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Some Residues and Contaminants in Milk and Dairy Products

HILAL COLAK*, HAMPARSUN HAMPIKYAN and ENVER BARIS BINGOL
Department of Food Hygiene and Technology, Faculty of Veterinary Medicine
Istanbul University, 34320, Avcilar, Istanbul, Turkey
Email: hcolak@istanbul.edu.tr

Milk and dairy products are important components of the human diet. Some residue and contaminants in milk and dairy products can be classified as antibiotics, mycotoxins, anthelmintics, pesticides, dioxins, hormones and heavy metals. Presence of the residual concentrations of these compounds in milk and dairy products can be an important direct indicator for the quality status of the milk and their products, because these agents can easily transported to milk and dairy products which are evaluated the most important contamination sources for the human health. In this review, some residue and contaminants and surveys on this subject in Turkey were considered.

Key Words: Residues, Contaminants, Milk, Dairy products.

INTRODUCTION

Milk is a basic food in the human diet, both in its original form and as various dairy products. As an excretion of the mammary gland, it can carry numerous xenobiotic substances (veterinary drugs, pesticides, heavy metals and various environmental contaminants), originated from the grazing animals in pasture and contaminated animal feed which may cause economic loses and technological problems for the producers and health problems for the consumers. Presence of the residual concentrations of these substances in milk and dairy products can be an important direct indicator for the quality status of the milk and their products. These agents can easily transported to milk and dairy products which are evaluated the most important contamination sources for the human health. Some residue and contaminants in milk and dairy products can be classified as antibiotics, mycotoxins, anthelmintics, pesticides, dioxins, hormones and heavy metals.

Antibiotics

Antibiotics are widely used in dairy cattle management for the treatment of disease and as dietary supplements. They may be administered orally as feed additives or directly by injection. The use of antibiotics may result in drug residues being present in the milk, especially if they are not used according to label directions[1].

The presence of antibiotic residues in milk may cause allergic reactions in sensitive individuals and interfere with starter cultures for cheese and other dairy products[2]. Antibiotics, such as ß-lactams, aminoglycosides, tetracyclines and chloramphenicol are the most detected residues in milk and dairy products in many countries.

Most commonly aminoglycoside antibiotics used in food producing animals are gentamycin, neomycin, dihydrostreptomycin and streptomycin. All aminoglycosides have well-known toxicological effects such as ototoxicity and nephrotoxicity. Moreover, in sensitive individuals allergic reactions can occur due to the presence of aminoglycoside residues. Intravenous or intramuscular injections of aminoglycosides normally produce few residues in milk[3]. However, intramammary or intrauterine use is a potential cause of the presence of residues in milk. So, maximum residue limits (MRLs) were established to protect the consumer. The FDA has set the tolerance levels as 125 ng/mL for dihydrostreptomycin, 150 ng/mL for neomycin and 30 ng/mL for gentamycin in milk[1]. The macrolide antibiotics are most effective against gram-positive organisms and they are used to treat a wide range of infections. β-Lactam antibiotics, which include the penicillins and cephalosporins, are widely used in veterinary medicine. Although penicillins are one of the oldest groups of antibiotics, they still enjoy extensive clinical utility[2]. Tetracycline antibiotics are widely used for the treatment of bovine mastitis and are added at subtherapeutic levels to cattle feeds for prophylaxis. The FDA has set the levels of concern for residues of chlortetracycline, oxytetracycline and tetracycline in milk as 30, 30 and 80 ng/mL, respectively[1].

In Turkey, Aksu *et al.*[4] studied the tetracycline and streptomycin residues in milk samples by ELISA. In this study, streptomycin was found in 98 of 126 samples (77.8%). Only one milk sample was higher than the maximum tolerance limit (200 ppb) accepted by Turkish Food Codex. Tetracycline was determined in 161 of 167 samples (96.4%) and all tetracycline residues were found to be below legal limit (100 ppb) in Turkish Food Codex.

Mycotoxins

Mycotoxins are toxic metabolites produced by various fungi growing in a wide range of food and animal foodstuffs. The main mycotoxins that occur frequently are aflatoxins, ochratoxin A, patulin, trichothecenes (such as nivalenol, T-2 toxin) and zearalenone[5]. The most common mycotoxins that are stable in milk and dairy products such as cheese, are citrinin, cyclopiazonic acid, penitrem A, roquefortine C and aflatoxin[6]. Aflatoxin

B1 (AFB1) is produced by certain *Aspergillus spp*. during their growth on animal feeds[7]. Mammals which consume feed contaminated with Aflatoxin B1, produce milk contaminated with Aflatoxin M1 (AFM1)[8]. Aflatoxin M1 is a hepatic carcinogenic metabolite found in milk of lactating animals which consume food with Aflatoxin B1[9]. In relation to cheese, the presence of aflatoxins may be due to three causes: a) presence of AFM1 in milk, b) synthesis of AFB1, B2, G1, G2 by fungi, c) the use of powdered milk with AFM1, to enrich milk employed in cheese production[10].

