants or removal of vital substance and it is a socio-economic problem especially in the developing countries. This malpractice has become a common problem in the developing countries, which lack strict vigilance by food safety authorities.

Almost all commercially available milk comes from cows and it is an important source of many of the nutrients essential for the proper development and maintenance of the human animal body [4].

Carbohydrates, which are obtain from consumption of cow milk, used as the primary source of energy. Specially, Glucose is the form of carbohydrates that can be used by the brain to perform different activities. Excess glucose is stored in the form of glycogen in the muscles and is important in hormonal regulation in the body. Fats are a structural component of cell membranes and hormones and concentrated energy source and are the main energy source used by the body during low intensity activities and prolonged exercise. Proteins are needed to help muscles contract and relax, and help repair damaged tissues. Vitamins are involved in vision, gene expression, reproduction, and immune response, as an enzyme co-factor, in the metabolism of proteins and glycogen.

Minerals have many roles in the body including enzyme functions, bone formation, water balance maintenance, and oxygen transport. Due to its nutritive value, milk is significant to young and old people. So, milk is a very nutritious food and, but it is also a very perishable liquid, since, it contains a lot of nutrients, it is very sensitive to microbial growth, enzymatic degradations and chemical reactions [5].

However, at different place like wholesaler or producer, retailer and at industries levels producer and seller of cow milk are adding adulterants to increase its quantity for income purpose either for financial gain or due to unhygienic conditions of processing, storage, transportation, marketing etc. Milk adulteration is an act of intentionally debasing the quality of food offered for sale either by the admixture /substitution of inferior subs or by removal of some valuable ingredients. Adulteration of milk is one of the most serious issues that the dairy sector of world food is facing today, which not only causes major economic losses for the processing industry, but also a major health risk for the consumers. Milk adulterated with contaminated water is a serious health hazard because of potential waterborne diseases. The chemicals which are being used as adulterants in milk may affect the health of consumers. Milk from surroundings of different countries is not only consumed, but also for adding into milk to increase it's quantities.

Major food adulteration occurs with the widely publicized adulteration of milk and milk products. It is a serious issue which has come under increased scrutiny as a food safety and public health concern in recent years and adulterated milk is one which may be spoiled or intentionally altered by illegal addition of a foreign chemical substance especially economically motivated adulteration is a subcategory of food fraud and is a cause of public health risks [6]. So, adulteration is the fraudulent, intentional substitution or addition of a substance in a product for the purpose of increasing the apparent value of the product or reducing the cost of its production [7]. Milk adulteration has been widely reported in developing countries [8]. To the diluted milk, inferior cheaper materials may be added such as reconstituted milk powder, urea, and cane sugar, even more hazardous chemicals including melamine, formalin, caustic soda, and detergents. Regulators, food producers, retailers, and consumers all have an interest in safeguarding foods and ensuring they are safe, genuine, and of the highest quality. Adding water to milk decreases the solid part and reduces the foamy look of the milk. The common additives used in milk are shampoo, detergents, washing powder, and urea, decreasing milk quality and increasing milk quantity. Health professionals determined that the contamination of milk causes serious health problems like hepatitis, failure of kidneys, heart problems, stomach tumors, cancer, nausea, asthma, pneumonia, and allergic reactions. Therefore, the objective of this review is to review study made by different numerous researcher and reviewer about effect of adulterants on quality and safety cow milk.

Literature Review

Nutritional Components of cow Milk and adulteration

Now a day's foods like milk are affected by different adulterants. Adulteration is a substance which reduces the vital importance of food. Now-a-days it is very common to hear or read news about the food items being adulterated and such products are being openly sold out and are consumed by people, which cause various health hazards. News has shown how milk and milk products are being adulterated with urea, soap and other hazardous chemicals [9]. Food Adulteration refers to the process by which the quality or the nature of a given food is reduced through addition of adulterants or removal of vital substance. Basically, during food adulteration, small quantity of non-nutritious substances is added intentionally to improve the appearance, texture or storage properties of the food. Food adulteration is quite common in the developing countries.

Milk contain all nutrients which necessary for growth and multiplications of all living things. The functional nutritional components of milk are: Water, carbohydrate, fat, protein, vitamins, minerals, and minor biological protein and enzymes. This is why the reason milk considered as perfect and complete food. However, these composition and component yields also can be affected by genetics and environment, level of milk production, stage of lactation, disease (mastitis), season and age of cow [10].

Milk adulteration is the act of intentionally decreasing the quality of milk offered for sale either the admixture or substitution of substance or removing of some valuable ingredient. In order to keep milk temporarily fresh, full fill supply and demand, increase shelf life through the milk supply chain to prevent the financial losses due to the spoilage of milk during its transportation and sale [11]. For instance, the addition of water to increase volume of milk, thickening agents like starch, flour, skimmed milk powder, whey powder or other ingredients to counter the dilution and extend the solids content of the milk [12].

There are many milk adulterants like of water, thickening agents (like starch, flour, skimmed milk powder), or other ingredients to counter the dilution and extend the solids content of the milk, Vegetable oil, sugarcane or urea to compensate the fat, carbohydrate or protein content and Some chemicals (hydrogen peroxide, carbonates, bicarbonates, antibiotics, caustic soda and formalin) to increase the storage period of milk [12].

Generally, Consumption of adulterated milk has hazardous health effects. The detergent in milk can cause food poisoning and other gastrointestinal complications. Its high alkaline level can also damage body tissue and destroy proteins. Other synthetic components can cause impairments, heart problems, cancer or even death. While the immediate effect of drinking milk adulterated with urea, caustic soda and formalin is gastroenteritis, the long-term effects are far more serious and an extent that there is very less nutritive value in it [13].

