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Review Article

Nutritional Quality, Level of Chemical Contaminants and Adulterants in Milk and Dairy Products in Ethiopia: A Review

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Abstract: Milk is a highly nutritious food, and it is a source of necessary macro and micro-nutrients for the growth, development and maintenance of human health. However the quality and safety of milk and dairy products become major health concern for consumers particularly to infants and children. This paper attempts to review the state of knowledge on nutritional quality, chemical contaminants and adulterants of milk and dairy products in Ethiopia. It also focuses on the method for analysis and identifies gaps for future work. Some work has been done in nutritional quality of milk and dairy products. The nutritional quality of Ethiopian milk products are substandard due to poor hygienic practices and water adulteration at farm level and value chain actors. Few of the research results reviewed for aflatoxin M_1, organochlorine pesticide, heavy metals and antibiotic residues exceed international maximum permissible limit standards. The use of adulterants for economic gain is adding of water (dilution) in raw milk. In general there are limited reports in chemical contaminants in the country. Further research is required on quantification, implementation of monitoring and controlling system to improve the quality and safety of milk products across value chain in the regions of the country.

Keywords: Adulterants, Chemical Safety, Nutritional Quality, Milk Products

1. Introduction

Milk is a highly nutritious food containing many macro- and micronutrients that are essential for the growth and maintenance of human health [1]. Milk quality and safety is a great concern in developing countries where production of milk and various milk products takes place under unhygienic conditions poor production and management practices. The common milk and dairy products contaminants are aflatoxins, toxic metals, pesticides, antibiotics and adulterants which can be controlled or/reduced by implementation of good agricultural practices and good hygienic practices at farm level and other value chain actors.

Aflatoxins are metabolic by products produced mainly by molds *Aspergillus flavus* and *Aspergillus parasiticus*. The presence of aflatoxin B_1 (AFB_1) in feed and the subsequent exposure of lactating animals to it leads to the contamination of milk with the hydroxyl metabolite AFM_1 [2-4]. AFM_1 is known to be carcinogenic and can be a potential health hazard to humans particularly to infants and children since they are more susceptible to its effect than adults [5].

Heavy metals are persistent contaminants in the environment that can cause serious environmental and health hazards [6]. This can be caused by the increase of industrial, use of new technologies and urban emissions. Milk products contain different amounts of toxic contaminants due to the grazing of livestock on contaminated land and ingestion higher levels of metals have been found in milk as a result of bioaccumulation [7, 8]. These residues in milk are of particular concern even in low concentrations because milk is largely consumed by infants and children [9].

Pesticides, including the organochlorines (OCPs) are chlorine containing compounds which are found in the environment as a result of human activities [10]. OCPs are persistent and highly stable under most environmental conditions [11], which lead to high biomagnification in the food chain across a wide range of trophic levels [12]. Milk producing animals accumulate pesticides from contaminated feed and air and they are subsequently translocated and excreted through milk fat thereby consumers of milk products could be exposed to these residues [13].

Antibiotics are the primary tools for treating bacterial infectious diseases [14], and to enhance animal growth and feed efficiency in lactating cows [15]. Problems associated with antimicrobial residues in milk include increased resistance of pathogenic bacteria towards antimicrobials, risk of allergy [16], decrease acid and flavor production of butter, reduce the curdling of milk, cause improper ripening of cheeses [17].

Economically motivated adulteration is emerging risks, being addition of low cost ingredients creates an economical problem, a health risk for consumers and lowers the milk quality [18, 19]. Milk is a constant target of adulteration especially in the developing world due to increased global production and consumption of milk [20]. Therefore the objective of this review is to provide information on nutritional quality, chemical contaminants and adulterants of milk products.

2. Materials and Methods

Review materials were collected through searching from Addis Ababa University (AAU) library, AAU website data, Science Direct, Google Scholar and Internet to gather publicly available information on the nutritional quality, chemical contaminants and adulterants of milk products. In this review method of analysis and sample sizes are mentioned in detail. The study results of articles were discussed with local and international maximum permissible limit standards of milk products. Citations are cross-check with reference lists of scientific sources.

