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Antibiotic Resistance: Role of Fruits and Vegetables in the Food Basket

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ABSTRACT

Antibiotics act as growth promoters but can contribute to an increased human exposure to antibiotics, development of pathogens with antibiotic-resistance and increased allergies due to its presence in foods. In fact, the presence of residual antibiotics in foods constitutes an important health risk because the increased microbial resistance detected in latest years. In addition, the presence of residual amounts of antibiotics produces important difficulties to food processors for the extent and control of food fermentation.

Key words: *Antibiotic resistance, Food processing, Growth promoters, Residual antibiotics.*

INTRODUCTION

A great number of antibiotics are used either directly or indirectly during the production, processing and storage of food of animal origin. The rate of urbanization and industrialization is increasing day by day in India and all over the world leading to increased environmental pollution in conjunction with it, the inappropriate use of veterinary drugs may induce the presence of residues in food products, which can pose a major threat to public health. Antibiotic residues are small amount of remnants of antibiotics or their break-down products (called metabolites) that are present in an agricultural or animal product following treatment with that antibiotic. It is evident that there are important benefits for the farmer when using these illegal substances, mainly consisting in an increased feed conversion yield and an increased lean meat with less fat. But, it is also evident that there are important prejudices for the processing industry, like lower quality of products and problems in fermentation and very important prejudices to the consumers, not only for the worse quality or the higher water content but because of the presence of residues and its associated harmful health effects on humans.

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For all these reasons, there is an evident interest of both officials and food industry to control the presence of these substances in farms and foods of animal origin.

Sources of Antibiotic resistance incorporation into Fruits and vegetables

1. **Application of manures to the farm from slaughter houses:**

Manure is a "hot spot" of bacteria carrying Antibiotic Resistant Genes (ARG) residing on mobile genetic elements. When soils are treated with manure, Antimicrobial Agents and their metabolites as well as bacteria carrying ARG are introduced into the soil. In soil, ARG are likely to be horizontally transferred to soil bacteria, a process that is enhanced by manure[1].

2. **In vitro Propagation of crops (Tissue cultured plants):**

Antibiotics are used in the process. Antimicrobials are used several ways in plant tissue culture. Inclusion of antibiotics and/or antimycotics in the culture medium can prevent or often treat microbial contamination[2]. Commonly used antibiotics are streptomycin, tetracycline, rifampinicin, penicillin, beta-lactam antibiotics such as timentin, cefotaxime sodium salt, meropenem trihydrate and augmentin. Chances of buildup of antibiotic resistance can happen through this channel also.

3. **Antibiotics spray on the crops in the orchard:**

If bacteria on the plants and in the soil are sprayed with an antibiotic, those with genes for resistance to the chemical increase compared to those susceptible to the antibiotic. Resistance genes exist for both streptomycin and tetracycline, and spraying with these chemicals increases the frequency of resistant genotypes by killing those susceptible to the antibiotic and leaving the others. Those genes may be taken up by other bacteria by a number of mechanisms, collectively known as "horizontal gene transfer." They include transformation, in which bacteria pick up DNA that is free in the environment –for example, from dead and degraded bacteria, conjugation– from direct cell-to-cell contact, which may involve unrelated bacteria and is mediated by plasmids or transposons, and transduction –the transfer of DNA via phage[3].

4. **Soil and water contamination with fecal material and effluent from farm animals at the field:**

Influence of bacterial soil community and selection for AMR, the introduction of AMA to soils also results in uptake of AMA into plants, mainly through water transport and passive absorption[4]. There is limited understanding of the interactions of AMA concentrations in manure and soil, AMA chemical characteristics, characteristics of specific crops, the plant growth stage, and plant physiology on plant uptake of AMA. Since treated wastewater and lake water have been shown to contain ARG[5], water obtained close to such sources for irrigation purposes in plant production may pose a risk for transmission of ARB and ARG onto fresh produce. Irrigation water is generally regarded as one of the important bacterial contamination sources in vegetable growth during the pre harvest phase[6].

5. **Genetic engineering causing increased antibiotic resistance:**

First gene-altered food for sale in the U.S. (Calgene's Flavr Savr Tomato) contains a marker gene that confers resistance to the antibiotic kanamycin. The FDA admits that antibiotic-resistant genes can reduce the benefit of prescribed antibiotics. All bioengineered foods contain antibiotic-resistant genes currently without labeling[7].