Water

For all animals, water is the nutrient required in the highest quantity, this amount of water is controlled by the amount of lactose synthesized by the secretory cells of the mammary gland

Milk is approximately 87% water, so it is a good source of water in the diet. Water does not provide a nutritional benefit in the same manner as proteins or vitamins, for example. However, water is extremely important in human metabolism and other body regulation activities [14]. Adulterating milk with water reduces SNF (solid, not fats) components, particularly protein, one of the essential nutrients required for normal growth and development. Therefore, the amount of SNF can determine the amount of water added to milk [15].

Carbohydrate

Cow milk contains approximately 4.9% carbohydrate in the form of lactose. Lactose is a disaccharide made up of glucose and galactose when the bonded together by glycoside bond. Before it can be used by the body, the bond must be broken by the enzyme lactase in the small intestine. Carbohydrates are the primary source of energy for activity. Glucose is the only form of energy that can be used by the brain [16].

It is well accepted that mastitis causes a decrease in the concentration of milk lactose. The decline in milk lactose in affected quarters probably is in part due to the damage to the alveolar epithelial cells. Given the key role of lactose as the osmotic regulator of milk volume, the reduced lactose concentrations are unlikely to be due to reduced synthesis and secretion at the cellular level and can only be depressed; there is an increased influx of electrolytes during mastitis [17].

Fat

Fats provide about half of the calories in milk. A high-quality protein called Casein is present in milk that contains almost all the amino acids essential for normal body growth and tissue regeneration. The difference in water content may be attributed to the additional changes in water in the milk of cow. Cow milk is approximately 3.4% fat. But the fat content of milk may vary according the varieties. Fats are a structural component of cell membranes and hormones. Fats are a concentrated energy source and are the main energy source used by the body during low intensity activities and prolonged exercise. The fatty acids in milk fat are approximately 65% saturated, 29% monounsaturated, and 6% polyunsaturated.

The polyunsaturated fatty acids in milk fat include small amounts of the essential fatty acids linoleic and linolenic and approximately 5% Tran's fatty acids [18]. The concentration of milk fat and protein is highest in early and late lactation and lowest during peak milk production through mid-lactation. Normally, an increase in milk yield is followed by a decrease in the percentages of milk fat and protein, while the yields of these constituents remain unchanged or increase [19].

Protein

Milk is approximately 3.3% protein and contains all of the essential amino acids. Proteins are the fundamental building blocks of muscles, skin, hair, and cellular components. Proteins are needed to help muscles contract and relax, and help repair damaged tissues. They play a critical role in many body functions as enzymes, hormones, and antibodies. Proteins may also be used as an energy source by the body [20].

Milk protein consists of approximately 82% casein and 18% whey (serum) proteins. Both casein and whey proteins are present in milk, yogurt, and ice cream. Whey proteins contain immunoglobulin's which are important in the immune responses of the body [21].

Milk protein content gradually decreases with advancing age. A survey lactation records indicates that milk protein content typically decreases 0.10 to 0.15 unit over a period of five or more lactations or approximately 0.02 to 0.05 unit per lactation [22].

Vitamins

Vitamins have many roles in the body including metabolism co-factors, oxygen transport and antioxidants. They help the body use carbohydrates, protein, and fat. Milk contains all the major vitamins. It contains both fat- and water-soluble vitamins. The fat-soluble vitamins A, D, E, and K are found mainly in the milk fat. The B and C vitamins are found in the aqueous phase of milk. The functions of vitamins are involved in vision, gene expression, reproduction, and immune response, as an enzyme cofactor, in the metabolism of proteins and glycogen, in maintaining blood calcium and phosphorus balance, antioxidant activity and in blood clotting [23].

Minerals

Minerals have many roles in the body including enzyme functions, bone formation, water balance maintenance, and oxygen transport. All minerals considered essential (22) to the human diet are present in cow's milk. However, the major minerals in milk are calcium and phosphorous which are associated with casein micelles. Therefore, whey has relatively little Ca and P compared with whole milk.They help the body use carbohydrates, protein, and fat [24].

Minor Biological Proteins & Enzymes

Other minor proteins and enzymes in milk that are of nutritional interest include lactoferrin and lacto peroxidase. There are many other enzymes in milk but these do not have a role in human nutrition [25].

Factors affecting milk Composition

Milk composition can affect by genetic factors and environmental factors. The composition of milk varies considerably with the breed of cow, stage of lactation, feed, season of the year, and many other processing factors. Nutrition or dietary influences readily alter fat concentration and milk protein concentration. Fat concentration is the most sensitive to dietary changes and can vary

over a range of nearly 3.0 percentage units. Dietary manipulation results in milk protein concentration changing approximately 0.60 percentage units. The concentrations of lactose and minerals, the other solids constituents of milk, do not respond predictably to adjustments in diet. It can also affect by genetics and environment, level of milk production, stage of lactation, disease (mastitis), season and age of cow. There are various feeding management practices that can enhance levels of milk fat and protein concentration in milk. Feeding strategies that optimize rumen function also maximize milk production and milk component percentages and yield. However, some relationships between constituents are very stable and can be used to indicate whether any tampering with the milk composition has occurred [26].

Genetics factors

Genetics factors are Species and strain or breed of animal. Yields of milk, fat, protein and total solids are easily impacted by genetics. This indicates that some genetics of milking cow have high fat and protein composition percent while others other have medium.

Table1. Breed difference for percentages composition of fat and protein in cow milk

Breeds	Total fat %	total protein %
Ayrshire	3.88	3.31
Brown Swiss	3.98	3.52
Guernsey	4.46	3.47
Holstein	3.68	3.16
Jersey	**4.64**	**3.73**
Milking shorthorn	3.59	3.26

Source (Harmon, 1994 J. Dairy science)

According to the above table 1, jersey breed has high protein and fat content [27].