3. Results and Discussion

3.1. Nutritional Quality of Milk Products

Nutritional qualities of milk and dairy products so far done in Ethiopia are presented in Table 1. The study by Dehinenet et al. [21] on raw cow's milk quality found a significant difference in all physico-chemical milk quality parameters among the districts. Breed, parity number, feeding system, farming experience and distance from dairy technology dissemination centers had significant influence on fat and protein percentages. In this work, protein level correlated positively and negatively with lactose and freezing point respectively. Dilution of milk by water (adulteration) strongly affected the nutritional quality of fresh milk. Another study by Eyassu reported average moisture, fat, protein and ash in *Metata Ayib*, a traditional Ethiopian fermented and spiced cottage cheese procured from a local market. A big variation in the gross nutritional composition was observed among the different *Metata Ayib* samples which could be attributed to the difference in the manufacturing procedure especially the spices used by the different producers. He recommended that there is a need to standardize the manufacturing procedure with respect to spices used so as to produce *Metata Ayib* with consistent properties.

The research accomplished by Teklemichael et al. [23] evaluated the physico-chemical properties of cow milk samples collected from dairy farms and milk vendors and reported significant difference in total solids, SNF due to poor milk handling practices in the farms and vendors. Similar study by Woldemariam and Asres [24] conducted to investigate physico-chemical qualities of different brands pasteurized milk and found no significant difference for total solids and protein contents in all pasteurized milk samples but significant difference for fat contents and total ash. The variation in physico-chemical compositions could be due to failure of regular standardization throughout the production period and they recommended to routinely examining the qualities of pasteurized milks immediately before the products are released into the market.

An assessment of physical and chemical quality of raw cow's milk produced and marketed in Shashmenie town undertaken by Teshome et al. [25]. Results showed significant difference for values of temperature, pH, titratable acidity, total solids, fat, protein, ash and lactose contents between sources of milk sample collected from collection centers, hotels, small shops and small scale producers. They conclude that nutritional composition was adequate as compared to the standard level. Evaluation of nutritional composition of raw milk conducted by Alganesh [26] from Horro cows and found similar nutritional composition of the milk in both locations and meet the acceptable standards. Significant differences for total solid, fat and protein between raw cow's milk of local and crossbred found in Walmera district [27]. They concluded that the nutritional quality of the collected raw cow's milk were within recommended levels of FAO standards. Teshome and Tesfaye [28] also reported similar finding in raw cow milk collected from three districts of Benji Maji-zone, southwestern Ethiopia.

The study by Gurmessa [29] found higher values of total solids, fat, SNF, protein, ash and lactose in milk samples from open market than household milk producers. Bruktawit and Ashenafi [30] obtained under the acceptable level of protein and fat of raw milk sample from all scale of production except freezing point, SNF and total solids in Addis Ababa sub-cities from small, medium and large farms. They suggested following hygienic practice on milk production and handling. The finding by Fikirneh et al. [31] on nutritional composition of fat, protein and SNF of raw milk obtained significantly different between breeds and among study districts. However the results of nutritional composition were adequate as compared to the standard level. Another study by Tseday and Asrat [32] observed significantly lower values for fat, SNF and water percentage of milk samples collected from consumers than producers. The poor handling practice and substandard quality of composition could be due to limited knowledge of producers and consumers on the improved hygienic handling practices.

