Technologies For Pesticide Residue Elimination on Temperate Fruits for Safe Consumption

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Abstract

To overcome pests and disease menace in temperate fruits, farmers use a number of insecticides and fungicides. Fruits contaminated by pesticide residues pose a risk to both ecological security and human health. One of the essential methods for removing residues to ensure environmental sustainability and safety is food processing. Traditional thermal processing techniques, including as baking, roasting, blanching, and drying, have been shown to significantly lower pesticide levels; however, concentration effects can occasionally arise, producing more hazardous metabolites. A number of innovative non-thermal processing techniques, such as pulsed electric fields, cold plasma, high-pressure processing, and ultrasound, have emerged recently and demonstrate a significant ability to remove pesticide residues with little to no negative effect on the quality of fruit and vegetables.

Introduction

The temperate fruits belong to family *Rosaceae* which includes apple, peach, plum, apricot, pear, nectarine etc and one of the main challenges for successful production of these fruits is susceptibility to insect pest attacks. Their fruits make up a large portion of human diets because regular consumption may lower the risk of heart disease and some types of cancer. The estimated yield losses resulting from the attacks of different pests on different crops during different seasons vary from 10% to 35%. Unlike agricultural crops, temperate fruit crops which are grown as monoculture, the pest problems are entirely different and complex in nature. Pesticides (insecticides, fungicides) are widely being used to manage insect pests, fungal infestations of temperate fruit crops as they are prone to diseases and pests. Using pesticides increases food production, enhances food quality, and reduces crop/yield losses. It has been reported that the variety of pesticides has increased and that their global use is growing annually. Furthermore, it has long been a habit to abuse or misuse older, more hazardous, and persistent pesticides in the environment. As a result, widespread detections of pesticide residues have been seen in soil, water, and the air. Their presence has resulted in harmful impact on human health as well as negative consequences to the ecosystem. High levels of pesticide exposure are linked to serious diseases such as headache, diarrhea, nausea, convulsions, irritation of the eyes, breathing difficulties, and even death and cause environmental pollution (**Figure1**). Furthermore, the human body contains higher amounts of pesticides than the environment does because of a process known as biomagnification. As a result high-pressure processing (HPP), fermentation, ozone, radiation, pulsed electric field (PEF), etc. are being used to reduce the residual effect of pesticides. In addition, a variety of home and commercial washing techniques may help lower pesticide concentrations. On the other hand, concentration effects can lead to a rise in pesticide residues under certain conditions, and processing might result in the development of more harmful transformation products or metabolites. In addition, certain pesticide characteristics (physicochemical properties like water solubility, vapor pressure, octanol-water partition coefficient, volatilization, etc.), the kind of fruits and environmental factors (temperature, relative humidity, etc.) influence how long pesticides remain in the fruits.

Importance of elimination of residues

Pesticide residue removal is critical for a number of reasons, including biodiversity preservation, human health, and environmental sustainability. Pesticides can leave residues on fruits, vegetables, and other crops even while they are successful at controlling crop pests. When consumed by people, these residues may build up over time and have harmful effects on health. Numerous health problems, including as neurological impairments, reproductive troubles, and carcinogenicity, have been related to long-term exposure to pesticide residues. Moreover, the effects of pesticide residues extend