Environmental factors

Interval between milking

The fat content of milk varies considerably between the morning and evening milking because there is usually a much shorter interval between morning and evening milking than between evening and morning milking. If cows were milked at 12-hour intervals the variation in fat content between milkings would be negligible, but this is not practicable on most farms.Normally, SNF content does not vary with the length of time between milking [28].

Stage of lactation

The fat, lactose and protein contents of milk vary according to stage of lactation. Solids-not-fat content is usually highest during the first two to three weeks, after which it decreases slightly. Fat content is high immediately after calving but soon begins to fall, and continues to do so for 10 to 12 weeks, after which it tends to rise again until the end of the lactation. The high protein content of early lactation milk is due mainly to the high globulin content. Diseases can affect milk component content and distribution, mastitis has been the predominant disease affects compositional changes in milk constituents associated with elevated somatic cell counts. Mastitis results in a reduction in fat and casein content and an increase in whey content of milk. These changes in the milk proteins in conjunction with alterations of lactose, mineral content and milk pH. There are various feeding management practices that can enhance levels of milk fat and protein concentration in milk. Feeding strategies that optimize rumen function also maximize milk production and milk component percentages and yield [29].

Milk and milk products adulteration

In developing countries, the industrialization brought a series of problems along with the much-appreciated progress, with the mass collection and distribution of milk from various sources playing the role of potential vehicle for disease transmission. In olden days, milk was collected from small groups of animals in farms and it was supplied to a small number of people living nearby [30]. But with the advent of industrialization, population growth and urbanization, the demand increased drastically. Milk supply through the small farms no longer met the increasing demand [31]. Hence commercialization of the milk industry ultimately took place [32]. Milk adulteration involves adding water to milk and removing the beneficial fats from milk. According to [33], often soya milk starch, groundnut milk, and wheat flour are added to milk and girl ghee added into butter. The producers deliberately adulterate milk and its products in order to promote the level of these essential nutrients after reduction of a given amount and/or to mislead the consumers to increase their profit margin by several chemicals like urea, starch, flour, cane sugar, vegetable oils, and detergents.

Various preservatives like formalin and some antibiotics are also added in milk to increase its shelf life. This addition decreases the nutritive value of milk and its incidences are at increase over the years [35,36]. Although milk is produced throughout the year yet the supply and demand of milk are related to the seasonal fluctuations due to this milk used by the people for consumption is adulterated to such an extent that there is very less nutritive value in it and may also be toxic for public health their profit margin by three ways dilution, extraction of valuable components like milk fat which is removed as cream, addition of cheap substances like

starch to increase the value of total solids up to a level which is acceptable by the consumers [35,37]. And all dairy foods are made from milk, and their components are the same as those of milk, except butter being comprised mainly of milk fat, but in varying amounts are also adulterated in one or another forms [38,39]. Milk and its products can be exposed for adulteration at different points such as at farm and procurement level, while transporting and processing, in view of the fact that fresh milk is pure when it comes out of the udder and free of adulterants and microbes but can be contaminated by bacteria, yeast, fungi and dust, water, different chemicals or adulterants and animal hair due to livestock keepers' unhygienic milking, handling and storage practices, some dishonest producers retailers and manufacturers [21]. Counterfeiting and product adulteration are now commonly practiced in the global food marketplace [40]. Because of its high nutritional value and unique flavor, the price of natural bee milk is relatively much higher than that of other sweeteners.

Types of adulteration and food items

Either because of high demand or seasonality in supply, various food products and drinks can be adulterated in diverse situations.

Intentional Adulteration

This is a kind of adulteration in which dishonest producers and traders deliberately adulterate different milk and its products in order to promote the level of their essential nutrients after reduction of a given amount in order to increase their profit margin by several chemicals like urea, melamine, and increase its volume by adding substances such as starch, flour, cane sugar, water, and skim milk, etc. into various food items as reported by different authors such as El-loly et al.(2013), Asrat and Yilma (2014), Narayan (2014) and Faraz et al.(2013) [35,41-43]. Also, these adulterants are added as a deliberate act with intention to increase profit. E.G. sand, marble chips, stones, chalk powder, etc.

As compared with that of unknown adulteration, this one is the most dangerous because of amounts of nutrients deducted and extraneous substances added into food like products like milk items that is done by business-oriented people just forgot the humanity in behind of money-making mentality as report that, milk, honey, orange juice, coffee and apple juice are the most likely food ingredients to be targets for intentional or economically motivated adulteration of food, or food fraud, according to analysis of the first U.S [44-45]. public database created to compile information on risk factors for food fraud published in the Journal of Food Science.

Incidental/unknown adulteration

Incidental Adulteration is found in food due to negligence, ignorance or lack of proper facilities. Examples packaging hazards like larvae of insects, droppings, pesticide residues, etc. This type of adulteration is brought due to lack of proper hygienic conditions of food products and drinks throughout production site to consumption table. Here the producers or traders/retailers are not in position to add different adulterants but, the ways the products are produced, handled, passed, processed, stored, transported and marketed may be the places where they were contaminated or adulterated since any substance without its original is extraneous to the product; include: residual pesticides from cans, rodent droppings, preservatives, mercury from effluents, lead from water, [41,42].

Reason for Food Adulterated

The main reason that attracts adulteration is for boosting their cash income by increasing its volume. Even though increasing their profit margins-initiated adulteration done by some selfish producers, processors and retailers, the main cause for adulteration is dishonesty and lack of accidental quality assessment on products suspected [41]. It is the same fraudulence which is so extremely ingenious in every department of life that has devised an inferior material of the quality one. On the other hand, food products are fake and adulterated when demand for popular and or expensive products are high. Thus, it still follows that there is economic motive for adulteration and counterfeiting of products which enter the supply chain right from the production of raw ingredients through the point of sale [46].