Table 1. Nutritional quality of milk and dairy products

S/n	Milk products	Study area	Sample size (n)	Results obtained	Reference
1	Raw milk	Amhara and Oromia regions	384	Fat, SNF and protein obtained were 5.22, 8.44 and 3.12% respectively	[21]
2	Metata Ayib	West Gojam	19	Average moisture (42.3%), fat (28.7%), protein (43%), ash (3.2%), titratable acidity (0.43%) and pH (4.0)	[22]
3	Raw milk	Dire Dawa town	30	The mean protein, fat, total solids and SNF contents were 3.42, 3.862, 12.575 and 8.75 respectively	[23]
4	Pasteurized milk	Bahir Dar and Addis Ababa	Not known	Fat (2.7-4.7%), total solids (9.8-11.93%), ash (0.6-0.8%), protein (3.42-4.79%), SNF (1.9-4.16%) and lactose (1.14-4.7%)	[24]
5	Raw milk	Shashmenie town	48	Total solids, fat, protein, ash and lactose contents were 4.28, 8.59, 3.43, 0.74 and 4.43 respectively.	[25]
6	Raw milk	Guto Wayu and Bila Sayo districts of East Wolloga	15 each	The means for the total solids, SNF, protein, casein, fat, lactose, ash, and specific gravity were 14.31, 8.22, 3.31, 2.63, 6.05, 4.51, 0.70 and 1.03%, respectively	[26]
7	Raw milk	Walmera district	30 each	The means for total solids, fat, SNF, protein, ash and lactose of local breed cow's milk were 14.71, 5.46, 9.26, 3.07, 0.72 and 5.47% where as for crossbreed were 13.03, 4.04, 9.01, 2.70, 0.73 and 5.85 respectively.	[27]
8	Raw milk	Benji Maji zone	45	Overall mean of 6.02, 3.98 and 0.79% for fat, protein and ash respectively	[28]
9	Milk products	Borona zone	60	Total solids=15.47%, fat=6.01%, SNF=9.46%, protein=3.94% ash=0.8%, lactose=4.72	[29]
10	Raw milk	Addis Ababa sub-cities	90	Overall mean of 4.42, 3.2, 7.6 and 12.02% for fat, protein, SNF and total solids, respectively	[30]
11	Raw milk	Mid-rift valley	48	Fat (5.48%), protein (3.46%), and SNF (9.10%)	[31]
12	Raw milk	Hawassa and Yirgalem towns	120	4.4, 8.23, 3.14 and 4.87% contents of fat, SNF, protein and lactose, respectively	[32]
13	Raw milk	Bishoftu and Akaki towns	52	Fat, protein, SNF, total solid, lactose and ash contents were 3.60, 3.27, 7.78, 11.38, 3.93 and 0.62% respectively	[33]
14	Raw milk	Harar	36	Ash, protein, fat, total solid, SNF and lactose contents were 0.68, 3.51, 5.12, 13.10, 7.98 and 3.79%, respectively.	[34]
15	Raw milk	Ejere, Walmera, Selale and Debre-Birhan	108	The means values of 3.76, 3.10, 12.24, 0.61, 5.08 and 8.56% for fat, protein, total solids, ash, lactose and SNF respectively	[35]
16	Pasteurized milk	Addis Ababa	30	Overall mean for fat, protein, total solids and SNF were 2.95, 2.75, 9.45 and 6.46% respectively	[36]
17	Raw milk	Adea berga and Ejerie districts	90	The overall mean value of fat, protein and SNF percents were 3.51, 3.09 and 12.19, respectively.	[37]
18	Butter	Menz district	5	Overall mean moisture content (15.05%) and fat content (82.62%)	[38]
19	Raw milk	Jimma	54	The mean fat, protein, lactose and SNF content were 4.38, 2.96, 4.34 and 7.79, respectively.	[40]
20	Raw milk	Sebeta, Sululta and Holeta districts	60	Ash (0.47-0.86), protein (2.28-3.29), fat (2.79-4.58) and SNF (9.13-13.02)	[41]
21	Canned dry milk	Addis Ababa	4 brands	Fat (Labeled=26.2- 28.8%; determined= 2.715-5.125%). Protein (Labeled=24- 26%; determined= 8.021-17.133%).	[43]
22	Raw milk	Debre-Libanos district	65	The fat, lactose, SNF and protein were 3.93, 4.13, 7.54 and 2.73%, respectively.	[44]
23	Raw milk	Jigjiga district	20	Cow milk had 6.30 pH, 0.29 titratable acidity, 14.6 total solid, 0.75 ash, 3.54 protein, 5.54% fat and 1.06 specific gravity.	[45]
24	Butter	Dire Enchini and Ejere Districts	Not known	Dire Enchini district: average ash, fat, protein, CHO and SNF contents of 0.10, 82.73, 2.32, 1.18 and 4.45%, respectively. Ejere district were 0.13, 84.71, 1.87, 0.86 and 2.19%, respectively.	[46]

The research performed by Dessalegn et al. [33] found significant difference in nutritional composition of milk samples across value chain points of Bishoftu and Akaki towns, which slightly fulfilled to the global and Ethiopian standard. The finding by Hawaz et al. [34] also showed significant difference in protein, fat, total solids and SNF of raw milk collected from milk shed through random sampling along the dairy value chain. The overall mean value of the fat and protein (5.13 and 3.51%) in the study area is higher than the Ethiopian standard (value of 3.50 and 3.20%). Alganesh [35] conducted to assess nutritional composition of milk from producers in districts of central highlands through purposive random sampling technique. The average composition of protein, total solids and ash were below Ethiopian Standard Agency. The lower average total solids might be due to the practice of adulteration and fat skimming before taking milk to collection points. The lower protein content might be due to deficiency of crude protein in the cow ration.