There are several studies on presence of aflatoxins in milk and dairy products in our country. Bakirci[11] found AFM1 in 79 (87.77 %) of 90 of milk samples examined. 35 (44.30 %) of the positive samples were higher than the maximum tolerance limit (0.05 ppb) accepted by Turkey and some other countries. In other study, it was determined the occurrence of AFM1 in some cheese types by Gurses *et al.*[12]. In this study, 63 samples of cheese consisting of 23 white cheeses, 14 kashar cheeses, 11 tulum cheeses, 9 civil cheeses and 6 lor cheeses were analysed by ELISA. In 28 of 63 samples (44.4 %), the presence of AFM1 was detected in concentrations between 7-202 ng/kg. The mean level of AFM1 were 28.08 ng/kg in white cheeses, 22.80 ng/kg in kashar cheeses, 74.05 ng/kg in tulum cheeses, 12.32 ng/kg in civil cheeses and 15.95 ng/kg in Lor cheeses. Sarimehmetoglu *et al.*[7] determined the levels of AFM1 in cheeses consumed in the province of Ankara. A total of 400 cheese samples containing 100 samples each of white, kashar, tulum and processed cheeses were analysed by ELISA. 110 cheese samples (27.5 %) were found to have levels that exceed the legal limits of 230 ng/kg establishes by the Turkish Food Codex. Among these, 27 % of white cheese, 24 % of tulum cheese, 34 % of kashar cheese and 25 % of processed cheese exceeded the Turkish safety limits.

Anthelmintics

Anthelmintic drugs are widely used in the veterinary medicine for protecting or treating the animals mainly against gastrointestinal nematodes and lungworms. The anthelmintic drugs are generally of very low toxicity to mammalian hosts, but some benzimidazole compounds such as albendazole are known to be teratogenic[13].

Benzimidazole anthelmintics are effective against nematode, cestode and trematode parasites, and they are used as antiparasitic drugs in veterinary and human medicines[14-16]. In Turkey, thiabendazole (TB), albendazole (AB), oxfendazole (OF), triclabendazole (TKB), fenbendazole (FB) and mebendazole which are the members of benzimidazole anthelmentics are widely used against several helminths of cattle, sheep, goat and poultry[17]. If the animal breeders do not follow the recommended withdrawal times, residue levels in the milk can reach ro high levels. In order to avoid residue problems, the European Union set MRLs for the anthelmintics. The MRL values for TB, OF, OB, AB, FB and FE are 100, 10, 50, 100, 10 and 10 mg/kg, respectively[18].

Pesticides

As synthetic pyrethroid substances are effective for insects, they are widely used against many pests. Their main uses are field-treatment of crops, protection of stored products, hygienic treatments in houses, stable premises and on animals to control ecto- and endo-parasites. Possible contamination sources of pesticides to the milk and dairy products are:
a) foodstuffs containing high levels of pesticide residues from post-harvest treatment; b) foodstuffs manufactured from plant material that has been treated during the growing season with insecticides; c) use of insecticides directly on the animal against disease vectors; d) use of insecticides against insects in stables and in milk processing factories[19].

TABLE-1
MRL IN MILK FOR PYRETHROIDS ACCORDING TO EUROPEAN UNION LEGISLATION AND FAO-CODEX ALIMENTARIUS[20]

Compound	MRL (mg/kg)	
	EU	FAO
Tefluthrin		
Tetramethrin		
Cyphenothrin		
Cyfluthrin	0.02*	0.01*
Flucythrinate		
Fluvalinate		
Deltamethrin		0.02
Fenpropathrin		
λ-Cyhalothrin	0.05	
Permethrin	0.05	0.1
α-Cypermethrin	0.02	0.05
Esfenvalerate	0.05	
Tralomethrin		

*at or about the limit of determination.

Dioxins

Dioxins is the generic name for two classes of organochlorine compounds, namely, 75 polychlorinated dibenzo-*p*-dioxins (PCDD) and 1,3,5-polychlorinated dibenzofurans (PCDF), of which 17 tetrachloro-substituted are highly toxic[21]. These compounds are lipophilic unwanted by-products[22]. Dioxins cause a wide array of adverse health effects in both animals and humans. They are potent cancer-causing agents and are considered to be a known human carcinogen by the World Health Organisation's International Agency for Research on Cancer[23].

