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Pesticide residues in food: distribution, route of exposure and toxicity: in review

Abstract

The safety of food has significant impact on human health hence the increasing concern on safe food consumption. One of the recent issues that have globally attracted the concern of consumers is the presence of pesticide residues in food. These residual chemicals are persistent organic contaminants that have serious lethal effect on human health when exposed beyond certain levels. The fears of the envisaged increased in the global population has further increased the use of pesticides due to concern for food productivity and security. The present paper examines the presence of pesticide residues in food, their sources and strategies for reducing the concentrations of these toxic chemicals. Attempt is also made in reviewing the Risk Assessment of Pesticide Residue in Food.

Keywords: food, pesticide, lethal, residue, risk, toxicity

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Introduction

The use of pesticides in agriculture has further increased due to fast growing human population which is estimated to reach 8.5 billion by 2030, hence the fear of the impact of this population on food security. On a global scale, the average usage of acaricides, fungicides, herbicides and fungicides was 353,000, 566,000, and 342,000 respectively.[1] The highest users of pesticides are Europe, followed by China and then the United States of America. For African countries the usage makes up about 25%, with most common cases in the cultivation of vegetables.[2]

One of the prominent reasons for the use of chemical substances in agricultural farmlands is for the protection of crops from various pests, thereby boosting the overall agricultural yield and productivity. The essence of pesticides application is for the control of varieties of weeds, disease causing organisms, and pests that are capable of causing damage to plants. Pesticides are therefore biocidal in nature and when applied to plants they eventually come in contact with man through crops. Pesticides are also of concern due to their potential of being carried across the various components of the environment.[3] The need to resolve problems associated with global challenge of food security has resulted to the current shift in emphasis to organic based farming. However the general acceptance of this new trend in developing nations has been largely on the poor side due to several reasons.

Concept of pesticide residues

According to the WHO, pesticide residue refers to any chemical substance or a combination of substances present in food for animals or man that comes from the application of pesticide including various derivatives like conversion and degradation products, impurities and metabolites that have toxicological significance.[4]

The impact of pesticide application on the overall yield of crops is remarkable. The application is usually done prior to the growing process as well as after harvesting of the crops. The residue of pesticides in this produce constitutes serious harms to man and other organisms. The variation in the quantity of pesticides applied during farming calls for the need to continually assess their presence in food.[5]

Pesticides are substances that are introduced into the environment with the primary intent of controlling or destroying pests, animals as well as unwanted plant species.[6] They are usually applied at various stages of cultivation including production, early storage, distribution and feed processing. They are also used in farm animals so as to protect them against ecto parasites such as lice, bed bugs etc.[7] Basically pesticides include chemical substances that are used in the regulation of plant growth, thinning of fruit, inhibiting the process of sprouting, defoliating as well as substances that are used in plants during transportation or storage for effective protection against organisms that could affect their quality or cause deterioration. They include herbicides, fungicides, insecticides, avicides and nematicides. Agricultural productivity has increased significantly due to the application of pesticides to farm lands. This has also enhanced the protection of crops and livestocks thereby increasing the overall incomes of the farmers.[8]

Distribution of pesticide residues in different food

There are different route through which humans get exposed to pesticides from food. Findings from various studies have documented that for some cereal grains the pesticide residues are mainly found in the outer covering hence processing such as milling and related processes can bring about the reduction in the amount of the pesticide residues. Usually cereal crops are sprayed with insecticides before storage so that they can be preserved for more than one year without being attacked by pests. For pesticides that are more lipophilic, their residues usually remain on the coat of the seed although a little amount tend to move to the portion with a high amount of triglycerides such as the germ. In agricultural crops such as pulses, it is not possible to remove residues of deltamethrin and cypermethrin by cooking or washing of stored grains which implies that the pesticide must have penetrated the inside of the grains. For the pulses, the highest content of cypermethrin was found in the seed coats.[9]

Sometimes, insecticides and other pesticides are noticed to have contaminated various milk and related products from the fodder and feed that remained linked to the fat portion. This accounts for why pesticide residues are found in high amount in cheese, butter and milk products. Pesticides also concentrate preferentially in the fat portions of meat. Those that are fat soluble, tend to accumulate more in the yolk of egg when compared to the albumin. On the other hand, pesticides that are more soluble in water and other polar solvents are found more in the albumen of eggs. Most of the organic pesticides have preference for oils this is responsible for the difficulty in removing them from oil and fats.[10]