Another reason for faking and adulteration of goods and services is outsourcing to offshore producers [47]. Outsourcing became possible because comparatively labor is cheap in some countries and this is also what makes product faking easy since the cost of producing is far less compared to the super normal profits being made [36]. That is why Cofie (2012) argues that counterfeiting thrives on the whole process of globalization because spread of capital and know-how to new markets is usually achieved through globalization. Similarly, any break in steady supply of original product or service could induce the introduction of fake and adulterated ones in order to meet the demand by users. Here, the new sources may not be immediately differentiated or identified and therefore the stringent measures which original producers are subjected to would have been avoided [48].

In general cow milk adulterated for the following six reasons as reported by Narayan (2014) [42]. These are:-

1. When the demand is more than the supply in the market,
2. To come at par with the market competitors by lowering the cost of production,
3. The greed for increased profit margins,
4. The common man cannot afford food items with their original constituents,
5. Lack of trained manpower with outdated food processing techniques and
6. No idea about the disease outbreaks caused due to adulterated food products.

In addition to above reason there are also different causes like,

- ✓ Profit motive of traders: Done as a part of the business strategy
- ✓ Food insecurity: To increase quantity of food production and sales.
- ✓ Increased Urbanization: To make maximum profit from

food items by fewer investments.

✓ High population demands: Increased food demand of the population and its changing trends.

✓ Illiteracy of general public: Lack of consciousness of proper food consumption.

✓ Lack of effective food laws

✓ Lack of government in initiative

Milk and It's Products Is Adulterated If

✓ The food sold does not meet the nature of the substance or quality as per the demand of consumer.

✓ The food contains inferior or cheaper substance

✓ The food has been prepared, packed or kept under unclean conditions leading to contamination.

✓ Food contains substances that depreciates or injuriously affects the health.

✓ If the food's original nature is substituted wholly or partially by abstracting a portion of vital substance from food.

✓ If it is an imitation of some other food substance.

Impact of food adulteration

The problems of adulteration makes the food items used in our daily life unsafe and unhygienic for use due to poor handling [41].

Food adulteration has a great impact on producers/farmers, consumers, enterprises and government. The main challenges are public health problem, lack of acceptance in the market due to lack of originality, decrease in consumer confidence. Regulations that penalize such a criminal traders and dishonest producers/processors that adulterate different food products in various places should be applied. Also, since, adulteration is the act of either by adding extraneous substances (adulterants) into food items or products or reducing essential nutrients partly or wholly for financial gain or due to carelessness and lack of proper hygienic condition during processing, storing, transportation and marketing. This ultimately results that the consumer is either cheated or often become victim of diseases.

Because of that it is important for the consumer to know the common adulterants and their effect on health since the increasing number of food producers and the outstanding amount of foodstuffs import enables the producers to mislead and cheat consumers [49].

Impacts on enterprises

Enterprises are impacted by a loss of consumer confidence in their products, recalls and destruction of contaminated products, complaint expenses and increases of insurance premiums and costs related to equipment's replacement or cleaning. A supplier's fault is inevitably reported in the mass media, casting doubt on that company's reputation [50]. A producer that depends on a banned imported foodstuff not only suffers economic loss to the impacted product but also faces lost sales caused by loss of public confidence. The resulting brand damage can be devastating, and recovery can require significant time and expense when consumers have moved on to other suppliers' products [51]. People have lost their trust in the products. For example, about 40 to 60% of consumers either ceased or were unwilling to purchase domestic milk products, whereas those who purchased imported milk powder increased from 34% to 47% in China due to milk adulterating by melamine as Qian et al. (2011) [52].

Impacts on Farmers/Producers

Adulteration not only has an effect on big enterprises but also farmers or producers (like dairy, honey, coffee, wheat, etc) can be affected by the weakest link in the industry chain. Many farmers suffered massive losses, cost increases due to feed costs, milk cow shortage caused by mass sales or slaughter during the crisis, for example in the case of China dairy Scandal and lack of acceptance of the products [52,53].

Impacts on Consumers

Hazardous effects of food adulteration is associate with diarrhea, abdominal pain, nausea, vomiting, eyesight problem, headache, cancer, anemia, insomnia, muscular paralysis and brain damage, stomach disorder giddiness, joint pain, liver disorder, dropsy, gastrointestinal problems, respiratory distress, edema, cardiac arrest, glaucoma carcinogenic effects, kidney failure, digestive system disorders, etc. [43-44,49].

Common adulterant in cow milk

Milk is most commonly diluted with water. The other excessively documented adulterants used to adulterate milk are diluent (water), thickening agents (starch, flour, urea etc.), preservatives (formalin, sodium hydro oxide. etc.), reconstituting agents (cane sugar and animal fats and milk powder) and others [54].

Milk from different rural and urban areas is adulterated with different substances. The applications of this adulterant have different levels. Water is the most common one used in most areas as adultrants.

Table 2: percent of milk adulteration of milk samples

Types of adulterant	No of sample	Adulterated sample
Water	40	40
Starch	40	10
Hydro-peroxide	40	9
Urea	40	7

Source: This shows 100% of the sample was adulterated with water, 25% of samples with hydrogen per oxide, 22.5% with starch and17.5% with urea Daily, 2008). This shows adulteration in milk with would have significance influence on the composition of milk.

Effects of common Adulterants on nutritional quality of cow milk

Effect of water

The most common form of milk adulteration has been added water, to increase its volume for greater profit. Adding water alters the composition and reduces foamy appearance, specific gravity and nutritional value of milk [55,56]. Adulteration of extraneous water in milk apparently increase the moisture content of corresponding milk [57]. This not only reduces its nutritional value, but contaminated water can also cause additional health problems. In humans, consumption of milk adulterated with contaminated water may cause stomach disorders in elders and serious health hazards in infants and children whose basic diet is milk.

