Chapter

Perspective Chapter: Current Situation of Insecticide Residues in Food Commodities and Possible Strategies for Management of Residues

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Abstract

Pesticides have evolved into a crucial instrument in agriculture's evolution as a plant protection agent for increasing food output. Moreover, pesticides contribute significantly by preventing a number of terrible diseases. However, both occupational and environmental pesticide exposure can lead to a number of health issues in people. It has been noted that pesticide exposures are becoming more and more associated with immune system suppression, hormone disruption, lowered intellect, abnormalities in reproduction, and cancer. Because of the great demand for farm produce and their lack of awareness of the hazardous consequences of pesticide residues in food, some farmers do not wait long enough for the residues to wash off after spraying before harvesting. As a result, residues in food products have appeared as a result of increased pesticide use in agriculture. Some of the primary tactics for reducing human exposure to pesticides are pesticide safety, regulation of pesticide usage, appropriate application technology, and integrated pest management.

Keywords: pesticide, pesticide residues, environmental pesticide exposure, pesticide safety, integrated pest management

1. Introduction

The usage of pesticides is common to ensure high agricultural yields. They are employed in the production of agricultural products as well as their post-harvest handling. The growing usage of chemical pesticides, however, has had a negative impact on human health as well as contaminated the environment. It has long been of great concern that food products may contain pesticide residues. When these products are eaten fresh, the issue becomes even more serious. Pesticides have been linked to a variety of risks to human health, from immediate effects like headaches and nausea to long-term ones like cancer, reproductive damage, and endocrine disruption. Pesticides applied during the fruit growth period can dissipate faster because of the growth dilution effect [1]. However, when applied after fruit growth, they are likely to be carried over to the harvested produce and processed products. Processing is considered as effective tool which implies transformation of fresh commodity into value-added product and ultimately affect the nature and magnitude of residues and during processing pesticide residues may increase or decrease in the transformed product [2]. Processing Factor (PF) is used to assess the risk associated with the consumption of pesticide residues, particularly for processed food products [3].

For pest management and the eradication of disease vectors, developing nations (like China) frequently utilize insecticides (including organophosphorous and pyrethroid) and fungicides (including triazoles and chloronitriles). Pesticide poisonings are far more common in poorer nations than in developed ones as a result of poor pesticide handling procedures, farmers' use of more harmful pesticides, and insufficient monitoring and oversight of these chemicals. Because of a lack of funding and the absence of strict regulations, pesticide residue control initiatives are frequently ineffective in poor nations.

1.1 Insecticide residues found in various food commodities

Insecticide residues discovered in various food commodities were tabulated in **Table 1**.

1.2 Management strategies to reduce pesticide residues

1.2.1 Effect of processing on the level of pesticide residues in various fruits and vegetables

Consumers have little control over pesticide residues that are left in food products in various proportions after harvesting and which are damaging to human health. Hence, pesticide residues present a significant challenge to the international trade in food products. Since pesticide-treated food crops always retain varying amounts of these chemicals, finding non-toxic methods for decontaminating food are essential. The molecular composition, product mix, and environmental conditions all have an impact

Name of the commodity	Insecticides found	Reference
Tomatoes	Oragno chlorines & Organo phosphates	[4]
Citrus	Chlorpyrifos, Deltamethrin and Spirotetramat	[5]
Tomato Ketchup	Cypermethrin	[6]
Wheat	Deltamethrin Permethrin Malathion	[7]
Rice	Diazinon & Chlorpyrifos	[8]
Apple	Abamectin, Diazinon & Chlorpyrifos	[9]
Sugar beet	Chlorpyrifos	[10]

Table 1.
List of insecticides found in various food commodities.

on the levels of pesticides in various food items. Washing is the most popular technique of processing, and it is an important first step in both home and industrial preparation. As a result, it is critical to consider techniques that may successfully assist in reducing residue content at the individual level in order to limit dietary pesticide exposure.

The effects of commonly used household processes such as washing by tap water, saltwater, lukewarm water, lemon water, tamarind water and ozone water are discussed below.

Tap water washing for 2 minutes eliminated 30–50% of phosalone residues and 65.3% of chlorpyrifos residues [11, 12], whereas tap water washing for 10 minutes removed 53.4, 53.3% dimethoate residues in grapes [13, 14]. Awasthi [15] found that washing mangoes with tap water removed 66–68% of the dimethoate and fenitrothion. Washing guava with tap water reduced dimethoate residues by 42.5–45.9% [16].