Factors that favour the presence of pesticide residues in food

Various studies have already documented the contamination of different components of the environment such as water, air and soil by pesticide residues such as organo phosphate and organochlorine compounds. Various factors contribute to the higher amount of these residues in most developing countries. One is the wrong dosage and poor adherence to standards with respect to the application of these pesticides. Although some pesticides such as hexachlorcyclohexane as well as dichlorodiphenyltrichloroethane (DDT) have been banned, most farmers still use them for agricultural activities and pest control. Also most of the highly toxic pesticides whose usage has been banned are still currently being used in most of these countries; this shows the need for adequate sensitization on best practices globally acceptable for the management of pesticides.[11]

Poisoning due to pesticide is a serious health issue at both national and global level. This is associated with the various agro allied and agricultural activities in different countries of the world, which has also put the users of these chemicals at risk. It has also been reported that exposure to pesticides at occupational level is more in Nigeria when compared to other countries in the worlds because of the low level of protection among the workers. Other factors responsible for the increasing exposure to pesticide poisoning include the poor disposal facilities, poor technical skills as well as unsafe storage procedures. Some workers use faulty devices for the application thereby increasing the extent of contamination through occupation.

According to the World Health Organisation[12] documentation, the exposure to pesticides is affected by several factors such as the readiness with which the pesticide is absorbed, the route of the exposure, dosage exposed to, nature of the pesticide itself, metabolites present, extent of bioaccumulation and persistence as well as the status of the individual that has been exposed with respect to health. There are different agencies set up by government for the purpose of effective monitoring and regulating of the proper utilisation of pesticides and adherence to related policies. Other factors affecting the amount of pesticides residue found in food include the amount and nature of the pesticide used, environmental factors such as rainfall, sunshine and wind direction and the nature of the processing the food is subjected to prior to consumption.[13]

Toxicity due to pesticide residue in food

Various illnesses have been reported to be associated with the consumption of plants food substances that have pesticide residues beyond the MRLs with respect to the daily intake and acute reference dose (ARD). Based on this, a consumer is not considered to be at risk, when the dietary intake that is estimated is not beyond the ARD. The process of monitoring and establishment of permissible limits for pesticide residues in various commodities and foods aid the efficient mechanism of control for human safety.[14]

Some of the adverse health effects associated with exposure to pesticides include vomiting, headache, irritation of skin, dizziness, difficulty in breathing, neurological diseases as well as other diseases associated with intense poisoning by pesticides such as cancer and eventual death.[15]

Some pesticides cannot be acted upon by microorganisms in the environment hence they remain for years in the environment and capable of bioaccumulating with a long half life in the environment and human tissues.[13] Also the continuous application of pesticides has contributed significantly to the killing of microorganisms that are beneficial, brought about the loss of biodiversity as well as increasing the resistance in pest. Typical examples of pesticides that tend to remain for long in the environment include aldrin, endrin, chlordane and DDT. Other kinds of pesticides include insecticides such as endosulfan, permetrin, kelthane, esfenvalerate and cypermethrin; fungicides such as mancozeb, viclozolin, benomy; herbicides like alachlor, simazine and atrazine. They are reported to have different levels of toxicity.[16]

Infertility plague has recently been identified by WHO as a social challenge that is connected to pesticides residue present in agricultural products. Studies have also reported that the quality and quantity of Europeans sperms has also decline since the introduction of the use of pesticide for agricultural processes.[17] On this note, Howard (2005) emphasised that infertility is associated with pesticides build-up in the body and is responsible for reproductive challenges in about 15-20% cases of infertility in women. The various chemical contaminants present in human bodies go in mostly through ingestion or inhalation route. Gilman et al., 1997 carried out a study in which they assessed the content of some compounds in the plasma of some selected women around the circumpolar zone regions. They observed that even in countries that are considered to be relatively free from pesticide contaminants, the human plasma has been shown to contain pesticides residues. Due to the toxic impact of these products on human health, some of them were already removed from use around the 70s. In the samples tested, the presence of some active compounds of pesticide origin such as chlordane and mirex was also reported.

