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Pesticide Residues in Fruits: Health Risks and Safety Measures

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Abstract: Fruits are an important part of our daily diet. They are naturally good and contain vitamins and minerals that can help to keep us healthy and also help to protect against some diseases. Fruit constituents such as vitamin A (beta-carotene), vitamin C, vitamin E, Magnesium, Zinc, Phosphorous, and Folic acid may reduce the risk of many diseases (type 2 diabetes, stroke, cardiovascular disease, cancer of bowel, stomach and throat, and high blood pressure/hypertension). Fruits also reduce blood levels of homocysteine, a substance that may be a risk factor for coronary heart disease. In recent times, to increase the yield from fruit crops and for protection from many pests, chemical pesticides are applied on the larger scale. Due to this excessive use of pesticides, many of the pesticides contaminate the natural environment and via the contamination of the soil, some of the pesticide residues enter fruits also. Though, it was said that modern formulations of pesticides are safe, many scientific reports have demonstrated that pesticide residues from the food can produce long-term negative effects on the health of fauna, humans and the environment. Present study mainly focuses on the fruits (definition, nutritive and therapeutic benefits); pesticides (definition, types, benefits and adverse effects); and pesticide residues. This review also focus on the pesticide residues recorded in commonly consumed fruits, health effects of pesticide residues, and safety measures for pesticide residues in fruits. Daily practice of safety measures include preference to organic fruits, washing of fruits with water, and eating of processed fruits. At the agricultural level, rational use of pesticides, use of bio-pesticides or natural pesticides such as neem extract, will lower the pesticide residues in fruits.

Keywords: Pesticide residues, Fruits, Health risk, Cardiovascular disease, Obesity, Blood pressure

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Introduction

Fruits are one of the most consumed foods since they provide essential nutrients that are required for most of the reactions occurring in the body. Fruits are attacked by pests and diseases during production and storage leading to damages that reduce the quality and the yield. To reduce the loss and maintain the quality of fruits harvest, pesticides are used to destroy pests and prevent diseases. The use of pesticides have increased because they have rapid action, decrease toxins produced by food infecting organisms and are less labour intensive than other pest control methods.

However, the use of pesticides during production often leads to the presence of pesticide residues in fruits after harvest (Keikotlhaile, 2011).

Fruits -- Definition, Nutritive and Therapeutic benefits:

Fruit is the edible parts of plants that contain the seeds and pulpy surrounding tissue; have a sweet or tart taste; generally consumed as breakfast beverages, breakfast and lunch side-dishes, snacks or desserts (IARC Press, 2003). According to Kandasamy and Shanmugapriya (2015), fruit is the fleshy growth that arises from the ovary of a flower and may not necessarily include any other structures or fruit is the edible product of a plant or tree that includes the seed and its envelope and can typically be described as juicy, sweet, and pulpy. A true fruit or eucarp is a mature or ripened ovary, developed after fertilization (Rezaei *et al*., 2020).

Constituents of fruits include sugar, polysaccharides, organic acids, N-compounds, lipids, pigments, aroma substances, vitamins and minerals of nutritional importance. Composition of fruits is strongly influenced by the variety and ripeness. The dry matter content of fruits varies in the range of 10% to 20% (Molnar, 1997; FAO, 2020). Fruits represent a vital source of phytochemicals, dietary fiber, protein, carbohydrates, vitamins, carotenoids, flavonoids, and other components (Kazi *et al*., 2015). Therefore, daily consumption of fruits, nuts, dried fruits, and fruit juice provide important components for body health (Abobatta, 2021).

Dreher (2018) documented that, health benefits of fruits include: protection against colonic gastrointestinal health; promote long-term weight management; reduce risk of cardio vascular diseases (CVD), type II diabetes and metabolic syndrome; defend against colorectal and lung cancers; improve odds of successful aging; reduce the severity of asthma and chronic obstructive pulmonary disease; enhance psychological well-being; lower the risk of depression; enhance bone mineral density in children and adults; and help to attenuate autism spectrum disorder severity (Smith *et al*., 2022).

Further, fruits also reduce the risk of: Asthma, Cancer, Chronic Inflammatory Bowel Diseases (IBD), Chronic Obstructive Pulmonary Disease (COPD), Coronary Heart Disease (CHD), Dementia, Eye diseases, Hypertension, Obesity, Osteoporosis, Rheumatoid Arthritis (RA), Stroke, and Type 2 Diabetes mellitus (PBHF, 2015; Techane, 2022).

Pesticides -- Definition, Types, Benefits and Adverse effects:

According to EPA (2009), 'Pesticides is a substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest (insects, mites, nematodes, weeds, rats, etc.), including insecticide, herbicide, fungicide, and various other substances used to control pests'. 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 (Yamada, 2017).

