



## Effects of Pesticide Residues in Animal By-products Relating to Public Health

Hozan Jalil Hamasalim<sup>1</sup>, Hemin Nuradden Mohammed<sup>1</sup> and Haidar Anwar Arkwazee<sup>2</sup>,  
Nasreen Mohialddin Abdulrahman<sup>3\*</sup>

<sup>1</sup>Animal science, College of Agricultural Engineering Sciences, University of Sulaimani, Iraq

<sup>2</sup>Horticulture, College of Agricultural Engineering Sciences, University of Sulaimani, Iraq

<sup>3</sup>Anatomy and Histopathology, College of Veterinary Medicine, University of Sulaimani, Iraq

\*Corresponding Author: Nasreen M. Abdulrahman, E-Mail: [nasreen.abdulrahman@univsul.edu.iq](mailto:nasreen.abdulrahman@univsul.edu.iq)

### ABSTRACT

Pesticides are used on a large scale and have become unavoidable in the modern agricultural economy. Tones of them are used on a daily basis for a variety of functions, which are mostly used for agricultural activities. So, what exactly is a pesticide? A pesticide is a chemical substance used to keep undesired plants, animals, and microorganisms from harming humans, animals, and plants. It is a compound or mixture of chemicals designed to repel pests chemically and physically. Pesticides include herbicides, fungicides, insecticides, bactericides, rodenticides, and many others. Using these chemical compounds aids in the battle against pests, allowing us to improve our plants and animals and ensure the safety of the food production process for all people on the globe. However, studies show that abuse and excessive use of pesticides may have serious consequences for human health and the overall ecosystem. Pesticides are used in crops to manage pests, and they leave residues in animal feed. Consequently, as a result of the transportation of agricultural goods and animal products, pesticide misuse can extend hundreds of kilometers beyond the geographical region of usage. The use of pesticides for pest mitigation has become a common practice all around the world. The increase in pesticide use in agriculture has paralleled the increase in the quality and quantity of food products over the years. This article reviews the current evidence on the management of acute pesticide poisoning. Acute poisoning with pesticides is a global public health problem and accounts for as many as 300,000 deaths worldwide every year. Pesticides can impact human health directly through direct exposure to different types of pesticides or indirectly through the use of agricultural products (plants and animal products). The pesticide residues have also been detected in almost all animal products, such as meat, milk, dairy products, and eggs. The aims of this article are to highlight the possibility of pesticide deposition in various animal products and the acceptable range of some common pesticides according to reliable standards.

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### INTRODUCTION

Since ancient times, pesticides have been utilized for various objectives. Sulfur was burned by the ancient Romans to kill insects, and salts, ashes, and bitters were used to manage weeds. In addition, arsenic as a pesticide was advocated by a Roman naturalist (History of Pesticide Use, 1998). In 1867, an impure form of copper (arsenic) was used to control the outbreak of the Colorado potato beetle in the USA (History of Pesticide Use 1998). The livestock industry has expanded at an unprecedented rate worldwide over the past few decades (Rojas-Downing *et al.*, 2017). In order to boost yields and offset the global decline in agricultural land, chemical

compounds are increasingly applied as pesticides and fertilizers. Despite higher output, the widespread use of mineral fertilizers damaged aquifers, especially with nitrate, which decreased the quality of water fit for human consumption (Schroder *et al.*, 2004; Camargo and Alonso, 2006). To increase crop output and eliminate pests, pesticides are frequently employed in agriculture. However, their residues can linger in the environment and on crops (Kalyabina *et al.*, 2021).

Pesticides are classified into several classes; however, the two most common chemical types of agricultural pesticides implicated in poisoning are organophosphates (OPs) and carbamates (Goel and

**Aggarwal, 2007**). The most popular over-the-counter insecticides for residential and agricultural use are OP pesticides. They are responsible for most pesticide-related fatalities (**Eddleston et al., 2004**). Maximum residue limits were set by national governments and the international government due to the serious negative impacts of using pesticides heavily in agricultural activities around the world. Maximum residue limitations are influenced by environmental and agricultural circumstances, which differ from one country to another (**Lyons, 2000; Neff et al., 2012**).

Because pesticides are designed to kill or harm living creatures, they are dangerous to humans, non-target plants, and animals by nature. They not only pollute the ecosystem, but they also bioaccumulate in the food chain and may be found in plant and animal tissues, posing major health risks (**Neff et al., 2012**). The main focus of this review article is on the hazards of pesticide residues in feed and animal products, including meat, eggs, and milk, as well as how these products may affect human health.