Effect of Starch and Cereal Flours

Wheat flour, arrowroot, rice flour, starches and dextrin are may be added to milk to increase the solids-not-fat content and viscosity [28]. Starch is the most common of these adulterants. These ingredients are added to increase the density of milk and prevent detection of added water. In humans, consumption of starch-adulterated milk may cause diarrhea due to the effects of undigested starch in colon and its accumulation in body may prove fatal for the diabetic patients [37].

Effect of urea

Urea is added to milk to provide whiteness, increase the consistency and shelf life of milk, and for standardizing the content of solids-not-fat present in natural milk [58].

For safety concerns, urea-containing milk is quite harmful for humans, particularly for pregnant women, children, and sick individuals. The presence of urea above the upper limit in milk can cause severe health problems, including indigestion, acidity, ulcers, cancer, malfunctioning of kidneys, and osteoporosis [59]. An excess of urea in milk at high temperatures decomposes to carbonic acid, acetic acid, and ammonia, leading to potential ammonia-containing calculi formed by the partial fermentation of urea in the bladder. Also, it may be converted to biuret, which causes a decrease in blood pressure and produces strong irritation in the urinary tract [60].

Effect of formalin

Formalin is a potentially hazardous toxic or injurious substance. It is a potent carcinogen [61]. Formalin is used to adulterate milk in order to neutralize milk or to increase its shelf life. Consumption of an elevated dose of formalin can cause vomiting, abdominal pain and diarrhea. It may also disturb the optic nerves and may cause blindness.

Formalin are added in milk to emulsify and dissolve the oil in water phase giving a frothy appearance, characteristic white color or to enhance the cosmetic nature of milk [54].

Effect of Sodium Hydroxide

Neutralizers such as sodium hydroxide to milk are used to mask the acidity of spoiled milk, which can be detected by titirable acidity. Neutralization of milk, whether with lime, soda, or caustic soda, invariably increases the ash content and the total alkalinity of the ash from a fixed quantity [62].

Effect of Cane Sugar

Cane sugar or sucrose is added in the milk to reconstitute its compositional requirement followed by adulteration of extraneous water in the milk. It imparts role in maintaining the characteristic sweet taste of milk which is usually lost by water adulteration. Also, sugar is added to milk in order to raise the lactometer reading and thus specific gravity of the milk that was diluted with water, so that by lactometer reading the detection of added water is masked [63]. The increase in milk density is much higher due to addition of glucose and or cane sugar than for other adulterants, such as urea .With addition of sugar, permittivity (permittivity is a complex term used to describe the dielectric properties of food)of milk decreases but loss factor (describes the ability to dissipate energy in response to an applied electric field or various polarization mechanisms, which commonly results in heat generation) increases up to 1 GHz and then subsequently decreases [64].

Detection of Adulterants in Market Milk

Extraneous Water

The extraneous water in market milk was detected from depression of freezing point through Cryoscope as reported by (AOAC, 2000). The values of freezing point of market milk greater than the values of freezing point of control was assumed as presence of extraneous water in market. Thickening Agents, Chemical Preservatives, Constitutional Adulterant and Neuterlizing Agents Thickening agents, chemical preservatives, constitutional adulterants, sorbitol, neutralizing agents and quaternary ammonium compounds in market milk were detected through milk adulteration testing (MAT) kit. Skimmed Milk Powder (SMP) Skimmed milk powder was determined according to the method as reported

by Khaskheli (2014). Extent of Extraneous Water in Market Milk Extent of extraneous water in market milk was observed from the depression of freezing point (through Cryoscope) and calculated by subtracting the observed freezing point of market milk from that of freezing point of base (control) and thereafter by dividing it with freezing point of base using following formula [65].