The finding by Anteneh et al. [36] showed that the protein, total solids and SNF of pasteurized milk marketed in Addis Ababa were below the minimum regulatory limit of the Ethiopian standards except for the fat content. The likely causes for the lower values of nutritional and physical composition were the use of low quality starting milk or addition of water. Another study by Saba et al. [37] found 32.2% positive milk samples with alcohol test while 18.8% of the samples were positive to clot on boiling test. They concluded that adequate sanitary and hygienic measures should be taken at all stages from production to consumer level. The study by Mego et al. [38] reported lower cooking butter quality due to unhygienic production and processing of butter in the study area which calls for improvement. The average moisture and ash content of butter collected from open markets of Delbo and Kucha were 18.86% and 0.16% respectively, the quality could be affected by different factors in the supply chain [39]. Belay and Janssens [40] assessed the physical and nutritional quality of raw milk collected from dairy farms which almost meets the accepted standards.

Raw milk samples collected from Sebeta, Sululta and Holeta districts contained unhygienic and poor handling practices and considered as substandard which will result in public health hazard to the consumer [41]. Of chemical composition of milk parameters, significant difference was observed in the mean fat composition among different mastitic milk [42].

3.2. Level of Chemical Contaminants in Milk Products

3.2.1. Aflatoxin M_1

AFM_1 is a hydroxylated metabolite of AFB_1 that is excreted in milk in the mammary glands of both humans and lactating animals [47]. AFM_1 in milk and dairy products have been previously reviewed in different countries [1, 48-51]. The researches done on AFM_1 in milk and dairy products in Ethiopia are mentioned in Table 2. The finding by Yohannes et al. [52] showed that presence of AFM_1 in milk samples and contamination level between 0.02-0.31 $\mu g\ l^{-1}$. About 60% animal feed samples contaminated with total of AFB_1, AFB_2, AFG_1 and AFG_2 ranged between 4.22 and 10.54 $\mu g\ l^{-1}$ in 10 samples of feed. The increase in aflatoxin caused by use of contaminated mixed daily feed by dairy farmers (mixture of wheat bran, noug cake and cotton seed cake) for cow feeding.

The research performed by Selamawit et al. [53] also studied levels of AFM_1 in milk products from industrial and local sources and found maximum mean concentration of AFM_1 in milk and yogurt from the local market relative to the industrial. However the mean values of aflatoxin contamination of all dairy types from local source were lower than the samples from industrial sources. This is because during the production processes of dairy products in the dairy industry in which raw milk collected from more than 30 individual raw milk suppliers having both higher and lower concentration of the toxin in the raw milk. Therefore they concluded that the reason for finding the maximum mean concentration of aflatoxin in the industrial dairy products is due to cross contamination during the production process.

The study conducted by Rehrahie et al. [54] reported higher AFM_1 (0.088 μg/l), from Bishoftu followed by Hawassa (0.057 μg/l) and Holetta (0.017 μg/l) sites in smallholder urban dairy producers. Likewise, concentrations of AFB_1 in different feed samples were 33.64, 20.28 and 11.07 μg/kg in Bishoftu, Holeta and Hawassa sites respectively, this indicates that AFB_1 level in the feed samples had a direct contribution for the increase in AFM_1 level in milk samples across the studied locations. Aflatoxin levels were quantified by commercial enzyme-linked immunosorbent assay (ELISA).

Another research finding by Gizachew et al. [55] on aflatoxin levels in milk samples collected from dairy farmers, milk collectors and dairy feeds (dairy farmers and processors) in the Greater Addis Ababa milk shed. They reported presence of AFM_1 in all milk samples and contamination level ranged between 0.028 and 4.98 μ/L. Overall, only nine (8.2%) out of a total of 110 milk samples contained ≤ 0.05 mg/l of AFM_1 and 29 (26.3%) exceeded 0.5 mg/l. All the feed samples were contaminated with AFB_1 (7-419 μg/kg). Out of a total of 156 feed samples collected, 41 (26.2%) of the feed samples contained AFB_1 at a level exceeding 100 mg/kg. They also found significant linear regression associations between the presence of noug cake in the feed and the levels of contamination of both AFM_1 in milk and AFB_1 in feed. Similar study by Abenet et al. [56] found mean AFM_1 levels of 11.30, 11.94, 12.88 and 29.93 ppb for Sululta, Debrebirhan, Bishoftu and Addis Ababa study sites respectively. They also reported significantly AFM_1 contamination in milk from non-grazing cows than milk from grazing cows and milk collected from Addis Ababa city.

