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# AGRICULTURAL CHEMICALS AND PESTICIDES IN FOOD PRODUCTION

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**ABSTRACT:** Chemicals such as pesticides, antibiotics and hormones are used in plant and animal farming to boost production, reduce food waste and ensure adequate food supply.Food Standards Australia New Zealand (FSANZ) sets the maximum allowed limits for agricultural and veterinary chemical residues present in foods in Australia (both domestic and imported foods).The levels of agricultural and chemical residues that are allowed in foods are considered safe and must represent the lowest level possible, complying with best industry practices.The use of pesticides can dramatically increase crop production and ensure a higher quality of produce. However, pesticides are also toxic chemicals designed to kill agricultural pests, and some can cause problems if they are consumed by humans in large amounts.In animal farming, drugs such as antibiotics and hormones are used to boost growth and cut down on feed requirements. Residues of these drugs can also be hazardous to humans. The level of harm from exposure to pesticides, animal antibiotics and hormones is dose related, meaning the more you consume, the greater the potential risk.

**KEYWORDS**-agriculture, pesticides, chemicals, food, standards, toxicity

## I. INTRODUCTION

Chemical sensitivities and food

Some people are more sensitive than others to pesticide residues. However, allergic reactions and sensitivities to naturally occurring chemicals – such as those found in eggs, shellfish, milk and nuts – are much more common.

Pesticide residues and food

The levels of pesticide residue in fruits and vegetables have been closely monitored in Australia for the past 30 years. For most pesticides, a minimum time between spraying and harvesting of produce is set to ensure safe food. Levels of chemical residues in Australia are consistently found to be very low and well within safe limits.

Government-run produce-monitoring programs are in place to regulate the proper use of farm chemicals such as pesticides. The amount of pesticide residue in food depends on many factors including:

- The type and amount of pesticide used.
- The amount of rain, wind and sunshine that fell on the crop.
- The kind of processing that food undergoes (such as storage time, washing or peeling).

Balancing food supply and pesticides

The challenge is to balance a reliable, high-quality food supply with the need to protect the consumer from unnecessary exposure to chemicals.

Maximum limits for safe human consumption of pesticide residue include wide safety margins. However, in the past sometimes a pesticide that was thought to be safe for human consumption had undesirable effects.

One example is DDT (or Dichlorodiphenyltrichloroethane) because of its environmental persistence and ability to accumulate in body fat. Although DDT is no longer used in Australian crop production, it is still used in some countries.

Antibiotics in animal farming

Antibiotics are drugs that kill bacteria. They are used in animal farming to keep animals healthy, promote growth and cut down the amount of feed required. The over-use of antibiotics may increase the possibility of breeding antibiotic-resistant strains of bacteria.

Strict regulations are in place to ensure that animals are not given any antibiotics in the few weeks leading up to slaughter. This helps reduce the amount of antibiotic residue left behind in the meat.

There are some concerns that antibiotic residues in milk may make people who are already susceptible to an allergic reaction, much more sensitive to penicillin.

Hormones in animal farming

Sex hormones (such as oestrogen and testosterone), are used in cattle to accelerate weight gain so they can be sent to market earlier. They have been widely used in the Australian beef industry for over 30 years. The use of hormones is highly regulated by the Australian Pesticides and Veterinary Medicines Authority (APVMA), which ensures they are safe for consumers and not harmful to animals.

Although unlikely in Australia due to our tight regulations, eating meat that contains unacceptably high levels of hormones can lead to many side effects in people (including breast enlargement and ovarian cysts).

Eating organic produce

Many people choose to buy organic produce to avoid pesticide residues. Organic farming grows produce without the use of synthetic chemicals or pesticides. However, organic foods are not necessarily completely chemical free because organic farmers may use natural pesticides on their crops.

If consumed in large amounts, even naturally occurring pesticides may cause problems to humans if they are consumed in large amounts.

Organic pesticide residues are also regulated by FSANZ to ensure they can be consumed safely.

Reducing our exposure to pesticides and other chemicals in food

To reduce your exposure to pesticides and other chemicals:

- Buy organic produce.
- Thoroughly wash all fruit and vegetables (even organic).
- Grow your own vegetables.
- Peel vegetables or remove the outer layer of leaves.
- Trim visible fat from meats – as many residues are fat soluble.
- Cook meat and chicken thoroughly.
- Consume a variety of foods (including meat alternatives like legumes, tofu, nuts and eggs) to reduce your intake of antibiotic-resistant bacteria, hormones and pesticides.