% water added = Freezing point base- observed freezing point x 100

Freezing point base

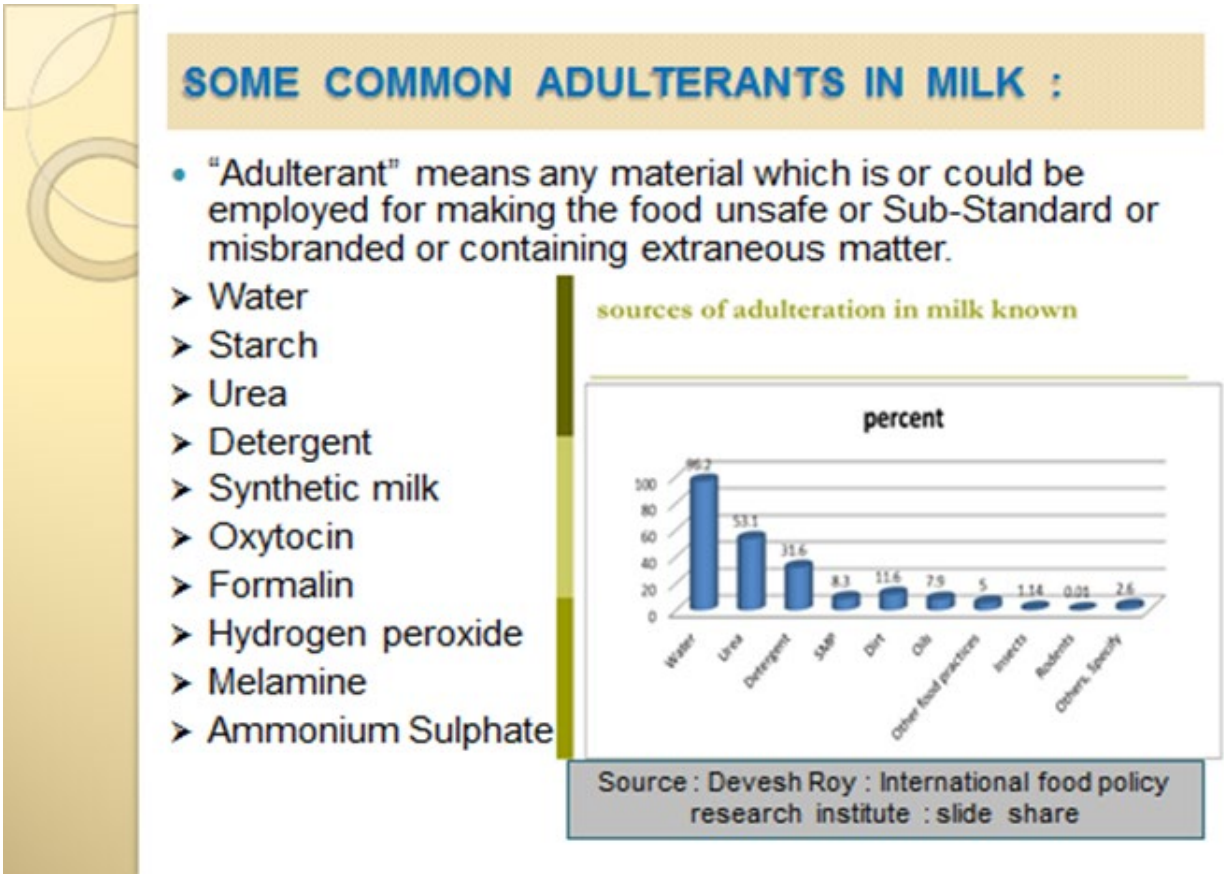

Figure 1: Milk adultrants.Source: Devesh Roy : International food policy research institute

Mitigation Measures for Addressing Food Adulteration

✓ There must be proper surveillance of the implementation food laws.

✓ There should be monitoring of the activities with periodical records of hazards regarding food adulteration.

✓ There should be periodical training programmes for Senior Officer/Inspector/Analysts for food safety

✓ There should be consumer awareness programmes organized by holding exhibitions/seminars/training programmes and publishing pamphlets.

✓ There should be strict actions regarding the punishment for those who are involved in food adulteration.

✓ There should be help and support from International INGOs for implementation of food laws.

Therefore, to control problem of milk adulteration the following action should be forwarded;

i. In developing countries, adequate laws, funding and staffing should be appeared to control above discussed challenges

ii. ii. Different stakeholders should play great role to develop appropriate sampling programs based on statistical validity and sound sampling methodologies

Summary

Cow milk is a lacteal secretion obtained by the complete milking of cow used as sources for milk. Almost all commercially available milk comes from cows. In its natural form milk has high food value. It contains nutrients like proteins, fat, carbohydrates, vitamins and minerals.The composition of milk varies considerably with the breed of cow, stage of lactation, feed, season of the year, and many other processing factors. Milk adulteration is the act of intentionally decreasing the quality of milk offered for sale either the admixture or substitution of substance or removing of some valuable ingredient. The common adulterants used in cow milk are water, starch, flour, urea, formalin, sodium hydro oxide and cane sugar and others. These adulterant s have Considerable effect on the nutritional quality of cow milk by decreasing the concentration of ingredients found in it and wholesomeness of the milk.

On the basis of above review, we can conclude that, the milk adulteration is becoming serious problem in the world. About 68% milk delivered to consumer is not as per standards. Consumption of lower quality adulterated milk may lead to serious human

health issues. Hence it is important to have an efficient and reliable quality control system that will regularly monitor and ensure quality supply of milk to the consumer. The human and technology interface may help to eradicate the problem of adulteration. But Consumption of adulterated milk has considerable effect on the wholesome of the milk and it's product. The detergent in milk can cause food poisoning and other gastrointestinal complications, and an extent that there is very less nutritive value in it. This have Considerable effect on the nutritional quality of milk by decreasing the concentration of ingredients found in it. This activity has direct effect to consumers in health and economic fraud through the supply chain of milk.

Declarations

Author contribution statement

Tolcha Techane Alemu, this author was responsible for the accomplishment of all of the works, searching literature data and write up of the paper. He also contributed standardize the article and prepare the document. He made numerous contributions to the creation of this work and gave his approval for its publication. This author was in charge of completing all of the tasks, including literature research and paper writing.

ETHICAL STATEMENT

This study does not involve any human or animal testing.

Funding statement

This review paper did not receive any specific grant from funding agencies.

Declaration of interest's statement

The authors declare no conflict of interest.

Acknowledgements

The information in this review article was compiled from a variety of previously published sources, thus we would like to thanks all of the writers of those works. Also, Vietnam national university agriculture and Jimma University have great thanks for their support.