The reduction of AFM_1 levels (57.33 and 54.04%) during lab-scale *ergo* (traditional Ethiopian fermented yoghurt) production was investigated by Tsige and Alemayehu [57] through determination of the residual levels of AFM_1 using ELISA. Microbiological investigation showed increasing LAB counts with incubation time. A gradual decrease in pH of the milk samples was observed during fermentation. Considering the fact that both viable and dead bacterial cells could remove AFM_1 during ergo production, the mechanism is proposed as predominantly involving non-covalent binding of the toxin with the chemical components of the bacterial cell wall.

3.2.2. Heavy Metals

Some of heavy metal contamination in milk products are summarized (Table 3). The study performed by Rehrahie et al [54] found average concentration of Cd, Pb, As and Cr in cow milk samples analyzed using graphite furnace atomic absorption Spectrophotometer (GFAAS). They found that the Cd and As contents of all milk samples were within the permissible limits, whereas the concentrations of Pb in majority and Cr in all milk samples were above the permissible limits which are indicative of environmental pollution. Similarly Tassew et al. [58] studied concentrations of selected heavy metals in fresh cow's milk samples collected from four dairy farms. The elements, Co, Ni, Cd and Pb were not detected in all the milk samples. There is no significant difference in the mean concentrations of Cr and Mn between the milk samples of four farms where as that of Zn is significantly different. They reported that the detected heavy metals (Cr, Mn, Cu and Zn) can be found naturally in food. They are essential elements and thus, these metals can be found in cow's milk.

The research done by Akele et al. [59] reported heavy metal concentrations in milk samples in the following decreasing order: Zn > Mn> Cu > Cr > Cd > Pb in Chilga and Dembia and Mn> Zn > Cu > Cr in Wogera milk samples. The highest concentration in milk samples is probably due to high mineral enrichment and metal leaching (especially Cd and Pb) from coal deposits cross contamination in the chain. A study undertaken in Hawassa around Tikur-Wha textile industry on heavy metal content of milk which were reported to be unsafe [60]. This is because of contamination of livestock and irrigation areas from the industry effluents discharges. Gashu et al. [61] reported beyond acceptable level of toxic metals (Cd and Pb) in the samples of cow milk from Addis Ababa sub cities which can be a health concern for consumers. The contamination could be from environmental pollutions. Heavy metals content of traditionally prepared Ethiopian fresh butter was investigated by Shitaye et al. [46] and obtained followed in the decreasing order; Fe > Zn > Cu >Mn (mg/ Kg) in butter sample from Dirre Enchini district. Similar order was found from Ejere district, except Cu > Zn. The concentrations of the metals were in a good agreement with the international standards and indicating no risk exposure of using the butter from the investigated areas.

Table 2. *AFM_1 levels in milk and dairy products.*

S/n	Milk products	Study area	Sample size (n)	Analysis method	Results obtained (µg/l)	Reference
1	Raw milk	Guragie zone	10	ELISA HPLC	0.02-0.31	[52]
2	Milk, Cheese Yoghurt	Bishoftu and its surrounding	266	ELISA	0.265-2.212 (industrial source) and 0.191-1.628 (local source)	[53]
3	Raw milk	Bishoftu, Holetta and Hawassa	160	ELISA	0-0.146	[54]
4	Raw milk	Addis Ababa	110	ELISA	0.028-4.98	[55]