## II. DISCUSSION

There are more than 1000 pesticides used around the world to ensure food is not damaged or destroyed by pests. Each pesticide has different properties and toxicological effects.

Many of the older, less costly (off-patent) pesticides, such as dichlorodiphenyltrichloroethane (DDT) and lindane, can remain for years in soil and water. These chemicals have been banned by countries which signed the 2001 Stockholm Convention, an international treaty that aims to eliminate or restrict the production and use of persistent organic pollutants.

The toxicity of a pesticide depends on its function and other factors. For example, insecticides tend to be more toxic to humans than herbicides. The same chemical can have different effects at different doses, that is, the amount of chemical to which a person is exposed. Toxicity can also depend on the route by which the exposure occurs, such as by swallowing, inhaling or direct contact with the skin.

None of the pesticides currently authorized for use on food in international trade are genotoxic (damaging to DNA, which can cause mutations or cancer). Adverse effects from these pesticides occur only above a certain safe level of exposure. When people come into contact with large quantities of pesticide, the result may be acute poisoning or long-term health effects that may include cancer and adverse effects on reproduction.

Scope of the problem

Pesticides are among the leading causes of death by self-poisoning, particularly in low- and middle-income countries.

Since pesticides are intrinsically toxic and deliberately spread in the environment, their production, distribution and use call for strict regulation and control. Regular monitoring of residues in food and the environment is also required.

WHO has two objectives in relation to pesticides:

- to ban the pesticides that are most toxic to humans, as well as pesticides that remain for the longest time in the environment;
- to protect public health by setting maximum limits for pesticide residues in food and water.

Who is at risk?

The population most at risk are those who are directly exposed to pesticides. This includes agricultural workers who apply pesticides and anyone else in the immediate area during, and shortly after, pesticides are spread.

The general population – those not in the area where pesticides are used – is exposed to significantly lower levels of pesticide residues through food and water.

Prevention and control

Nobody should be exposed to unsafe amounts of pesticide.

People spreading pesticide on crops, in homes or in gardens should be adequately protected. People not directly involved in the spreading of pesticides should stay away from the area while spreading takes place, and for some time afterwards.

Food that is sold or donated (such as food aid) should equally comply with pesticide regulations, in particular with maximum residue limits. People who use pesticides when growing their own food should follow instructions for use and protect themselves by wearing gloves and face masks as necessary.

Consumers can further limit their intake of pesticide residues by peeling or washing fruit and vegetables, which also reduces other foodborne hazards such as harmful bacteria.

Global impact

The United Nations Population Division estimates that by the year 2050 there will be 9.7 billion people on Earth – around 30% more people than in 2017. Nearly all of this population growth will occur in developing countries.

The Food and Agriculture Organization of the United Nations (FAO) estimates that in developing countries, 80% of the increase in food production needed to keep pace with population growth, is projected to come from either increases in yields and/or the number of times each year crops can be grown on the same land. Only 20% of extra food production is expected to result from an expansion of farming land.

Pesticides can prevent large crop losses and will therefore continue to play a role in agriculture. However, the effects of exposure to pesticides on humans and the environment are a continuing concern.

The use of pesticides to produce food, both to feed local populations and for export, should comply with good agricultural practices regardless of the economic status of a country. Farmers should limit the amount of pesticide used to the minimum necessary to protect their crops.

It is also possible, under certain circumstances, to produce food without the use of pesticides.

WHO response

WHO, in collaboration with FAO, is responsible for assessing the risks to humans from pesticides, whether through direct exposure or residues in food, and for recommending adequate protection measures.

Risk assessments for pesticide residues in food are conducted by an independent, international expert scientific group, the Joint FAO/WHO Meeting on Pesticide Residues (JMPR). These assessments are based on all data submitted for national registrations of pesticides worldwide, as well as all scientific studies published in peer-reviewed journals. After assessing the level of risk, JMPR establishes limits for safe intake to ensure that the amount of pesticide residue to which people are exposed through eating food over their lifetime will not result in adverse health effects.

These acceptable daily intakes are used by governments and international risk managers, such as the Codex Alimentarius Commission (the intergovernmental body that sets food standards), to establish maximum residue limits (MRLs) for pesticides in food. Codex standards are the reference for international trade in food, meaning that consumers everywhere can be confident that the food they buy meets the agreed standards for safety and quality, no matter where it has been produced. Currently there are Codex standards for more than 100 different pesticides.

WHO and FAO have jointly developed the International Code of Conduct on Pesticide Management. The most recent edition of this voluntary framework was published in 2014. It guides government regulators, the private sector, civil society and other stakeholders on best practices in managing pesticides throughout their lifecycle, from production to disposal.