Other fruit crops viz., mangoes where 66% dimethoate residues were removed by tap water washing [15], 45.9% in guava [16]. Washing with salt water (2%) solution for 10 min was recorded as an effective decontaminant in removal of acephate, chlorpyrifos, quinalphos, bifenthrin residues (51.80–72.80%), acephate (72.74%), chlorpyrifos (67.52%) and quinalphos (65.0%), respectively in grapes [17–20], imidacloprid (61.89%) in field bean [21, 22], tetraniliprole (61.49%) in tomato [23] and NaCl (5%) removed 90% of quinalphos and profenofos in chili [24].

Pesticide residues combine with sodium chloride solution, a powerful electrolyte solution, which lowers their concentration and offers an appealing source for pesticide residue removal. When dipped in the solution, neonicotinoids with high water solubility were easily separated from the fruits in salt media. Vijayasree et al. [25] discovered that tamarind water (2%) and salt chloride (2%) solutions eliminated 85.56 and 100% of the emamectin benzoate in cowpea pods, respectively. Buprofezin residues in oranges were reduced by 36.50 and 27.51%, respectively, after washing with tap water and salt chloride solution (2%) [26].

Citric acid, the active component of lemon water, was mostly responsible for the residue elimination. The findings supported research in which a 52.2% reduction in dimethoate in tomato [16] was noted. Dimethoate and quinalphos were both eliminated by washing in lemon water (1%) for 10 minutes, along with 45% of the pesticide acetamiprid from tomatoes [27, 28].

The removal of residues by tamarind water solution is due to its acidic nature which is contributed by furan derivatives and carboxylic acids [29]. Studies where tamarind water (2%) washing resulted in a 69.1% reduction of chlorpyriphos in tomatoes, 58.8 and 80.4% reduction of dimethoate and quinalphos in grapes, 58.8% of dimethoate in grapes [14, 16, 27].

It is evident that the ozone concentration administered, the physical characteristics of the food matrix, and the residual ozone present in the medium all affect how effective ozone intervention for pesticide degradation is. The parameters that affect the clearance rate include the application environment (pH, temperature, and humidity), the application method (aqueous vs. gaseous), the ozone concentration, the rate of formation, and the geometry-size of pesticide residue [30]. Dipping apples in ozonated water of 0.25 ppm resulted in reducing the levels of azinophos-methyl on the surface of apples to 75% [31]. Ikeura et al., [32] studied the effect of ozone water (2.0 mg L-1) for 10 min on the level of fenitrothion residues in strawberries and removal rate were concluded as 25%. Removal of chlorpyrifos in lychee fruits with aqueous ozone water concentrations of 2.2, 2.4, 3.2 and 3.4 mg L-1 for 10, 20, 30 and 60 min resulted in 0, 25.8, 29.7 and 67.4% reductions, respectively. Similarly, fumigation of O_3 at 80, 160, 200 and 240 mg L-1 for 10, 20, 30 and 60 min resulted in 10, 18, 30, 45% reductions, respectively [33]. Treating the citrus fruits with ozonated water (10 mg L-1) for 5 min reduced the chlorpyrifos by 94.2% [34]. Washing of strawberries in ozonated water (1 mg L-1) for 5 min resulted in removal of chlorpyrifos by 71.5% [35]. Washing of tomatoes in ozonized water for 30 seconds removed chlorpyrifos by 86% [36].

To ensure that customers are not exposed to any health hazards, monitoring pesticide residues ingested through food is necessary. Few foods are consumed without processing, including washing, peeling, drying and pasteurization. During harvest, the residues left on the fruits can be carried into processed foods, such as juice, squash, jams, jelly, and raisins [37]. It is well established that food processing affects residual pesticide concentrations. Therefore, when fruits are processed, it is predicted that the residues will decay due to exposure to various processing procedures. Consequently, it is critical to include processing factors when assessing pesticide residues in processed foods.

Camara et al., [38] conducted various food processing procedures viz., cutting, washing and drying in lettuce to monitor the behavior of imidacloprid and they concluded that PF was 0.53 for imidacloprid which indicates reduction of residue content than in fresh lettuce due to food processing. Pasteurization resulted in the loss of 60.42–100% imidacloprid residues in tomato juice and paste [39, 40]. Pasteurization was found to reduce imidacloprid residues (32.45%) in strawberry juice preparation [40]. Imidacloprid residue reduction (82.66% and 66.55%) in sugared pulp and paste of winter jujube [41], 50.64 and 84.41% removal of imidacloprid residues during strawberry syrup and jam preparation, respectively [40]. Hot air over drying reduced imidacloprid residues by 70% in pomegranate, 36.73% in zucchini processing, 53% in lettuce [38, 42, 43], respectively. Processing of apples were concentrated to 0.162, 1.039, 0.102, 0.049 from 0.061, 0.372, 0.047 and 0.02 mg/kg of quinalphos, chlorpyrifos, cypermethrin and deltamethrin respectively in apple juice than in unprocessed apples [44]. Commercial processing of tomato fruits into tomato juice (under hot break) reduced 100% of imidacloprid residues [28]. Cypermethrin residues were concentrated in seedless variety of grapes to 0.46 ppm when compared to residues in fresh grapes (0.40 ppm), a study conducted by [2]. Producing apple juice from freshly harvested apples resulted in reduction of chlorpyrifos and methomyl residues by 100 and 78.1%, respectively [45].