Pesticides such as lindane, and DDT (dichlorodiphenyltrichloroethane) tend to remain in the environment for a very long period of time. These pesticides are relatively older and cheaper. Due to their toxicity and persistence in the environment, some countries signed into law and banned their use in the Stockholm convention of 2001.[18]

Several factors are known to affect the toxicity due to pesticide usage in agriculture. For instance, generally, herbicides are less toxic to humans when compared to insecticides. The doses of the chemical can also affect differently, the route of exposure whether oral, dermal, nasal is also vital. Most of the pesticides currently allowed to be used by monitoring agents and other regulatory bodies do not pose genotoxic effect. Adverse consequences only occur when they are used beyond the recommended level.[19]

Reduction of pesticide residues in food

Taylor and Bush, et al., 2002 reported that the processes in food storage help in the reduction of pesticides present in peaches to a level below detection. There are various practices that can aid in the reduction of pesticide contaminants in food products. This involves proper washing using water, soaking in salt solutions as well as other chemicals such as ozone, hydroxylper acid, detergents and iprodione. Various preliminary steps involved in food preparation such as canning, boiling, blanching and steaming also bring about a reduction

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in these chemicals in food. There are other available techniques and processes that have been reported to further reduce these chemicals such as malting, milling and brewing. Other post harvest treatment procedures have also proven effective in bringing down the content of pesticides in food.[13]

Nath et al., 1975 in their work reported a decrease in the content of malthion from 86.82 to 75.97 as a result of steam and open cooking okra. In some cabbage from china, after boiling for about 30 minutes, it was observed that dieldrin, fenitrothion and diazenon decomposed from a range of 72 to 99%. Nagesh and Verma (1997) reported that various steps involved in the processing of food such as peeling, washing, and cooking can contribute to the reduction in the content of pesticide residue in crops. There are other preliminary activities prior to food processing which also affects the contents of these residues such as drying, heat treatment, fermentation steps, juicing, milling, cooking, storage amongst others.[20]

Also foods that are sold must also comply with the demand of maximum permissible limits, while the food consumer would also help to reduce the intake of the pesticide residues by washing or peeling of the fruits such as oranges.[4] Furthermore, there is also need to explore other alternatives of food production with the use of toxic chemical pesticides. Detection and quantification of pesticide residues in food becomes pressing due to the concern for food safety by the consumers and government agencies.[21]

Risk assessment in pesticide residue in food

There are independent bodies charged with the responsibility of carrying out assessment of risks with respects to pesticide residue in food. This assessment is done on the basis of data that are collated from various national registrations of pesticides globally as well as findings published in peer reviewed journals. After an assessment of the risk level, a limit for safe intake is also established by JMPR. This is to ensure that the amount of these residues that individuals are exposed to as a result of consumption over a long duration in their life time will not constitute a deleterious effect.[22] International risk managers as well as governments and agencies make use of the acceptable daily intakes for the establishment of maximum residue limits (MRLs) for the pesticides in food. At present, there are standards from Codex for more than a 100 different types of pesticides.[7]

A code of conduct for the management of pesticide was collectively developed by the WHO and FAO. The most current version was published in 2014. The essence of the document is to provide guidance for regulating agencies, private bodies, as well as various stakeholders on acceptable practices in the use of pesticides. Prior to the use of pesticide in agricultural food crops, the USEPA must carry out an assessment study to ensure their safety for human within reasonable level. After this risk assessment, the tolerance of this pesticide is also assessed. This refers to the highest dose of the residue that can remain and legally acceptable in a particular food. Similarly, the Food and Drug Administration (FDA) is charged with the responsibility of monitoring and enforcing the tolerance of pesticides in processed foods as well as raw agricultural products. Imported as well as domestic foods are all subjected to these regulations.[23–28]

Conclusion

The role of pesticides in boosting agriculture with a view to ensure food for man cannot be overemphasized. The sources, distribution, toxicity and strategies for reducing environment contamination by pesticides have been reviewed. Taking into consideration the toxicity of chemical pesticides on humans as well as the hazardous impact on the environment, there is therefore pressing need for environmental friendly pesticides derived from biological sources that are green in their functioning without hazardous effect in the environment.

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Conflicts of interest

The authors hereby declare that there is no conflict of interest in this work.

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