On the basis of chemical composition, pesticides are categorized into: organo-chlorine, organophosphate, pyrethroids, carbamates, and bio-pesticides (Keikotlhaile and Spanoghe, 2011; Nayak and Solanki., 2021). Based on the target organism controlled or killed, pesticides are classified into: acaricides (kill mites, ticks and spiders); fungicides (kill fungi and moulds); herbicides (kill weeds or prevent growth of weeds); insecticides (kill or repel insects and related species); molluscicides (kill snails, slugs, etc); nematicides (kill nematodes); rodenticides (kill rats, mice, moles and other rodents); and miscellaneous pesticides (kill or repel pests of all types) (Gyawali, 2018).

Environmental impacts of pesticides include contamination on natural environment (water, soil, air); impact on food safety, non-target organisms; and threats to aquatic and terrestrial biodiversity. According to Shah (2020), impacts of pesticides on human health include neurotoxic, genotoxic, carcinogenic, and reproductive effects (Poudel *et al*., 2020).

Pesticide Residues:

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' (WHO, 2016; Inobeme *et al*., 2020). Pesticide residue means any specified substance in food, agricultural commodities, or animal feed resulting from the use of a pesticide. The term includes any derivatives of a pesticide, such as conversion products, metabolites, reaction product, and impurities considered to be of toxicological significance (TAS, 2008).

Mazlan *et al*. (2017) reported contamination of different components of the environment such as water, air and soil by pesticide residues such as organophosphate and organochlorine compounds. Major factor contributing to the higher amount of these residues in most developing countries is the wrong dosage and poor adherence to standards with respect to the application of these pesticides. The amounts of pesticide residues primarily depend on nature of pesticides, environmental conditions, good agricultural practices, waiting periods and storage conditions (Racke, 2007).

Therefore, the objective of present study was to review the concentration of pesticide residues in commonly consumed fruits and to generate awareness about the lethal effects of these pesticides on human beings as well as to estimate the potential health risks associated with the pesticide residue with regard to consumers.

Articles relevant on pesticide residues in fruits were searched in EMBASE, Google Scholar, Medline, NCBI, PubMed, Science Direct, Scopus, and Web of Science databases. Data and information was collected from the thorough study of the journal articles, research papers, reports and various literatures. The keywords used for reviewing the literature were the ones that refer to the issues concerning the 'fruits' and 'pesticide residues'. For literature search, keyword "fruits" is combined with: pesticide residues, health and safety measures, risk assessment, hazard to human health and the environment.

Pesticide residues recorded in common vegetable crops:

For the collection of primary data on pesticides residues in fruits, scientific papers and review articles published in reputed journals were reviewed. Details on the fruits, pesticides detected, area of the study, and reference is presented in Table 1.

Health Effects after exposure to pesticide residues:

Increased use of pesticides results in contamination of the environment and the excess accumulation of pesticide residues in food products. Pesticide residues in food and crops are directly related to the irrational application of pesticides to the growing crops. Accumulated pesticide residues in food products have been associated with a broad variety of human health hazards, ranging from short-term effects to long term toxic effects (Grewal *et al*., 2017).

Impacts of pesticide residues in fruits on human health:

- Negative impact on central and peripheral nervous systems (Bjorling-Poulsen et al., 2008).
- Carcinogenicity due to exposure to pesticides (Keikotlhaile, 2011).
- Pesticides bind with the enzyme acetylcholinesterase and disrupts the nerve function, resulting in paralysis and may cause death (Grewal *et al*., 2017).
- Acute exposure to pesticides affects the meiosis, urination, diarrhoea, diaphoresis, lacrimation, excitation of central nervous system and salivation.
- Chronic exposure involves neurotic and behavioural effects.
- Cancer, allergies and hypersensitivities, reproductive disorders and disruption of the immune system (Mishra *et al*., 2014).

