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SCIENTIFIC KNOWLEDGE APPLICABLE TO ENHANCING THE SAFETY OF FRESH PRODUCE

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Abstract

In the last years, there has been an increased concern about the food safety of the world food supply. Since the fresh fruits and vegetables are important to the health and well being of consumers, ensuring the safety of fresh produce is the top priority for the produce industry.

Fresh produce is not generally considered a common source of foodborne illness but the proportion of illness associated with this category has increased over the last number of years. Since food safety continues to grow in importance the produce industry faces the key challenge which standard(s) to apply. Systems that assure the safety and wholesomeness of fruits and vegetables during growing, harvesting, postharvest handling, and processing fall into three prevention program categories: Good Agricultural Practices (GAPs), Good Manufacturing Practices (GMPs), and Hazard Analysis Critical Control Points (HACCP).

As food safety continues to be a worldwide public health issue, the national and international food safety systems are based on the premise that safety must be guaranteed throughout the food chain if the health of consumers is to be protected. The slogan 'From farm to fork' describes how the whole supply chain is responsible for guaranteeing food safety. To accomplish this goal, all players in the food chain should rely on a risk analysis approach to enhance the scientific basis of regulatory decisions, evaluate risk management options and implement food safety programs.

Key words: *Food safety, fresh produce, fruits, vegetables, HACCP, GAP, GMP*.

1. Introduction

The food system is a complex, concentrated, and dynamic chain of activities that begins with the production of raw agricultural commodities and moves to value-added processed and manufactured products and than to retail food stores and foodservice establishments where they are merchandised, prepared, and sold to customers. The whole food sector has its own characteristics, and diversity, and customer demands, and for each segment in the food chain the important role plays sanitation and food safety (Marriott and Gravani [1]).

The increasing globalization of the food supply has resulted in an attempt to develop food safety standards that are recognized across national and international boundaries. When it comes to fresh produce, food safety issues continue to pose challenges.

The bottom line is a need for a common set of science-based standards and regulations that protect food products (Palma *et al*. [2]).

2. Food safety

Food safety is undoubtedly the most important concern of food industry. Food processors are responsible for the quality and safety of the food they produce. To reach this goal processors have to apply Good Sanitation Practices (GSP), Good Manufacturing Practices (GMP), and Hazard Analysis and Critical Control Point (HACCP) program. They are required at each step in the food production chain to ensure safe food and to show compliance with regulatory and customer requirements (Vasconcellos [3]). The success in developing, installing, monitoring and verifying successful food safety management procedures depends on overcoming a complex mix of managerial, organisational and technical hurdles. Also, consumer should be integral part of food safety systems because it is a vital link between retail and home (Raspor *et al*. [4]).

Globalization and international trade have changed the way food is sourced, produced, transported and consumed (Cwikowski [5]).

Now, a new approach to food safety is being discussed in the context of the Codex Alimentarius Committee on Food Hygiene. It is based on an entirely different principle: instead of being targeted at hazards in foodstuffs, it is focused on the risk, namely the likelihood and magnitude of impact on public health (Cerf [6]).

2.1 Food safety standards

A plethora of food safety "standards" has been developed for produce over the last decade. Even at a basic level, the use of the word "standard" has come to mean very different things within the produce industry, even among government regulators. Today, we have everything from Codex Alimentarius to emerging globally benchmarked standards, to proprietary third-party standards, to commodity-specific standards. All are referred to commonly as "standards", when in fact they are very different tools designed for different purposes (Whitaker [7]).

It is known that for some 20 years, the European Hygiene Engineering and Design Group (EHEDG) have developed protocols for handling safety issues in the industry (Raspor *et al*. [4]). The Food and Agriculture Organization (FAO) of the United Nations summarised the myriad challenges to food safety in its 2006 report, 'Food Safety and Risk Analysis, A Guide for National Food Safety Authorities'. The FAO listed biological, chemical and physical hazards to food safety, including: infectious bacteria, toxin-producing organisms, moulds, parasites, viruses, prions, naturally occurring toxins, food additives, pesticide residues, veterinary drug residues, environmental contaminants, chemical contaminants from packaging, allergens, metal, machine, fillings, glass, jewellery, stones and bone chips (HuLST [8]).