Antibiotic resistance in different crops

1. **Fruits and Vegetables:** In the case of fruits and vegetables, *Enterococci mundtii* was the dominant species after *Enterococci faecalis* and *Enterococci faecium*[8]. Species other than *E. faecalis* and *E. faecium* isolated from food are also seen to harbour the potential for virulence. Antimicrobial susceptibility testing using the disk diffusion method showed that of the total 250 isolates, 46% were resistant to cephalothin and 38% to ofloxacin. Lower antibiotic resistance was seen with ampicillin, chloramphenicol, gentamicin and teicoplanin and none of the isolates was found to be resistant to vancomycin[8]. Microbiological quality and antibiotic resistance patterns of pathogenic bacteria

isolated from vegetable samples from local and super shops were investigated by Ahmed Kabir *et al*[9]. Concentrations of total heterotrophic bacteria, total coliform, faecal coliform, Pseudomonas spp., *Listeria spp., Staphylococcus aureus, Salmonella spp., Shigella spp.* and *Vibrio spp*. were determined. Antibiotic sensitivity patterns of the isolated bacteria were determined using Imipenem, Ceftriaxone, Sulphamethoxazole, Ampicillin, Gentamicin, Aztreonam, Cefuroxime and Oxacillin antibiotic discs. Higher proportions of *E.coli* (57.14%) was observed by local market vegetables whereas *Pseudomonas spp*. and *Listeria spp*. (71.42%) in super shop vegetables. Pathogenic bacteria isolated from the super shops showed increased resistance against (62.5%) antibiotics[9].

2. **Salads:** Health conscious people prefer fresh salads due to high fiber and less calorie yielding food item, which is consumed without preheating. Gbonjubola *et al.*[10] studied bacterial load of the salad samples ranging between 6.0 x 10^4 to 2.0 x 10^6 cfu/ml with the predominant bacteria isolated were *Staphylococcus aureus, Salmonella spp, Escherichia coli* and *Pseudomonas aeruginosa*. All the bacteria isolates were found to be sensitive to Ofloxacin but resistant to Amoxycilin except a strain of *Escherichia coli*. Some of the strains of these isolates showed multiple antibiotic resistance to the antibiotics used[10]. Commonly used raw salad vegetables such as tomato, cucumber, carrot, green chilli, lemon, coriander leaf, pepper mint and beet root were studied by Nipa *et al*[11]. Vegetables were highly contaminated with coliform, fecal Coliform, yeast and mold. A total of 266 bacterial isolates of ten genera and three fungi Rhizopus, Penicilium and Aspergillus were identified. *Enterobacter spp*. (21.80%) was the most dominant followed by *Pseudomonas* spp. (19.17%), *Vibrio* spp. (16.92%), *Lactobacillus* spp. (15.04%), *Staphylococcus* spp. (10.15%), *Klebsiella* spp (9.04%), *E. coli* (4.89%), *Citrobacter* spp. (2.26%), *Serratia* spp. (0.37%) and *Salmonella spp*. (0.37%). Multiple drug resistance was observed in 98.06 % isolates with a resistance to antibiotics such as Erythromycin, Gentamycin, Ampicillin, Ciprofloxacin, Cephalexin, Chloromphenicol and Streptomycin.

Listeria monocytogenes which causes listeriosis in animals and human are present in salad vegetable and ready to eat vegetable salads (cabbage, cucumber, lettuce, tomato and colesaw). Antibiotic susceptibility testing showed that 92.9% of the isolates were resistant to ampicillin followed by oxacillin (85.7%) while ciprofloxacin has the lowest resistance (14.3%) and majority (64.3%) of the isolates were resistant to more than four antimicrobial agents[12].

3. **Organic food:** Organic foods are generally considered to be safe and carry less of resistant bacteria. There were no significant differences in rates and densities of colonization by resistant bacteria between organic and conventional fruits and vegetables eaten raw[13]. When resistant bacteria are widespread in food animals, it is very likely that soil and waterways contaminated with fecal material and effluent from farm animals will carry resistant bacteria which can colonize fruits and vegetables, even if raised organically.

Suggestions to combat Antibiotic resistance in food chain

- Removal of antibiotic resistance genes from genetically modified (GM) crops removes the risk of their transfer to the environment or gut microbes. Integration of foreign genes into plastid DNA enhances containment in crops that inherit their plastids maternally. Efficient plastid transformation requires the *aadA* marker gene, which confers resistance to the antibiotics spectinomycin and streptomycin. Siriluck Iamtham and Anil Day[14] has exploited plastid DNA recombination and cytoplasmic sorting to

remove *aadA* from transplastomic tobacco plants.

- Necessity to follow the hygienic practices in handling the vegetables in open markets as well as the super shops to reduce the load of multiple antibiotic resistant bacteria.
- Ginger fresh and dry ethanol extracts showed inhibitory effect against the resistant bacteria isolates from the vegetable salad samples[10].
- The highest antimicrobial potentials were observed for the extracts of *Caryophyllus aromaticus* (clove) and *Syzygyum joabolanum* (jambolan), which inhibited 64.2 and 57.1% of the tested microorganisms and with higher activity against antibiotic-resistant bacteria (83.3%). Association of antibiotics and plant extracts showed synergistic antibacterial activity against antibiotic-resistant bacteria. *Pseudomonas aeruginosa* was inhibited by clove, jambolan, pomegranate and thyme extracts[15].
- GE food manufacturers should not sell bioengineered foods without safety testing or disclosure for antibiotic-resistant genes contained in fruits and vegetables.
- Increasing awareness and advocacy on antimicrobial resistance and related threats.
- Promoting good practices in food and agriculture systems, and advocating cautious use of antimicrobials.
- Strengthening governance structures, developing capacity for surveillance and monitoring i.e. policies and regulations related to antimicrobial use in food and agriculture.

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