## **Pesticide**

Pesticides are highly poisonous chemical compounds that are used to control pests that threaten crops and livestock. Furthermore, pesticides have also been employed in non-agricultural applications such as wood preservation, disinfection, and domestic applications. Despite their numerous benefits, certain pesticides are hazardous to humans and animals, and their continuous use is generating major environmental and food contamination issues (**Anon, 2008**). Pesticides are among the most widely utilized chemical compounds on a global scale, with an annual output of more than 3 million tons (**Roser and Ritchie, 2017**). Pesticides made of organophosphorus have a variety of physicochemical properties, such as polarity and water solubility. These medications also put human health at risk since they suppress the activity of the acetylcholinesterase enzyme (**Wesseling et al., 2002**).

The European Union passed legislation limiting the composition, manufacture, storage, transport, and use of pesticides to protect public health and animal welfare (Regulation EC No. 396/2005; Commission Regulation EC No. 178/2006; Commission Regulation EC No. 149/2008; Commission Regulation EC No. 260/2008; Regulation EC No. 299/2008; Commission Regulation EC No. 839/2008). Except for lindane, most organochlorine pesticides are relatively stable solids with low vapour pressure and water solubility. They are very lipophilic and microbially resistant (**UNEP, 2001; Kaushik and Kaushik, 2007**). While using pesticides has many advantages, like improved productivity, profitability, and grain quality, they also

pollute the environment, including the soil, water, and air (**Xue et al., 2005; Fernandez-Alvarez et al., 2008**).

## **Pesticide residues in animal products**

Animal products, including milk, meat, and eggs, contain residues because food-producing animals ingest polluted animal feed. Contamination of animal products cannot be avoided unless residues are controlled during the pre- and post-harvest periods as well as during the storage of animal feeds (**Kumar et al., 2012**). Organochlorine pesticides (OCPs) are extremely lipophilic (fat-soluble) and abundant in fatty meals. The main way that humans are typically exposed to OCPs through diet is through eating fatty foods like dairy, pork, and fish. Consuming polluted fruits and vegetables from agricultural soils can expose one to OCPs through their diet. According to a study, more than 90% of OCP contaminants come from food, especially fish (**Li et al., 2008**). Toxins can be absorbed by animals through contaminated feed and water. Because many insecticides are lipophilic, milk and other fat-rich foods are essential for their buildup (**John et al., 2001**). Dairy products (milk, cheese, and yoghurt) gathered from multiple farms in Accra, Ghana, also included OCP residues (**Amoako et al., 2017**). It is predicted that human exposure to OCPs is caused by contaminated food in excess of 90% of the time, with animal products and seafood making up the majority of this exposure (**Polder et al., 2010**). Pesticide residues accumulate in animals' fatty tissues and travel through food chains to humans. Many people carry pesticide residues, especially chlorinated pesticides.

The analyses on red meat and chicken samples revealed little or no chlorinated pesticide residues, whereas chlorinated pesticide levels in egg samples remained nearly consistent throughout a three-year period. More research is needed to detect pesticide residues in eggs (**Antary et al., 2012**). Pesticide residues in food have been found, despite the fact that the use of the majority of pesticides has been restricted. Herbivorous animals may consume pesticide-contaminated grasses, plants, and water, which may then be secreted in milk and/or meat. In this regard, food, particularly foods rich in fat, such as meat, fish, and dairy products is the main way that humans are exposed to organochlorines (**Amoako et al., 2017**).

## **Pesticide residues in egg**

Eggs are a food with a wide range of edibility that is consumed by humans ranging in age from the beginning of life to the elderly. Furthermore, eggs may be used as a raw material in a variety of meals. With the increased production and consumption of

eggs, the safety and quality of these products have come under scrutiny. Currently, the detection of drugs in eggs focuses mostly on antibiotics and other veterinary medications (Zhou, 2018). Pesticides are carried and circulated in the environment via the atmosphere, water, soil, and other media, which go on to animal items like meat and eggs. It is easy for bioaccumulation to occur throughout the food chain, resulting in chronic poisoning of the ultimate recipient organism. Fipronil was discovered in eggs in August 2017, according to the European Food Safety Regulatory Authority. Fipronil is a pesticide that is used to prevent and cure pests on vegetables and other crops. High doses can harm the liver, thyroid, and renal systems (Tingle *et al.*, 2003). Surprisingly, consumers were offered eggs with fipronil, prompting a panic. As a result, consumers have begun to place a premium on pesticide residues in eggs. Poultry may breathe in pesticide-contaminated air or may also consume pesticide-contaminated dirt and feed. This method yields eggs tainted with drug residues, which can be harmful to human health (Kumar *et al.*, 2012).