Table 3. *Heavy metal levels in milk and dairy products*

S/n	Milk products	Study area	Sample size (n)	Analysis method	Results obtained	Reference
1	Raw milk	Bishoftu and Holetta	30 each	GFAAS	Cd (34.24 µg/l), Pb (33.01 µg/l), As (6.70 µg/l) and Cr (95.35 µg/l)	[54]
2	Raw milk	Borena Zone	160	FAAS	Not detected (ND)-(Co, Ni, Cd and Pb) Cr (0.845–0.895 µg/ml), Mn (0.411–0.441 µg/ml), Cu (0.087–0.122 µg/ml) and Zn (5.003–6.218 µg/ml)	[58]
3	Raw milk	North Gondar	30	FAAS	Cr, Mn, Cu, Zn, Cd, and Pb concentrations ranged 0.468–0.828, 1.614–2.806, 0.840–1.532, 1.208–5.267, ND–0.330 and ND–0.186 mg/kg respectively	[59]
4	Raw milk	Hawassa	30	AAS	600, 150 and 150 mg/l for Pb, Cd and Cr respectively	60]
5	Raw milk	Addis Ababa sub cities.	32	FAAS	Fe (1.213 mg/kg), Zn (4.923 mg/kg), Cd (0.1 mg/kg) and Pb (0.993 mg/l)	[61]
6	Canned dry milk	Addis Ababa	4 brands	FAAS	Cd (0.202-1.991 mg/g), Cu (0.094-1.512 mg/g), Pb (5.37-15.99 mg/g) and Zn (16.17-23.67 mg/g)	[43]
7	Pasteurized milk	Addis Ababa	6 brands	AAS	Zn (1.93-3.31 µg/g)	[62]
8	Raw milk	Sebeta, Sululta and Holeta	60	AAS	Fe (0.06-0.086 mg/100g), Zn (0.356-0.299 mg/100g)	[41]
9	Raw milk	Haramaya University	3	FAAS	Zinc (3.527 mg/l), Copper (0.206) and Chromium (0.064 mg/l).	[63]

3.2.3. Organochlorine Pesticide Residue (OCP)

Few of research reports of OCP in milk and dairy product are presented in Table 4. Six persistent OCPs residues: aldrin, α-endosulfan, *β*-endosulfan, *p, p'*DDE, *p, p*'DDD and *p, p*'DDT in cow milks in Arsi, East Showa and Jimma which were selected based on information of pesticides use to control pests and malaria, reported by Deti et al. [64]. Aldrin (11.6 µg kg^{-1}) detected only in one cow milk sample and α-endosulfan detected in one goat milk sample at a level of 142.1 µg kg^{-1}, and in one cow milk sample (47.8 µg kg^{-1}) from the same region. DDE was detected in 40% of the milk samples analyzed while DDT and DDT were found in high amounts in almost all samples. The average total DDT (excluding DDD) in the samples was 328.5 µg kg^{-1}. Regions known for their malaria epidemics were the most contaminated with DDT residue. The accumulation pattern in both species was not clear under natural sampling. All pesticide residues found above the limit of quantification above the EU maximum residue limits (MRL). About 80% of the milk samples found to contain total DDT residue above EU MRL. Similar research by Gebremichael et al. [10] studied OCPs residues in cow's using GC–ECD and found total DDT mean levels of 0.389 μgg^{-1} in cow milk samples in the studied areas which are malarious, common annual spraying of DDT for malaria control, historical wide use and cheap availability in illegal markets in the area. They recommended to be carried out similar studies in other parts of the country to evaluate the breadth of the exposure.

3.2.4. Antibiotic Residue

Table 5 shows level of antibiotics in milk products. The research done by Desalegn et al. [65] reported higher prevalence and amount of oxytetracycline and penicillin G residues in bovine bulk milk from Nazareth dairy farms using Delvotest SP assay and positive samples were quantified by

HPLC. The antibiotic residue positive samples showed residues of oxytetracycline above the WTO/FAO/CAC established MRL of 100 µg/l were 40 (83.33%). For penicillin G, the number of samples above the MRL of 4µg/l, were 8 (16.66%). Desalegn [66] also found 34 (8.5%) positive milk samples of oxytetracycline and penicillin G residues in Debre Zeit dairy farm out of 400 samples analyzed. The major contributing factors to obtain higher prevalence and amount of antibiotic residues are lack of proper management and awareness of the people.

The study conducted by Yalelet et al. [67] found 36% penicillin residues out of 100 milk samples collected from healthy lactating cows of six dairy farms at Kombolcha dairy farms. Prevalence of penicillin residues in different farms ranged between 25 to 50%. Penicillin residues screened by using Delvotest SP. They recommended that coordinated nationwide surveillance of animals' by products for antibiotics residues together with determining their concentration, and initiating monitoring programmes and awareness campaigns to sensitize the populace on the dangers associated with residues in animal products in Ethiopia. The study by Tesfalem et al. [68] on antimicrobial residues in Bovine bulk milk and knowledge of farmers from Bishoftu dairy farms found high prevalence of antimicrobial residues and more than 88.5% of the farm owners' lacked proper management practices or awareness to avoid drug residues in milk and to prevent human health hazards. Takele et al. [69] conducted assessment of chemicals and drugs used for dairy and poultry farms and they recommended that laboratory investigation should be done to confirm the presence of drugs and/or chemicals in foods of animal origin (milk and its products, poultry meat, and eggs).