References

1. FAO/WHO. (2007). Joint FAO/WHO food standards programme FAO/WHO coordinating committee for Africa, seventeenth session, Rabat, morocco, 23-26.
2. Bereda, A., Yilma, Z., & Nurfeta, A. (2014). Dairy production system and constraints in Ezha districts of the Gurage zone, Southern Ethiopia. Global Veterinaria, 12(2), 181-186.
3. Khan, N., & Chittora, M. (2017). Milk adulteration: A chronic fear of real time. International Journal of Bioassays, 2278, 778X.
4. Tipu, M. S., Altaf, I., Ashfaq, M., & Siddique, S. (2007). Monitoring of chemical adulterants and hygienic status of market milk. Handbook published by Quality Control Laboratory, Univ. Vet. Anim Sci, Lahore, Pakistan, 7.
5. Neumann, C., Harris, D. M., & Rogers, L. M. (2002). Contribution of animal source foods in improving diet quality and function in children in the developing world. Nutrition research, 22(1-2), 193-220.
6. Spink, J., & Moyer, D. C. (2011). Defining the public health threat of food fraud. Journal of food science, 76(9), R157-R163.
7. Fatima, S., & Vasundhara, A. V. E. (2019). A study on milk quality testing and awareness of science and non-science students on milk adulteration. Journal of Food Safety and Hygiene, 5(2), 65-69.
8. Shaikh, N., Soomro, A. H., Sheikh, S. A., Khaskheli, M., & Marri, A. (2013). Detection of adulterants and their effect on the quality characteristics of market milk. Pakistan J Agric Eng Vet Sci, 29(2), 175-83.
9. Sharma, A., Batra, N., Garg, A., & Saxena, A. (2017). Food adulteration: A review. International Journal for Research in Applied Science & Engineering Technology (IJRASET), 5, 686-89.
10. Amenu, B. and Deeth, H.C., 2007. The impact of milk composition on cheddar cheese manufacture. Australian Journal of Dairy Technology, 62(3), p.171.
11. Naz, W. (2011). Subject: The dairy sector
12. Fakhar, H., Law, F., & Walker, G. (2006). The white revolution-dhoodh darya. Pakistan dairy development company, 72.
13. Loudon, I. (1986). Deaths in childbed from the eighteenth century to 1935. Medical history, 30(1), 1-41.
14. Guetouache, M., Guessas, B., & Medjekal, S. (2014). Composition and nutritional value of raw milk. J Issues Biol Sci Pharm Res, 2350, 1588.
15. Santos, P. M., Pereira-Filho, E. R., & Rodriguez-Saona, L. E. (2013). Application of hand-held and portable infrared spectrometers in bovine milk analysis. Journal of agricultural and food chemistry, 61(6), 1205-1211.
16. Fox, P. F., McSweeney, P. L., & Paul, L. H. (1998). Dairy chemistry and biochemistry.
17. Bruckmaier, R. M., Ontsouka, C. E., & Blum, J. W. (2004). Fractionized milk composition in dairy cows with subclinical mastitis. Veterinarni medicina, 49(8), 283.
18. MacGibbon, A. K. H. (2020). Composition and structure of bovine milk lipids. In Advanced Dairy Chemistry, Volume 2 (pp. 1-32). Springer, Cham.
19. Forouzmand, M. A., Ghorbani, G. R., & Alikhani, M. (2005). Influence of hybrid and maturity on the nutritional value of corn silage for lactating dairy cows. 1: Intake, milk production and component yield. Pakistan J. Nutr, 4(6), 435-441.
20. Jelen, P. and Rattray, W. (1995). Thermal denaturation of whey proteins. Heat-induced changes in milk., (Ed. 2), pp.66-85.
21. Singuluri, H., & Sukumaran, M. K. (2014). Milk adulteration in Hyderabad, India-a comparative study on the levels of different adulterants present in milk. Journal of Chromatography & Separation Techniques, 5(1), 1.
22. Öste, R., Jägerstad, M., & Andersson, I. (1997). Vitamins in milk and milk products. In Advanced Dairy Chemistry Volume 3 (pp. 347-402). Springer, Boston, MA.
23. Fardet, A. (2010). New hypotheses for the health-protective