## III. RESULTS

Pesticides are indispensable in agricultural production. They have been used by farmers to control weeds and insects, and their remarkable increases in agricultural products have been reported. The increase in the world's population in the 20th century could not have been possible without a parallel increase in food production. About one-third of agricultural products are produced depending on the application of pesticides. Without the use of pesticides, there would be a 78% loss of fruit production, a 54% loss of vegetable production, and a 32% loss of cereal production. Therefore, pesticides play a critical role in reducing diseases and increasing crop yields worldwide. Thus, it is essential to discuss the agricultural development process; the historical perspective, types and specific uses of pesticides; and pesticide behavior, its contamination, and adverse effects on the natural environment. The review study indicates that agricultural development has a long history in many places around the world. The history of pesticide use can be divided into three periods of time. Pesticides are classified by different classification terms such as chemical classes, functional groups, modes of action, and toxicity. Pesticides are used to kill pests and control weeds using chemical ingredients; hence, they can also be toxic to other organisms, including birds, fish, beneficial insects, and non-target plants, as well as air, water, soil, and crops. Moreover, pesticide contamination moves away from the target plants, resulting in environmental pollution. Such chemical residues impact human health through environmental and food contamination. In addition, climate change-related factors also impact on pesticide application and result in increased pesticide usage and pesticide pollution. Therefore, this review will provide the scientific information necessary for pesticide application and management in the future.

## Introduction

The group of substances known as pesticides pertains to substances used as insecticides, fungicides, herbicides, rodenticides, molluscicides, and nematicides [1]. It is generally accepted that pesticides play an important role in agricultural development because they can reduce the losses of agricultural products and improve the affordable yield and quality of food [2,3,4]. Because of the urgency to improve food production and control insect-borne diseases, the development of pesticides increased during World War II (1939-1945). Additionaly, from the 1940s onwards, the increased use of synthetic crop protection chemicals permitted a further increase in food production [1]. Moreover, worldwide pesticide production increased at a rate of about 11% per year, from 0.2 million tons in the 1950s to more than 5 million tons by 2000 [5]. Three billion kilograms of pesticides are used worldwide every year [6], while only 1% of total pesticides are effectively used to control insect pests on target plants [1]. The large amounts of remaining pesticides penetrate or reach non-target plants and environmental media. As a consequence, pesticide contamination has polluted the environment and caused negative impacts on human health [1,7].

This literature review firstly provides basic scientific information about the agricultural development process, the historical perspective of pesticide usage, general types of pesticide in use, and the role of pesticides in agriculture. Specific focus is then put on pesticide behavior in the environment, climate change-related factors in pesticide use and its adverse effects on the natural environment. Finally this study provides a new direction for the application and management of pesticides.

## Agricultural Development Process

Agricultural development has a long history in many places around the world. Agricultural practice began about 10,000 years ago in the Fertile Crescent of Mesopotamia, corresponding roughly to most of today's Iraq, Turkey, Syria and Jordan [8]. People who lived in these areas collected edible seeds through means such as fire-stick farming, and forest gardening. When the population became more settled and lived on farms, large amounts of wheat, barley, peas, lentils, chickpeas, bitter vetch, and flax were cultivated [9]. Rice and sorghum were farmed in the Sahel region of Africa about 7500 years ago [10]. Davies (1968) furthermore indicates that some local crops were also domesticated independently in West Africa as well as in New Guinea and Ethiopia about 7500 years ago. Rice and millet were domesticated in China [11]. America independently domesticated corn, squashes, potato, and sunflowers [12]. The farmed crops often suffer from pests, weeds, and diseases which could result in a considerable loss in crop yield. Without pesticide usage, the loss of fruits, vegetables, and cereals due to pests and diseases would be as much as 78%, 54%, and 32%, respectively [13]. Therefore, there is an urgent need for scholars and the public to look for ways to overcome the problems caused by pests and diseases.

## Historical Perspectives of Pesticide Usage

The history of pesticide use can be divided into three periods of time. During the first period before the 1870s, pests were controlled by using various natural compounds. The first recorded use of insecticides was about 4500 years ago by Sumerians [8]. They used sulfur compounds to control insects and mites. About 3200 years ago, the Chinese used mercury and arsenical compounds to control body lice. There was no chemical industry, so all products used were derived directly from readily available animal, plant, or mineral sources. For example, volatile substances were often applied by "smoking". The principle was to burn straw, chaff, hedge clippings, crabs, fish, dung, or other animal products, so that the smoke, preferably malodorous, could spread throughout the orchard, crop, or vineyard [8]. It was generally assumed that such smoke would eliminate blight or mildew. Smoke was also used against insects. People controlled weeds mainly by hand weeding, while various chemical methods were also reported [14]. Pyrethrum is obtained from the dried flowers of the chrysanthemum Cineraria folium, "pyrethrum daisies", and has been used as an insecticide for over 2000 years.