It is worth noting that, at the most recent FAO/WHO joint conference, the total pesticide MRL in shell-free eggs was advised not to exceed 0.2 mg/kg. Pesticide residue contamination in processed foods (Gilbert *et al.*, 2010) and eggs has also been recorded (Tao *et al.*, 2009). Pesticide contamination of poultry meat and eggs as a result of feeding a low-pesticide-content diet is a well-known phenomenon. According to the findings, poultry feed might be one of the biggest causes of contamination for hens and eggs (Aulakh *et al.*, 2006).

### **Pesticide residues in meat**

Organochlorine pesticides have been detected in the edible tissues of camels, cows, and sheep when it comes to pesticide residue in meat (Sallam and Morshedy, 2008), the flesh of slaughtered sheep (Shinde and Karim, 2009), and fish and poultry meat (Jadhav and Waskar, 2011). The muscle and liver tissues of sheep, cows, and dromedary camel bodies contained pesticides and toxic metal residues. All analyzed corpses had dazinon residues in their muscle and liver tissue. Depending on where the animals originated from, different pesticide residues were present (Ahmed *et al.*, 2019). Due to their low polarity and chemical resistance, persistent organic contaminants frequently bioaccumulate in higher-fat tissues (Darko and Acquah, 2008). In addition, these substances can bioaccumulate in foods like meat and milk, compromising human health due to their great resistance to biotransformation (Ronchi *et al.*, 2006; Kampire *et al.*, 2011; Deti *et al.*, 2014).

As a result of residual concentrations in tissues following cattle dipping or vector control or when they consume contaminated feedstuffs; meat may contain high amounts of pesticide residues. These compounds are dangerous to living things, and as they become more prevalent in the food chain, the general population may face serious health hazards (Jayashree and Vasudevan, 2007). Dichlorodiphenyl-trichloroethane (DDT) concentrations in beef fat from Buoho averaged 403.82 g/kg, although DDT concentrations in lean meat samples from the same sampling location averaged 10.82 g/kg. Although the majority of the organochlorine concentrations identified were below the FAO/WHO regulatory limits, bioaccumulation of these residues is likely to cause health issues in higher species, such as humans (Darko and Acquah, 2007).

### **Pesticide residues in milk**

Due to its abundance of vitamins, proteins, fatty acids, minerals, and nutrients like calcium and salt, milk is essential for a healthy and balanced diet (Haug *et al.*, 2007). Research has also shown that milk consumption is essential for bone formation and is associated with reducing chronic diseases like cancer, diabetes, obesity, and heart disease (Pereira, 2014). However, high-fat animal diets may contain contaminants, including persistent organic pollutants (POPs) like polychlorinated biphenyls (PCBs), organochlorine pesticides (OCPs), and polyaromatic hydrocarbons (PAHs). Along with being a crucial ingredient for baby growth, milk and its derivatives are widely consumed in the human diet. So, it's crucial to continuously evaluate OCP levels, especially in milk, to lessen the risk to human health (Luzardo *et al.*, 2012; Avancini *et al.*, 2013). As a result of contaminated water, the use of pesticides to treat ectoparasites directly in the animal, and the consumption of tainted pastures and/or feed, pesticide residues and metabolites can be found in milk (Bajwa and Sandhu, 2014). While the majority of OCPs are no longer used in Jordan, they have been found in mother's milk and dairy products such as milk, cheese, yoghurt, butter, and labneh, despite the fact that they are banned in many other nations (Salem *et al.*, 2009).

Furthermore, DDTs, hexachlorocyclohexane (HCH), and endosulfan are more commonly encountered products. No residues of the selected pesticides were found in any of the samples of pig muscle or pasteurized milk that researchers studied after collecting them from key cities in the Republic of Korea. However, the ranges of detection for those substances were 3.3 to 9 ppm and 3 to 8.1 ppm, respectively. As a result, the impact of pesticide residues on human food is greater, and contamination with these residues in milk and milk products is

strictly regulated (Neff *et al.*, 2012). Pesticide residues in animal feedstuffs are the primary cause of pesticide contamination in dairy products. Other elements that could contribute to this kind of pollution include the use of pesticides on farm animals, environmental contamination, and unintentional spills (Goodarzi *et al.*, 2010). Organochlorine insecticides can be found in high concentrations in fat foods, such as cow milk, and because they are lipophilic and have a propensity to bioaccumulate, they are not easily degraded in the environment. The distribution of organochlorine insecticides in various samples has also been documented (Chen *et al.*, 2007). The majority of sheep milk tests had pesticide residues, and consuming milk that has been exposed to pesticides may be harmful to human health (Shahzadi *et al.*, 2013). For the first time in Kumasi, Ghana, Darko and Acquah (2008) gave preliminary information on the content of various organochlorine pesticides in specific milk products.