beyond human health. These substances have a long half-life in the environment, polluting water and soil supplies. Water pollution can occur when pesticide runoff from crops enters rivers, lakes, and groundwater. In addition to endangering aquatic ecosystems, this contamination also puts wildlife and the larger environment at risk. The unintentional effects of pesticide use may harm birds, insects, and other non-target organisms which could lead to a decrease in biodiversity **(Figure 2)**. A shift towards sustainable agriculture methods is necessary to overcome these issues. Pests can be efficiently managed while minimizing residues through the use of integrated pest management (IPM) tactics that combine mechanical, cultural, biological, and chemical application methods. Another crucial step in removing pesticide residues from the food chain is adopting organic farming methods, which omit synthetic pesticides and use natural alternatives. To put it briefly, the removal of pesticide residues is a complex process that not only protects public health but also maintains ecological stability and environmental sustainability. A robust and healthy food system for the current and future generations depends on finding a balance between efficient pest controls and reducing the ecological footprint of agriculture. Consuming fruits is the main way that individuals are exposed to pesticide residues. For humans, the recommended daily intake (RDI) of vitamins, minerals, dietary fiber, and other essential components is met by consuming fruits. They are eaten fresh or processed into things like fruit juice, purees, crisps, cans, and so on. However, because of their high susceptibility to pests and plant diseases, fruits are often treated with pesticides during the growing period in order to limit loss and preserve the high quality, which leaves pesticide residues in them. Due to the frequent use of pesticides, they have been contaminated by two or more active chemicals in recent years. When compared with animal food items, it can lower the incidence of chronic non-communicable diseases linked to nutrition and the associated environmental impact. Therefore, the risk of foodborne diseases increases as fruit consumption rises above maximum residue levels (MRLs).

Technologies for elimination and mechanism of elimination

Multiple strategies have been used to reduce the pesticide residual amounts in fruits and vegetables. One of these strategies is food processing, which modifies nutrient bioaccessibility to ensure food safety, prolong shelf life, and maintain or improve food quality. Food processing technologies can be broadly categorised based on the amount of heat input they require. These include thermal processing methods like boiling, drying, cooking, blanching, baking, roasting, sterilising, and so on, and non-thermal methods like ultrasound, cold plasma, high-pressure processing (HPP), pulsed electric field (PEF), radiation, ozone, fermentation, and so. It has been shown that following process treatments, the levels of pesticide contaminants in the final products decreases. Because of the highly oxidative potential of radicals and reactive species, ozone, for example, has been demonstrated to have a greater capacity for eliminating pesticides. Additionally, a number of commercial and home cleaning techniques may help lower pesticide concentrations. On the other hand, because of concentration effects, pesticide residues may rise in some unique situations, and processing may result in the development of more harmful transformation products or metabolites. For instance, photolysis, hydrolysis, and biodegradation would lead trichlorfon to change into more hazardous dichlorvos. The main criterion for evaluating the amount of pesticide residue in products produced by various food processing technologies when handling fruits is the processing factor (PF), which is based on the pesticide, the fruit commodity, and the processing technique. PF value is calculated as the ratio of pesticide residue concentration in the product after processing to pesticide residue concentration in fruits before processing. The concentration of pesticide is reduced when the PF value is less than 1. Conversely, a value greater than 1 indicates a pesticide concentration above the initial value observed prior to treatment. To determine the actual concentration following processing, the PF value is multiplied by the measured pesticide residue concentration of fruit. The PF value is essential for two reasons: (1) risk assessment of pesticide residues in fruits by adjusting

pesticide residues to measure dietary exposure and precisely establish MRLs; and (2) estimation of pesticide fluctuation during different processing steps.

Limitations

In order to maintain environmental sustainability and food safety, pesticide residue management is essential. However, managing pesticide residue comes with a number of limitations and difficulties. It is difficult to totally remove pesticide residues from fruits even with appropriate application and security measures. It is possible for residues to persist in water, soil, and on crop surfaces. Pesticide residue levels can vary greatly based on a number of factors, including crop variety, weather circumstances, and application techniques. It is difficult to create consistent rules and laws because of this variety. Standardized procedures for detecting and evaluating pesticide residues are lacking. The employment of various testing procedures and standards by different countries might make it challenging to compare and standardize results internationally. The possible effects and residue levels of newly produced pesticides may not yet be fully recognized. This makes it difficult to effectively control and manage the residues of newly developed insecticides. Over time, some pests become resistant to widely used pesticides. In response, farmers would use stronger pesticides or apply them more frequently, which would increase residue levels and raise possible environmental issues. There might not be enough infrastructure or resources in some areas to conduct thorough and frequent monitoring of pesticide residue levels. This may result in a higher chance of non-compliance and insufficient enforcement of the legislation. Even at recognized safety levels, pesticide residues can still be harmful to some individuals, including newborns, pregnant women, and those with weakened immune systems.