During the second period, between 1870 and 1945, people began to use inorganic synthetic materials. At the end of the 1800s, people in Sweden used copper and sulfur compounds against fungal attack in fruit and potatoes [15]. Since then, people have been using many inorganic chemicals, including the Bordeaux mixture, based on copper sulfate and lime arsenic, as pesticides, and they are still being used to prevent numerous fungal diseases [1].

The third period started after 1945 [8], represented by the use of synthetic pesticides with the discovery of the effects of Dichlorodiphenyltrichloroethane (DDT), β-Hexachlorocyclohexane (BHC), aldrin, dieldrin, endrin, chlordane, parathion, captan, and 2,4-D [16]. The disadvantages of many of these products were at their high rates of application, lack of selectivity, and high toxicity. For example, DDT was widely used all over the world since it had low toxicity to mammals, and it reduced insect-borne diseases, such as malaria, yellow fever, and typhus [17,18]. The book "Silent Spring" indicated the negative impacts of pesticides on the environment and human health. The book aroused great attention among scholars and the public [1]. DDT was banned in 1972 in the US because of its harm to non-target plants and animals, as well as problems with its significant ability to accumulate in tissues and persist, causing long-term damage [19]. Between the 1970s and 1990s, new families of chemicals, such as triazolopyrimidine, triketone and isoxazole herbicides, strobilurin and azolone fungicides, chloronicotinyl, spinosyn, fiprole diacylhydrazine, and organophosphate insecticides, have been introduced to the market and most of the new chemicals can be used in grams rather than kilograms per hectare [1,18].

In modern agriculture, scholars are trying to develop genetically engineered crops designed to produce their own insecticides or exhibit resistance to broad-spectrum herbicide products or pests. This new pest management could reduce chemical use and its negative impacts on the environment [1].

### Types of Pesticide in Use

Pesticides are classified by different classification terms such as chemical classes, functional groups, modes of action, and toxicity [20]. Firstly, pesticides are classified by different targets of pests, including fungicides, insecticides, herbicides, and rodenticides. For example, fungicides are used to kill fungi, insecticides are used to kill insects, while herbicides are used to kill weeds [21,22]. In terms of chemical classes, pesticides are classified into organic and inorganic ingredients. Inorganic pesticides include copper sulfate, ferrous sulfate, copper, lime, and sulfur. The ingredients of organic pesticides are more complicated [23]. Organic pesticides can be classified according to their chemical structure, such as chlorohydrocarbon insecticides, organophosphorus insecticides, carbamate insecticides, synthetic pyrethroid insecticides, metabolite and hormone analog herbicides, synthetic urea herbicides, triazine herbicides, benzimidazole nematocides, metaldehyde molluscicides, metal phosphide rodenticides, and D group vitamin-based rodenticides

## IV. CONCLUSION

Pesticides are widely used in producing food to control pests such as insects, rodents, weeds, bacteria, mold and fungus.

Under the Food Quality Protection Act (FQPA), EPA must ensure that all pesticides used on food in the United States meet FQPA's stringent safety standard. FQPA requires an explicit determination that a pesticide's use on food is safe for children and includes an additional safety factor, tenfold unless data show a different factor to be protective, to account for uncertainty in data relative to children.

The science and our understanding of chemical risk evolves and EPA continues to reevaluate each pesticide's safety every 15 years. EPA's continuous reevaluation of registered pesticides, combined with strict FQPA standards, major improvements in science, and an increase in the use of safer, less toxic pesticides, has led to an overall trend of reduced risk from pesticides.

Is food grown using pesticides safe to eat?

EPA is confident that the fruits and vegetables our children are eating are safer than ever. Under FQPA, EPA evaluates new and existing pesticides to ensure that they can be used with a reasonable certainty of no harm to infants and children as well as adults. EPA works continually to review and improve safety standards that apply to pesticide residues on food.