Pesticides are dangerous xenobiotics that can have a variety of negative effects on biological systems. Leftovers are sent to different organs and tissues after entering the animal body. They are also being moved to milk. Some leftovers might also be expelled by feces and urine. In 15 of the 100 samples of bovine milk taken from different parts of India, Kathpal *et al.* (2001) discovered endosulfan levels over the permitted residual limit (MRL). Nag and Raikwar, (2003) also reported that 26 of the 83 bovine milk samples obtained from locations in India's Bundelkhand area were infected with endosulfan. Endosulfan, when present in high concentrations in feed, can transfer into milk to some extent. According to a study, the excretion of endosulfan residues in goat milk increased with treatment duration (Subir *et al.*, 2007). The U.S. Environmental Protection Agency (EPA) is reviewing the allowable limits (tolerances) for pesticide residues in food, and OPPs are in the first priority group of pesticides to be reviewed (U.S. Environmental Protection Agency, 1999; Wheeler, 2002). Despite their poor stability, OPPs can accumulate in the food chain (U.S. Environmental Protection Agency, 1999). As a result, milk may be one of the sources of OPPs in the human diet. The identification of these residues in milk is crucial for a full assessment of the total consumer risk, with a focus on the safety of newborns and young children (Wheeler, 2002).

After being sprayed on soil or used to treat crops, pesticides are capable of migrating across different ecosystems and, ultimately, accumulating in food chains or persisting as breakdown products. Pesticide transport routes are summed up schematically in Fig. 1 (Kalyabina *et al.*, 2021).

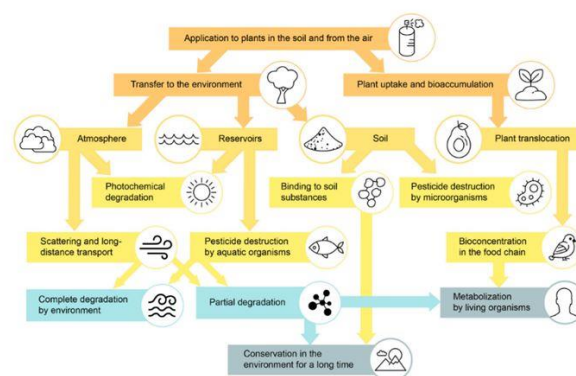


Fig.1: Schematic representation of Pesticide transport routes (Kalyabina *et al.*, 2021).

### Pesticide and Human Health

The human health risk assessment's main objective is to safeguard consumers from the severe negative effects of toxicants in their food or water (Anwar *et al.*, 2011). The overall number of toxicants of interest in food or water samples must therefore be checked to ensure that it does not exceed the recommended daily intake. Pesticide residues can have long-term harmful consequences on human and animal health as well as on environmental stability (Kalyabina *et al.*, 2021). Pesticides have enhanced human health by reducing the spread of vector-borne illnesses. However, its prolonged and careless usage has produced negative health effects. People are more sensitive to the negative effects of pesticides on babies and young children because of their non-specific nature and poor administration. In the past few decades, increased use of pesticides has increased the likelihood of human exposure to these chemicals (Isra *et al.*, 2015). According to the World Health Organization, around 3,000,000 cases of pesticide poisoning and 220,000 fatalities are reported each year in developing countries (Lah, 2011). An increased risk of exposure to pesticides exists for about 2.2 million people, the majority of whom reside in developing countries (Hicks, 2013). Some may irritate the skin or eyes, while others, like organophosphates and carbamates, have a neurotoxic effect. While some pesticides may have an impact on the body's hormone or endocrine system, others may have the potential to cause cancer (Sarwar, 2015).

The researchers discovered a six-fold rise in the risk factor for autistic spectrum disorders in the offspring of mothers who were exposed to organochlorine pesticides (Alavanja *et al.*, 2004; Montgomery *et al.*, 2008). OCPs are emitted into the environment from a variety of sources, including residential, industrial, and agricultural sources. Because of their bioaccumulation potential and toxicities in species, they pose significant hazards to human health and the environment (Ariman and

**Centinkaya, 2015**). OCPs are found in the blood, adipose tissue, and breast milk of humans, where they slowly deteriorate, build up in fatty tissues, and last for a very long time (**Padhi and Pati, 2016**). In humans, chlorinated benzene can induce liver damage, skin sores, ulceration, hair loss, and thyroid impairment (**Johnson et al., 2009**). In a study, OCPs were found in human fatty tissues and milk (**Azeredo**

*et al., 2008*). Based on WHO recommendations, intakes were calculated using the average and highest detected pesticide residue levels to evaluate long- and short-term health hazards to consumers (**GEMS/FOODS, 2012**). Table 1 lists the pesticide type, animal products containing pesticide residues, and the maximum residue limit.