Exposure of humans to dioxins occurs mainly (> 95 %) through contamination of food[24,25]. Cow milk and dairy products, bovine adipose tissue, eggs and fish are the main contributors to human dioxin exposure[24]. Contaminated feed with dioxins was delivered to poultry, rabbit, cattle and pig breeding and raising farms. Contamination of food is a major route through which livestock is exposed to dioxins, especially by using of contaminated citrus pulp in feedstuffs[25,26]. Dioxins in air settle onto soil, water and plant surfaces. They do not readily break down in the environment and over time they accumulate in the grazing animals. People ingest the dioxins with the consumption of the contaminated milk, dairy products, meat and eggs[27].

Hormones

Milk contains many natural hormones like corticoids, oestrogens, androgens etc. which are produced by mammals. The presence of these natural hormones in milk shows difference due to animal's physiological characteristics, different periods of lactation and pregnancy. In recent years, hormones and hormone like compounds have been used frequently in vegetables and livestock production to obtain a high performance in a short time. These anabolic compounds are used for increasing the rate of weight gain, improving the food efficiency, storing protein and decreasing the rate of fat storing[28-30]. But depending on the use of anabolics in animal food, residues which may occur in milk and dairy products present concerns human health risks[31] and because of this many countries restrict or prohibit the use of anabolic compounds in livestock production[32,33].

Zeranol (α-zearalanol) is a nonsteroidal, oestrogenic mycotoxin which is produced by several *Fusarium* species. It is used in livestock for increasing the rate of weight gain, improving the feed eficiency and for a good quality carcass with less fat[34]. Zeranol residues should not exceed 0.05 ppb in daily human food[35]. Trenbolone acetate (TBA), a kind of 19-nortestesteron is a synthetic steroid with anabolic properties[35-37]. TBA decreases the rate of both protein synthesis and degradation[38].

Clenbuterol is a well-known pharmaceutical product that belongs to the β-agonists[39-41]. β-agonists are used for the treatment of asthma in humans and animals[42,43]. At the same time, they are promoted for the increase in weight, performance and the growth rate with the decrease in fat storing in livestock[44]. The most well used β-agonist is clenbuterol[39,43].

Heavy metals

Technological progress, various industrial activities and increased roadway traffic have caused a considerable increase in environmental contamination[45]. Heavy metals enter the human body through inhalation and ingestion[46]. It is well established that lead and cadmium are toxic and children are more sensitive to these metals than adults. While copper and zinc are essential they can be toxic when taken in high doses[47]. Determination of the residual concentrations of metals in milk can be an important direct indicator of the hygienic status of the milk and/or of its derived products, as well as an indirect indicator of the degree of pollution of the environment in which the milk is produced[48,49]. Milk and dairy products constitute a major food, especially for infants and children, and relatively low levels of toxic elements can contribute significantly to dietary intakes and be hazardous for public health[50]. Heavy metals content of milk products are variable due to factors such as differences between species, geographical area, characteristics of the manufacturing practices and possible contamination from the equipment during the process[51].

Few surveys are available dealing with heavy metal contaminations in milk and dairy products in our country. Simsek *et al.*[52] determined the levels of lead, arsenic, copper and mercury in 75 raw milk samples collected from three different regions (an industrial, a rural and heavy traffic intensity region) around Bursa. The average amounts in the samples from these three regions for lead were 0.032, 0.049, 0.018 mg/kg; for arsenic 0.05, 0.009, 0.0002 mg/kg; for copper 0.58, 0.96, 0.39 mg/kg; while no Hg was detected in analyzed samples. Yuzbasi *et al.*[53] studied on some heavy metals residues in 240 kasar cheeses sold in retail markets of Ankara. It was reported the mean value (range) of lead, cadmium and copper contents of the samples were 86 (10-421) µg/kg, 1.8 (0.3-8.3) µg/kg, 0.7 (0.3-1.6) mg/kg, respectively. In a similar study 40 Turkish white cheese samples were analyzed for lead, cadmium, nickel, cobalt, chromium and copper contents by Orak *et al.*[54]. They found the mean values of lead, cadmium, nickel, cobalt, chromium and copper as 0.415, 0.127, 1.057, 0.470, 0.131 and 0.629, respectively. Mendil[46] determined the concentration ranges of manganese, copper, lead, chromium and nickel in 45 various cheese samples as 0.28-1.1, 0.10-0.27, 0.14-1.2, 0.02-0.62 and 0.18-0.34 µg/g, respectively.

In conclusion, milk and dairy products may contain harmful chemicals such as pesticides, dioxins, heavy metals and other industrial pollutants which can enter the food chain at any step of production process. The consumers especially infants and children have serious health risks associated with the consumption of milk and their products which are contaminated with various levels of toxic chemicals. It is necessary to consider the other potential sources of exposure such as air, water etc. to the contaminant in addition to milk, dairy and other food products. Therefore, routine controls have to be performed periodically for the detection of toxic residue and contaminants in milk and dairy products to prevent the consumer health.

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