National governments promote and promulgate food safety laws, regulations and legislation that can be in sharp contrast to those of other countries. Science and certainly scientific consensus on the status of the food, from a food safety perspective, may be overlooked during the rulemaking process (Boisrobert *et al*. [9]).

When it comes to food safety standards, more is not always better. That's the message from the growers and shippers of fresh produce today who are faced with multiple audits and audit expectations that are almost the same, but different enough, so that an operation can pass a food safety audit today according to one set of standards and fail tomorrow on a different set of standards (Gombas [10]).

2.2 Fresh produce sector

High consumer demand for healthy foods has led to the exponential growth of the fresh-cut produce industry. Fresh produce includes all fresh fruit and vegetables. They are often consumed raw or with minimal preparation (FDA [11]). 'Fresh-cuts' (ready-to-serve) are one category of minimally, or lightly, processed fruits and vegetables (New Zealand Food Safety Authority [12]).

For some time, the only fresh produce food safety risk, as far as consumers were concerned, was pesticides. Retail and foodservice buyers were also concerned about growers' compliance with pesticide limits, but otherwise were only worried about quality attributes such size, colour, shape, defects. Produce could become contaminated with pathogens in the field and cause consumer illness. Then, it wasn't long before the produce industry itself began developing "best practices" for field operations, and FDA published their *Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables*, more commonly known as the Good Agricultural Practices Guide. The GAPs Guide recommended that growers and harvesters consider and address potential pathogen hazards from irrigation and other agricultural water, manure and other soil amendments, domestic animals and wildlife and workers and their utensils, facility sanitation, and transportation (Boisrobert *et al*. [9] and FDA [11]).

2.3 Food safety in fresh produce sector

The safety and quality of fresh produce when it reaches the retail market is strongly influenced by the condition of the product at harvest. Further factors that affect these characteristics include additional handling (packing), processing, storage temperature, transportation conditions and the ultimate time between harvest and retailing (Cantwell [13]). Identifying each point in the process and the possible ways contamination can occur is essential. For that reason national food safety regulators, all over the world, create safety rules (Novak *et al*. [14]).

<u>Disinfection</u>

It is well known that disinfection is one of the most critical processing steps in fresh produce production, affecting the quality, safety and shelf-life of the end product. Washing is designed to remove dirt, pesticide residues and microorganisms responsible for quality loss, as well as to pre-cool cut produce and remove cell exudates that may support microbial growth (Zagory [15]). Different washing chemical agents have been studied to determine their efficacy in the inactivation of pathogenic bacteria (Ukuku *et al*. [16]) but chlorine is one of the most effective sanitizers to assure the safety of their product. However, there is a trend in eliminating chlorine from the disinfection process because of the concerns about its efficacy on the produce and about the environmental and health risks associated with the formation of carcinogenic halogenated disinfection by-products.

Organic acids have shown to be effective in reducing bacteria populations on some fresh-cut fruits and vegetables.

Gaseous antimicrobials such as chlorine dioxide (ClO_2) and ozone (O_3) can penetrate to sites that liquid sanitizer can't. This makes gaseous antimicrobials attractive for fresh-cut applications.

Most of the current investigations have been focused on the search for alternative sanitizers based on assuring the quality and safety of the produce (Ölmez and Kretzschmar [17]).

2.4 Novel methods and technologies

Because thermal processing of fresh produce is not an option, non-thermal interventions are the only means to include as a lethality step in processing and handling of fresh fruits and vegetables. Alternatives or modified methods have been proposed, such as antioxidants, ozone, organics acids, modified atmosphere packaging, irradiation, high-pressure processing, radio frequency, pulsed-electric fields, ultrasound, and others (Castell-Perez and Moreira [18]) for maintaining the quality and shelf stability of fresh produce, and their impact on product nutritional value, microbial quality and food safety. However, none have yet gained widespread acceptance by the industry. For this reason the development of alternatives and markers in order to measure the efficacy of these alternatives are needed. Before a new process can be used and a product can be sold, thorough reviews and assessments of safety have to be conducted by regulatory agencies (Rico *et al*. [19]).