Reddy et al., [46] studied processing effect on pesticide residues in grapes where Processing factor was calculated and was in the range of 0.01 to 0.35, 0.04 to 0.39 and 0.03 to 0.40 for juice, squash and raisin, respectively. In this study, imidacloprid was removed (59.75–67.94%) from grapes while, washing with water. Washing reduced chlorpyrifos residues (21%) in apple processing [47]. It is inferred that there is a strong correlation between water solubility (600 mg L-1) and removal of imidacloprid [48]. Crushing/homogenization does not impact residues, but it speeds up processes like hydrolysis, which releases isolated enzymes and acids from the cuticle layer more quickly, reducing residues in the juice. Partitioning characteristics of insecticide between pulp and juice are responsible for the low residual levels in juice and squash.

Clarification of juice may eliminate residues retained in the suspended particles. A negligible number of systemic insecticides might be absorbed by pulp or fruits [48]. Studies reported 93.26–97.85% removal of imidacloprid residues during processing of apples into juice [47]. Pesticide residues were significantly reduced during juice processing also reported [44, 45]. Pasteurization was found to reduce 60.42–100% of imidacloprid in tomato juice and paste [28] and imidacloprid residues (32.45%) in strawberry juice preparation [40]. During squash preparation, addition of sugar syrup to the juice reduced residues in 94.32% in present study as water was added in sugar syrup resulted in dilution of residues. Hendawi et al., [40] reported imidacloprid residue reduction during strawberry syrup (50.64%) and jam preparation (84.41%) and 66.55 and 82.66% reduction in sugared pulp and paste of winter jujube, respectively [41]. Because of evaporation and degradation, the drying process may have significantly reduced residual levels [49]. With regard to imidacloprid residues, 70.00% reduction in pomegranate by hot oven air drying [42], 53.00% in lettuce [38] and 36.73% reduction in zucchini processing [43], were reported.

In raisin preparation, residues of phosalone (68.04%) and ethion (69.55%) were removed [50]. The processing factor achieved for hexythiazox and bifenazate were 0.36 and 0.15 in grapes for raisin [51]. It is concluded that pesticides with low Kow may be removed through volatilization after drying and this is correlated with studied chemical imidacloprid where the Kow is low (0.57). Catherine et al., [52] reported that water solubility of a pesticide is an important factor during the juicing operation and pesticides with the highest water solubility were present in relatively higher amounts in the juiced carrots, tomatoes and strawberries [53]. Moreover, dimethoate is xylem mobile due to its low log Kow value of 0.7 and phloem mobile due to its pKa of 2. This is probably why washing and peeling are less effective at removing dimethoate than other organophosphates such as chlorpyrifos and parathion and thereby ending up in the filtered juice. Concentration of dimethoate quinalphos, chlorpyrifos, cypermethrin, deltamethrin were found in apple [44], chlorpyrifos in apple juice [47], in wine [54].

Pesticides residue levels were reduced during processing of food commodities but those pesticides (dimethoate, azoxystrobin, pyrimethanil) were not having a preferential partition between liquid and solid phase may be concentrated in the final processed product [55]. The poor transfer/presence of lower residues in filtered juice might be due to low water solubility (0.024 g/L) and high octanol co-efficient (Kow = 5.0) reported for emamectin benzoate, fenpropathrin and propargite in tea brewing [56, 57]. Lower residues of emamectin benzoate in grape and its processed products is might be due to high octanol co-efficient (Kow = 5.0) makes immobile in plant tissues. Our results are in line with studies where post-harvest processing and decoction of Chinese medicinal plant mugua resulted in 99.94% reduction of emamectin benzoate [58] PF of 0.06 in Chinese peony [59]. The processing of grapes into juice, squash and raisin resulted in reducing the residues as well as processing factor less than for imidacloprid, emamectin benzoate and dimethoate [46].

2. Conclusions

To reduce residue prevalence in food commodities, the governing bodies should undertake pesticide policy awareness campaigns and impose mandatory training to the grape farmers on pesticide usage, the consequences of excessive/improper pesticide use on the environment and the consumers.

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Appendices and nomenclature

PF	Processing Factor
%	Per cent
min	Minutes
P^H	Potential of Hydrogen
ppm	parts per million
g/L	grams per liter
mg L^{-1}	milligram per liter
mg/Kg	milligram per kilogram
Kow	Water Partition Coefficient
pKa	Acid dissociation Constant
O_3	Ozone

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