mechanisms of whole-grain cereals: what is beyond fibre?. Nutrition research reviews, 23(1), 65-134.
24. United States Dept. of Agriculture (USDA). Nutrient Database. (2006).
25. Fleming, C. M., Farkye, N. Y., & Fox, P. F. (2003). Indigenous phosphatases in milk. Advanced Dairy Chemistry—1 Proteins, 523-543.
26. Tyasi, T. L., Gxasheka, M., & Tlabela, C. P. (2015). Assessing the effect of nutrition on milk composition of dairy cows: A review. Int. J. Curr. Sci, 17, 56-63.
27. Harmon, R. J. (1994). Physiology of mastitis and factors affecting somatic cell counts. Journal of dairy science, 77(7), 2103-2112.
28. Barham, G. S., Khaskheli, M., Soomro, A. H., & Nizamani, Z. A. (2014). Extent of extraneous water and detection of various adulterants in market milk at Mirpurkhas, Pakistan. IOSR Journal of Agriculture and Veterinary Science, 7(3), 83-89.
29. Strickland, J. R., Looper, M. L., Matthews, J. C., Rosenkrans Jr, C. F., Flythe, M. D., & Brown, K. R. (2011). Board-invited review: St. Anthony's Fire in livestock: causes, mechanisms, and potential solutions. Journal of animal science, 89(5), 1603-1626.
30. Chanda, T., Debnath, G. K., Hossain, M. E., Islam, M. A., & Begum, M. K. (2012). Adulteration of raw milk in the rural areas of Barisal district of Bangladesh. Bangladesh Journal of Animal Science, 41(2), 112-115.
31. Dehinenet, G., Mekonnen, H., Ashenafi, M., & Emmanuelle, G. (2013). Determinants of raw milk quality under a smallholder production system in selected areas of Amhara and Oromia National Regional States, Ethiopia. Agric. Biol. JN Am, 4(1), 84-90.
32. Dhanashekar, R., Akkinepalli, S., & Nellutla, A. (2012). Milkborne infections. An analysis of their potential effect on the milk industry. Germs, 2(3), 101.
33. Ayza, A., & Belete, E. (2015). Food adulteration: its challenges and impacts. Food Sci Qual Manag, 41, 50-6.
34. Ayza, A. and Belete, E., (2014). Food adulteration: its challenges and impacts. Food Sci Qual Manag, 41, pp.50-6.
35. El-Loly, M. M., Mansour, A. I. A., & Ahmed, R. O. (2013). Evaluation of raw milk for common commercial additives and heat treatments. Internet Journal of Food Safety, 15(10).
36. Alauddin S (2012). Food adulteration and society.Global research analysis international.Vol. 1(7), pp3-5.
37. Afzal, A., Mahmood, M. S., Hussain, I., & Akhtar, M. (2011). Adulteration and microbiological quality of milk (a review). Pakistan Journal of Nutrition, 10(12), 1195-1202.
38. Fathizadeh, M., Madani, M., Khan, Y., Faraz, N., Yıldırım, A., & Tutkun, S. (2013). An effective modification of the homotopy perturbation method for MHD viscous flow over a stretching sheet. Journal of King Saud University-Science, 25(2), 107-113.
39. FAO/WHO. (2007). Joint FAO/WHO food standards programme FAO/WHO coordinating committee for Africa, seventeenth session, Rabat, morocco, 23-26.
40. Pilizota, V., & Nedic Tiban, N. (2009). Category: natural products advances in honey adulteration detection. Food Safety Magazine, 60-64.
41. Ayza, A., & Yilma, Z. (2014). Patterns of milk and milk products adulteration in Boditti town and its surrounding, South Ethiopia. J Agric Sci, 4(10), 512-6.
42. Narayan, D. (2014). Food Adulteration: Types, worldwide laws and futures. Health care.
43. Faraz, A., Lateef, M., Mustafa, M. I., Akhtar, P., Yaqoob, M., & Rehman, S. (2013). Detection of adulteration, chemical composition and hygienic status of milk supplied to various canteens of educational institutes and public places in Faisalabad. JAPS, Journal of Animal and Plant Sciences, 23(1 Supplement), 119-124.
44. Lakshmi, V. Food adulteration. Int. J. Sci. Invent. Today 2012, 1, 106–113.
45. Awasthi, M. K., Pandey, A. K., Khan, J., Bundela, P. S., Wong, J. W., & Selvam, A. (2014). Evaluation of thermophilic fungal consortium for organic municipal solid waste composting. Bioresource technology, 168, 214-221.
46. Dogarawa, A. B. (2013). Hisbah and the promotion of ethical business practices: A reflection for the shari'ah implementing states in Nigeria. International Journal of Islamic and Middle Eastern Finance and Management.
47. Hamburg M A. 2010.Food and Drug Partnership for Safe Medicines Interchange.
48. Ehsan, M., Rahman, M. M., & Saadi, H. (2010). Effect of fuel adulteration on engine crankcase dilution. Journal of Mechanical Engineering, 41(2), 114-120.
49. Anita, G., & Neetu, S. (2013). Hazards of new technology in promoting food adulteration. IOSR Journal of Environmental Science, Toxicology and Food Technology, 5(1), 08-10.
50. Kandpal, S. D., Srivastava, A. K., & Negi, K. S. (2012). Estimation of quality of raw milk (open & branded) by milk adulteration testing kit. Indian journal of community health, 24(3), 188-192.
51. Ibens D (2014). The great melamine scare. The scandal draws attention to standards and leads to development of new tests. Food Quality & Safety, Current Issue. October/November, 2014.
52. Qian, G., Guo, X., Guo, J., & Wu, J. (2011). China's dairy crisis: impacts, causes and policy implications for a sustainable dairy industry. International Journal of Sustainable Development & World Ecology, 18(5), 434-441.
53. Nie, Y. L. (2008). Collections of speeches in the Summit Forum of dairy industry development in China. China Dairy, 12, 10-19.
54. Walker, B., Holling, C. S., Carpenter, S. R., & Kinzig, A. (2004). Resilience, adaptability and transformability in social–ecological systems. Ecology and society, 9(2).
55. Finete, V.L.M.; Gouvea, M.M.; Marques, F.F.C.; Netto, A.D.P. Is it possible to screen for milk or whey protein adulteration with melamine, urea and ammonium sulphate, combining Kjeldahl and classical spectrophotometric methods? Food Chem. 2013, 141.
56. Yigrem, S., Beyene, F., Tegegne, A., & Gebremedhin, B.

(2008). Dairy production, processing and marketing systems of Shashemene-Dilla area, South Ethiopia. IPMS Working Paper.
57. Draher, J., Pound, V., & Reddy, T. M. (2014). Validation of a rapid method of analysis using ultrahigh-performance liquid chromatography-tandem mass spectrometry for nitrogen-rich adulterants in nutritional food ingredients. Journal of Chromatography A, 1373, 106-113.
58. Renny, E. F., Daniel, D. K., Krastanov, A. I., Zachariah, C. A., & Elizabeth, R. (2005). Enzyme based sensor for detection of urea in milk. Biotechnology & Biotechnological Equipment, 19(2), 198-201.
59. Trivedi, U. B., Lakshminarayana, D., Kothari, I. L., Patel, N. G., Kapse, H. N., Makhija, K. K., ... & Panchal, C. J. (2009). Potentiometric biosensor for urea determination in milk. Sensors and Actuators B: Chemical, 140(1), 260-266.
60. Prout, W. (2003). Preparation and analysis of urea., American Association for Clinical Chemistry. Inc Clinical Chemistry, 49, 699-705.
61. Gwin, M. C., G. Lienert and J. Kennedy. (2009). Formaldehyde exposure and asthma in children. A systematic review. Environment Health Perspective, 118, 313-317.
62. Sharma, P., Kaur, H., Sharma, M., & Sahore, V. (2011). A review on applicability of naturally available adsorbents for the removal of hazardous dyes from aqueous waste. Environmental monitoring and assessment, 183(1), 151-195.
63. Ragaee, S. and Abdel-Aal, E.S.M., (2006). Pasting properties of starch and protein in selected cereals and quality of their food products. Food chemistry, 95(1), pp.9-18.. Pasting properties of starch and protein in selected cereals and quality of their food products. Food chemistry, 95(1), pp.9-18.
64. Malame, P.R.; Bhuiya, T.K.; Gupta, R.K. (2014). Microwave reflectometry based electrical characterization of milk for adulteration detection. Adv. Electronic Electric Eng, 4, 487–492.
65. Ramalakshmi, K., Kubra, I. R., & Rao, L. J. M. (2007). Physicochemical characteristics of green coffee: Comparison of graded and defective beans. Journal of food science, 72(5), S333-S337.