2.5 Modified atmosphere packaging

Modified atmosphere packaging (MAP), the gas mixture surrounding fresh-cut produce to a composition different from that of normal air, have extended shelf-life and reduced decay and spoilage organisms, resulting in a shift in microbial population dynamics that may favour growth of human pathogens (Rico *et al*. [19]). There is still a major concern about the product safety associated with the use of MAP. The potential exists for the inclusion of additional bioactive compounds in the package or applied to the product that target human and plant pathogens. However, good temperature control is essential for effective use of this modified atmosphere packaging.

2.6 Irradiation

Infrared radiation has been tested as a minimal heat process. Low-dose gamma irradiation is very effective reducing bacterial, parasitic, and protozoan pathogens in raw foods. Irradiation was approved by the FDA for use on fruit and vegetables at a maximum level of 1.0 kGy. In some instances, the produce quality is extended while in others it results in a loss of quality attributes (Rico *et al*. [19]). Proper irradiation of fresh produce requires an engineering approach. In short, it involves an understanding and quantification of how great a dose is applied to the food, how uniform is the distribution of dose with respect to the food and what is the effect (if any) on the quality of the food when a target inactivation dose is applied (Novak *et al*. [20]).

2.7 Ultraviolet light

Ultraviolet light (UV) acts as an antimicrobial agent directly due to DNA damage and indirectly due to the induction of resistance mechanisms in different fruit and vegetables against pathogens. Another advantage of this technique is the relatively inexpensive and easy-to-use equipment needed (Rico *et al*. [19]).

2.8 High pressure processing

By subjecting foods to high pressures in the range 300-800 MPa, microorganisms and enzymes can be inactivated without the degradation in flavour and nutrients associated with traditional thermal processing (Rico *et al*. [19]). The innovative potential of HPP has still to be fully understood. Its "non thermal" nature opens up the possibility of keeping many of the natural qualities of food.

2.9 Hurdle technology

Hurdle technology is the combination of different preservation techniques as a preservation strategy. The most important hurdles commonly used in food preservation are based on controlling temperature, water activity, acidity, redox potential and the use of preservatives, modified atmosphere and competitive microorganisms (e.g., lactic acid bacteria). By combining hurdles, the intensity of the individual preservation techniques can be kept comparatively low, minimising the loss of quality, while the overall impact on microbial growth may remain high (Rico *et al*. [19]).

2.10 Microbiology and food safety of fresh products

Although numerous rapid detection methods are available commercially or are being developed, detection methods alone are inadequate. As detection is a final downstream event, the value of the information that it provides is dependent on critical upstream inputs such as effective separation of target cells from the food matrix and their subsequent concentration to analytically suitable volumes. Therefore, development of methods for effective pre-analytical sample preparation should play an important role in the further work.

The emphasis of current research on produce safety is on developing reliable and quick detection methods for human pathogens, improved efficacy of water disinfection methods, and developing methods for reducing microbial load on intact and fresh-cut fruit and vegetables (Kader [21]).

Current research topics include questions related to how and where in the food chain microbiological and chemical contamination of foods takes place, biotechnology and allergenicity issues, dietary supplement safety, colour additive safety, and consumer studies. The determination of microbiological and chemical risks and their mitigation drives research programs (Taylor [22]).

3. Conclusions

- One of the most challenging aspects of food safety in the produce industry is the absence of sound science on which to base food safety actions. Many of the protocols that have been imposed on industry over the past decades have been based on data extrapolated from other industries or even educated guesswork (Whitaker [7]).
- Prevention of foodborne pathogens in foods requires an understanding of how foods become contaminated during their production, processing, and distribution, and the availability of practical interventions to control or eliminate the biologic agent.
- Food-safety research is critically needed to develop the means to identify and characterize more rapidly and accurately foodborne hazards, to provide the tools for regulatory enforcement, and to develop effective interventions that can be used as appropriate to prevent hazards at each step from production to consumption.
- The scientific basis for reducing or eliminating all kind of food hazards in foods is of great importance and a strong basis for accuracy, quality, and reliability to suit specific food safety requirements. However, today we are witnessing that test systems for food biological (foodborne pathogens, mycotoxins, parasites) and chemical (pesticide, insecticide and fungicide residues) hazards become better and faster, and testing tools easier to handle with.

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