It is important to note though, that just because a pesticide residue is detected on a fruit or vegetable, that does not mean it is unsafe. Very small amounts of pesticides that may remain in or on fruits, vegetables, grains, and other foods decrease considerably as crops are harvested, transported, exposed to light, washed, prepared and cooked. The presence of a detectible pesticide residue does not mean the residue is at an unsafe level. USDA's Pesticide Data Program (PDP) detects residues at levels far lower than those that are considered health risks.

What has EPA done to decrease or restrict the amount of pesticides in food?

The 1996 FQPA directed EPA to completely reassess pesticide residues on food, with a special emphasis on the unique vulnerability of children. From 1996 to 2006, EPA used the improved safety standards in FQPA to cancel or restrict the use of 270 pesticides for household and food uses because they posed particular threats to children and infants. EPA also lowered the permissible pesticide residue levels for many kid's foods – for example, apples, grapes, and potatoes.

The FQPA safety standard isn't the only reason why EPA has been able to take so many steps to reduce children's exposure to pesticides in recent years. Once a pesticide is registered for its specific uses, it is not left unchecked. Starting in 2007, EPA began the systematic reevaluation of all old pesticides.

Here are some notable EPA actions:

- In 2009, EPA canceled all uses of carbofuran, canceled aldicarb use on potatoes and citrus, and canceled methamidophos use on all commodities.
- In 2010, EPA canceled methomyl use on grapes and strawberries.
- In 2010, EPA canceled all products containing methyl parathion.
- In 2012 EPA canceled acephate use on green beans, oxamyl use on soybeans, and imidacloprid use on almonds.
- In 2013, EPA canceled all domestic uses of methyl parathion and canceled all uses of formetanate HCI on apples, pears, and peaches.

We have seen, through USDA's Pesticide Data Program (PDP) data, an overall decrease in the amount of pesticide residues in food, especially since the passing of FQPA in 1996. The stricter standards of FQPA and major improvements in science and data, and an increase in the use of safer, less toxic pesticides, has led to an overall trend of reduced risk from pesticides.

For example, from 1995 to 2013, children's exposure to carbamates (a group of insecticides that affect the nervous system) fell by 70% – EPA canceled or restricted many carbamates during this time. From 1998 to 2008, tomatoes with detectable organophosphate pesticide residues fell from 37% to 9%, due to EPA canceling most organophosphates. It is important to note for some of the more recent actions, EPA expects declines will show up in future PDP data.

How does EPA regulate pesticides in food?

EPA evaluates every new pesticide and every new use for safety before registration. Before they may be sold, EPA must ensure that pesticides are safe for human health and the environment when used according to label directions. For each pesticide, EPA evaluates hundreds of different scientific studies.

Through these evaluations, EPA is ensuring the overall safety of proposed pesticide uses as required by FQPA. After pesticide registration, EPA reevaluates its safety every 15 years, taking into consideration any new data.

EPA's process for registering and re-evaluating pesticides is not a closed-door process between EPA and pesticide manufacturers. EPA relies on the best science available and places high value on transparency in decision-making. The public is invited to comment throughout the decision-making process – we request studies and data, take our findings to independent expert panels such as the FIFRA Scientific Advisory Panel, and consult the National Academy of Sciences on broad scientific policy questions. The agency also frequently receive hundreds or even thousands of comments from the public on our draft assessments and proposed decisions.

Public concerns about specific pesticides and food safety do not go unnoticed at EPA. We take incidents of pesticide poisoning and exposure very seriously and look at those incidents as part of our review. EPA can and has used its authority to have products removed from the market immediately when risks are imminent.

At the same time that we review dietary exposure to pesticides, we also look at worker exposure and environmental exposure. Risks to workers and the environment can lead to cancelations as well, or restrictions on how and when a pesticide can be used, including, when appropriate, establishing 'no spray' buffer zones to protect the surrounding communities and waterways.

Before allowing the use of a pesticide on food crops, EPA sets a maximum legal residue limit (called a tolerance) for each treated food. The tolerance is the residue level that triggers enforcement action. That is, if residues are found above that level, the commodity will be subject to seizure by the government. EPA receives information on how much pesticide residue remains on various foods through the PDP. Through annual sampling, PDP has collected thousands of samples on 10-15 food commodities and can detect residues at levels far lower than those that that pose health risks.

In setting the tolerance, EPA must make a safety finding that the pesticide can be used with "reasonable certainty of no harm." To make this finding, EPA considers the toxicity of the pesticide and its breakdown products, how much of the pesticide is applied and how often, and how much of the pesticide (i.e., the residue) remains in or on food by the time it is marketed. EPA ensures that the tolerance selected will be safe. The tolerance applies to food grown in the U.S. and imported food.

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