**Table 1: Name and type of pesticide, products that contain pesticide residues and maximum residue limit (APEC, 2016).**

Name of the Pesticide	Type of pesticide residue	Animal farm product	Maximum Residue Limit (MRL) according to FDA (2017) (mg/kg of product)
Chlorpyrifos	Chlorpyrifos (Fat-soluble)	Beef, meat of buffalo	1
		Poultry meat	0.01
		Egg	0.01
		Milk	0.02
Carbaryl	Carbaryl	Mammal meat	0.05
		Mammal offal	1
Carbendazim/benomyl	Combination of carbendazim, benomyl, thiophanatemethyl is reported as carbendazim	Beef, buffalo meat	0.05
		Poultry meat	0.05
		Poultry fat	0.05
		Egg	0.05
		Milk	0.05
Carbosulfan	Carbosulfan	Mammal meat	0.05
		Poultry meat	0.05
		Egg	0.05
		Milk	0.05
Cypermethrin	Cypermethrin	Mammal meat	2 (fat)
		Poultry meat	0.1 (fat)
		Chicken fat	0.1
		Egg	0.05
		Milk	0.05
2, 4-D	Combination of 2, 4-D and salt and ester of 2, 4-D reported as 2, 4-D	Mammal meat	0.2
		Poultry meat	0.05
		Egg	0.01
		Milk	0.01
Deltamethrin	Combination of alpha-R Deltamethrin and trans-deltamethrin (Fat soluble)	Beef, buffalo meat	0.5 (fat)
		Poultry meat	0.1 (fat)
		Poultry fat	0.1 (fat)
		Egg	0.02
		Milk	0.05
Dichlorvos	Dichlorvos	Mammal meat	0.05
		Poultry meat	0.05
		Milk	0.02
Dicofol	combination of dicofol and 2,2-dichloro-1, 1-bis (4-Chloro-1,1-bis	Beef, buffalo meat	3 (fat)
		Poultry meat	0.1 (Fat)

	(4-chlorophenyl) ethanol (p,p'-FW152) } reported as Dicofol (Fat soluble)	Egg	0.05
		Milk	0.01
Dithiocarbamates e.g. zineb, ziram, thiram, propineb, maneb and mancozeb	Dithiocarbamates analyzed and reported as CS2	Mammal meat	0.05
		Poultry meat	0.1
		Egg	0.05
		Milk	0.05
Diazinon	Diazinon	Mammal meat	2 (Fat)
		Poultry meat	0.02
		Egg	0.02
		Milk	0.02
Triazophos	Triazophos	Beef, buffalo meat	0.01
		Poultry meat	0.01
		Milk	0.01
Pirimiphos-Methyl	Pirimiphos-Methyl	Mammal meat	0.01
		Poultry meat	0.01
		Egg	0.01
		Milk	0.01
Profenofos	Profenofos (Fat soluble)	Mammal meat	0.05
		Poultry meat	0.05
		Egg	0.02
		Milk	0.01
Fenvalerate	Fenvalerate- all isomers (Fat soluble)	Mammal meat	1 fat
		Milk	0.1
Fenitrothion	Fenitrothion	Mammal meat	0.05
		Poultry meat	0.05
		Egg	0.05
		Milk	0.01
Acephate	Acephate	Mammal meat	0.05
		Poultry meat	0.01
		Egg	0.01
		Milk	0.02
Abamectin	Avermectin B1a (Fat soluble)	Mammal meat	0.01
		Poultry meat	0.01
		Egg	0.01
		Milk	0.005
Ethephon	Ethephon	Mammal meat	0.1
		Poultry meat	0.1
		Egg	0.2
		Milk	0.05

## CONCLUSION

Pesticide use is increasing every day as the world's population grows and there is a greater demand for food. According to studies, the residue of most pesticides can be found in all agricultural products and in crops used in animal feed. The pesticide residues have also been detected in almost all animal products, such as meat, milk, dairy products, and eggs, which are considered essential foods for many people. It is concluded that all

pesticides should be applied according to the manufacturer's instructions, with frequent inspections to guarantee that the pesticide residue in a particular product is within the permitted range set by a credible standard.

## Conflict of interests

There aren't any conflicts of interest among the writers at this point or anywhere else.

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