Table 4. *Levels of OCPs in milk and dairy products*

S/n	Milk products	Study area	Sample size (n)	Analysis method	Results obtained	Reference
1	Raw milk	Arsi, East Showa and Jimma	20	GC-MS	Aldrin (11.6 µg kg^{-1}) detected only in one cow milk sample. α-endosulfan in one cow milk sample (47.8 µg kg^{-1}). The average DDT (excluding DDD) (328.5 µg kg^{-1})	[64]
2	Raw milk	Asendabo, Serbo and Jimma	30	GC-ECD	Total DDT mean levels of 12.68 µg g^{-1} in the human and 0.389 µg g^{-1} in the cow milk samples	[10]

Table 5. *Levels of antibiotics in milk and dairy products.*

S/n	Milk products	Study area	Number of samples (n)	Analysis method	Results obtained	Reference
1	Bovine bulk milk	Nazareth dairy farms	400	Delvotest HPLC	Oxytetracycline and penicillin G in all samples ranged between 45-192 µg/l and 0-28 µg/l, with the mean residue level of 125.25 µg/l and 4.52 µg/l respectively	[65]
2	Bulk milk of cows	Debre Zeit dairy farms.	400	Delvotest HPLC	The mean residue level of oxytetracycline was 142.00 µg/l that of penicillin G was 4.77 µg/l.	[66]
3	Raw milk	Kombolcha Dairy farms	100	Delvotest SP	Penicillin residues were found in 36% of the samples test. Prevalence of penicillin residues ranged from 25% to 50%.	[67]

Table 6. *Adulterants in milk and dairy products.*

S/n	Milk products	Study area	Sample size (n)	Analysis method	Results obtained	Reference
1	Raw milk	Hossana city	10 each actor	Clot on boiling tests and alcohol perception test Density determination	Higher water adulteration found in cafeteria (2.30%) than milk producers (1.08%)	[70]
2	Milk and diary products	Boditti town and its surrounding	120	Survey pattern study	water, banana, vegetable oil, defatted milk and preservatives (spices and herbs) were extraneous substances added into milk products	[71]
3	Raw milk	Bahir Dar	9	Determination of specific gravity	76.7% of milk samples collected was free from water adulterant.	[72]
4	Raw milk	Ejerie and Adea Berga districts	90	Determination of specific gravity	The specific gravity of milk samples were in the range of 1.024 to 1.032 in Ejerie district and 1.022 to 1.031 in Adea Berga district.	[37]

3.3. Adulterants in Milk Products

Few findings in adulterants of milk and dairy products are shown in Table 6. Water is the most common adulterants in milk which is often added to increase the quantity of milk for economic gain. The study by Haftu and Degnet [70] found higher water adulteration in cafeteria (2.30%) than milk producers (1.08%) in randomly collected samples using Lacto scanner. They also reported superior quality milk sample in household than cafeterias using clot on boiling tests and alcohol perception. Ayza and Yilma [71] studied patterns of milk products adulteration and reported that water, banana, vegetable oil, defatted milk and preservatives (spices and herbs) are extraneous substances added into raw milk, cheese, fresh butter, defatted milk and milk powder. They recommended further research to be done for identifying, quantifying the adulterants and the impacts in the studied area. Mekonen and Mengistu [72] evaluated water adulteration of the collected raw milk samples around Bahir Dar and reported 76.7% of milk samples collected were free from water dilution.

4. Conclusion and Recommendations

Milk and dairy products have poor nutritional quality, contaminated with chemical hazards and adulteration practice (water dilution) in Ethiopia. Further research is required to assess knowledge and practices of quality and safety of milk products across value chain actors in the country. Chemical contaminants should be further investigated in the regions of country. Adulterants such as formalin, sugar, salt, starch, urea and preservatives need to be studied. Intervention and awareness s creation should be conducted to improve the quality and safety of milk products.

Conflict of Interests

The authors have not declared any conflict of interests.

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