Conclusion

Treatment with pesticides requires meticulous technical evaluation. Choosing an ineffective treatment method could result in additional hazardous byproducts, because different pesticides have different physical and chemical characteristics. All of these will help to determine the optimal approach or combination of techniques to get the best results in terms of pesticide removal. In order to maximise the station's cost-effectiveness, the processing technology employed must also be appropriate for every country, be able to adjust to its unique environmental conditions and rely on readily available resources (such as adsorbed materials). Ongoing research, international cooperation, and the creation of sustainable agriculture techniques are crucial in order to overcome these constraints.

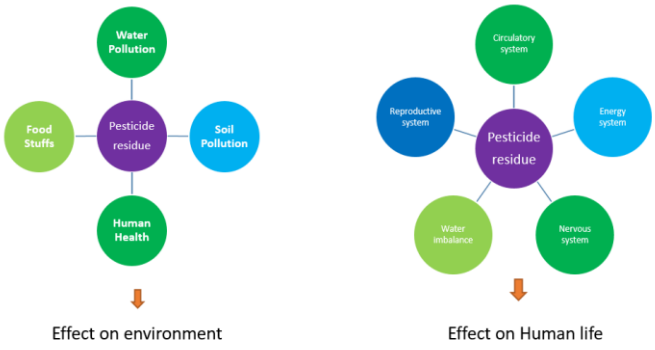

Figure 1: Effect of Pesticide residues on environment and human life

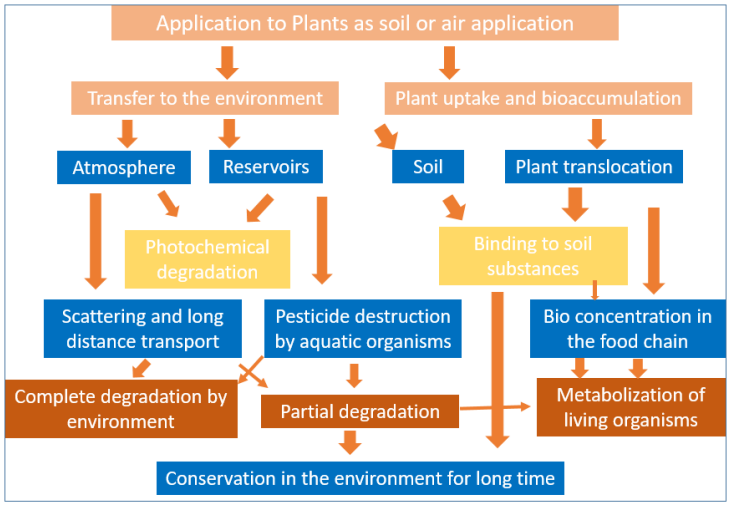

Figure 2: Schematic diagram of pesticide transport routes after application

References

Zhang, A. A., Sutar, P. P., Bian, Q., Fang, X. M., Ni, J. B., & Xiao, H. W. (2022). Pesticide residueelimination for fruits and vegetables: The mechanisms, applications, and future trends of thermal and non-thermal technologies. *Journal of Future Foods*, *2*(3), 223-240.

Bhilwadikar, T.,Pounraj, S., Manivannan, S.et al., Decontamination of microorganisms and pesticides from fresh fruits and vegetables: a comprehensive review from common household processes to modern techniques, Compr. Rev. Food Sci. Food Saf. 18 (2019) 1003-1038.

Bassey, E.J.,Cheng, J.H.,Sun, D.W. Novel nonthermal and thermal pretreatments for enhancing drying performance and improving quality of fruits and vegetables, Trends in Food Science & Technology 112 (2021) 137-148.

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