Table 1: Pesticides detected in fruits

Fruits	Detected pesticides	Area	Reference
Papaya, Banana, Watermelon, Mango, Pear, Pineapple	Gamma-HCH, Methoxychlor, Aldrin, Dieldrin, Endrin, p,p'-DDE, p,p'-DDT	Kumasi Metropolis, Ghana	Bempah *et al*. (2011)
Apple, Bananas, Kiwi, Grapes, Lemmon, Pears, Strawberries	Dithiocarbamates, Iprodione, Parathion, Procymidone, Vinclozolin	Belgium	Keikotlhaile (2011)
Apple, Guava, Orange, Grapes, Pear, Persimmon, Banana, Pear	Dichlorvos, Fenvalerate, Profenofos, Dimethoate, Methyl parathion, Fenitrothion, Cypermethrin, Endosulfan, Deltamethrin, Dicofol Mevinphos, Chlorpyriphos,	Nawabshah District, Sindh, Pakistan	Tahir *et al*. (2011)
Apples, Grapes, Pears, Guava	Chlorpyrifos, Diphenylamine, Malathion, Phosmet, Thiabendazole	Hyderabad, Secunderabad	Dasika *et al*. (2012)
Grapes	Endosulfan, Methyl parathion, Malathion, Chloropyrifos, Quinolphos, Cyhalothrin, Fenvelerate	Bangalore, Karnataka, India	Ramesh and Murthy (2013)
Apple, Apricot, Pear, Currant, Blueberry, Cherry, Gooseberry, Raspberry, Grape, Strawberry, Peach, Plum, Sweet cherry	Boscalida, Bupirimate, Cyprodinila, Chlorpyrifosa, Chlorpyrifos-methyla, Difenoconazole, Dithiocarbamates, Fludioxonila, Myclobutanila, Trifloxystrobin	Central and Eastern Region of Poland	Szpyrka *et al*. (2015)
Blackberries, Mangos, Strawberries, Papaya, Pepinos, Bitter melon	Imazalil, Thiabendazole, Endosulfan, Chlorpyrifos, Procymidone, Boscalid, Iprodione, Methidathion, Lambda-cyhalothrin, Carbendazim, Orthophenylphenol, Vinclozolin, Pyrimethanil, Prochloraz, Cyprodinil,	Haryana, India	Grewal *et al*. (2017)
Tomato, Oranges	Dichlorvos	Monze district, Zambia.	Mwanja *et al*. (2017)
Apples, Grapes	Dieldrin, Endrin, DDT, Aldrin, DDE, Bromopropylate, Permethrin, α-HCH, HCB, β-HCH, Heptachlor, Malathion, Chlorpyrifos, Heptachlorepoxide	Jordan	Tarawneh *et al*. (2019)
Dates, Apple, Orange, Lemon, Mango, Grape, Pomegranate, Banana, Cantaloupe, Watermelon, Peach, , Strawberry, Apricot, Cherries, Guava	Imidacloprid, Carbendazim, Methomyl, Acetamiprid,	Riyadh, Saudi Arabia	Khatri *et al*. (2020)
Oranges, Grapes	Acetamiprid, Carbendazim, Chlorpropham, Chlorpyrifos, Cypermethrin, Imidacloprid, Propargite,	Egyptian governorates	Ibrahim *et al*. (2022)
Apple, Banana, Grape, Mandarin, Pear, Persimmon, Schisandra berry	Chlorfenapyr, Procymidone, Etofenprox, Pendimethalin, fluopyram	Incheon, Korea	Park *et al*. (2022)
Tomato, Orange,	Carbaryl, Carbendazim, Bifenthrin,	Indonesia	Pitoi *et al*.

Lettuce, Brown rice, Strawberry	Chlorpyrifos-Ethyl, Chlorpyrifos-Methyl, Myclobutanil, Permethrin		(2022)
Apple, Orange, Banana, Mango, Grapes	Acephate, Dichlorovos, Edifenfos, Monocrotophos, Profenofos, Chlorpyriofs, Diazinon, Dimethoate, Ethion, Malathion, Triazophos	Gujarat State, India	Sivaperumal *et al*. (2022)
Fruits collected from farms, markets, streets, restaurants and homes.	Dithiocarbamates, Acephate, Mevinphos, Azamethiphos, Dichlorvos, Profenofos, Aminocarb, Methomyl, Methiocarb, Dioxacarb, Benfuracarb, Bifenthrin, Acetamiprid, Lambda-cyhalothrin, Cypermethrin, Spiritetramat, Flufenoxuron , Proquinazid	Kampala, Wakiso and Mukono Districts of the KMA in Uganda.	Ssemugabo *et al*. (2022)

- Persistent memory and cognitive deficits.
- Oxidative stress leading to hyperglycaemia.
- Reproductive disorders: Lower total sperm count, ejaculate volume and percentage of normal sperm, reduced fertility, early and late pregnancy loss, prolonged time-to-pregnancy, spontaneous abortion, and premature birth (Bretveld *et al*., 2006).

Safety Measures for pesticide residues in fruits:

The level of pesticide residues is affected by washing, preparatory steps, heating or cooking, processing during product manufacturing and post harvest handling and storage. The extent of reduction varies with nature of pesticide molecule, point of location, type of commodity, processing steps and product prepared (Bajwa and Sandhu, 2014).

Strategies to reduce pesticide residues in vegetables:

- Preference should be given to organic fruits than non-organic ones.
- Washing of fruits with water will reduce the pesticide residue to great extent.
- Processing of fruits also reduces the residual pesticides.
- Rational use of pesticides also lowers the residues in food products.
- Use of microbial pesticides/bio-pesticides.
- Use of natural pesticides (e. g. neem extracts).

Conclusion

This study demonstrated occurrence of pesticide residues in commonly consumed fruits. The consumers are exposed to concentration of pesticides that may cause chronic diseases. On the basis of the above findings, it is the need for continued survey and monitoring programs for pesticide in all food commodities in order to protect the end user for the indiscriminate exposure of pesticides. The study recommends future investigation with respect to risk assessment for a longer period of time that would allow obtaining a deeper knowledge about the presence of pesticide residues in fruits.

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