Microbial update *fresh produce*

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In recent years, the consumption of fresh fruits and vegetables has increased, largely due to advice on healthy eating and to the expansion of the market place Fresh produce is now available throughout the year (not just in the local growing season); more exotic fruits and vegetables are in stores; and much produce is available in an 'easy to use' or 'ready to eat' format.

There is no doubt that the increasing consumption of fresh fruits and vegetables is beneficial to the health of the consumer. Microbiologically, however, there are some real challenges to the production of fresh produce.

Growth of fresh produce

Fresh produce is generally grown in soil and outdoors. Both scenarios allow free access to a whole range of micro-organisms – soils contain a very high microflora and are in direct contact with parts of the plant for its whole life cycle, whilst the outside environment is almost uncontrollable from a microbiological viewpoint. The impact of soil flora and the external environment on the microbiology of a plant will vary depending on a number of conditions, including:

- The closeness of the plant to the soil. Lower areas of a plant have a greater chance of contamination with soil flora than higher parts.
- Rainfall. Whilst required for plant growth, rain may also cause soil splash onto lower parts of the plant.
- Irrigation. The water used for irrigation may come from farm reservoirs, streams or rivers, and so its microbiological quality may impact on the microbiology of the plant. If the water is sprayed from above, it may deposit micro-organisms on upper external surfaces of the plant. In addition, the 'splash' issue noted with rain may also occur. If the water is drip irrigated onto the soil directly under the plants, then it will not contact upper plant surfaces, and splash is very unlikely.
- Plant/soil nutrition. There has been a move away from the use of artificial fertilisers to the use of natural manures. In its 'fresh state' manure contains faecal organisms from the animal of source, and so its preparation should include a period under suitable conditions to eliminate potential pathogens. Additionally, after adding manure to soils, it is usual to allow a period of time for natural soil bacterial flora to develop before growing produce.
- Demands for year round and 'exotic' fruits and vegetables has resulted in a worldwide sourcing of produce, which means that some items will have been grown in areas where the natural microbiology and/or standards of hygiene may be very different to that at the point of consumption.
- Animals and people. Field growth gives the opportunity for animals to come into contact with the produce. This can result in animal faecal material being deposited onto growing plants. Additionally, much fresh produce is hand picked, so that the hygiene of the pickers is an important issue to consider. Many growers now install field toilets complete with good hand wash facilities to improve hygiene in this area.
- Hydroponics. Some crops are now grown in hydroponic conditions. This considerably reduces contamination issues relating to the environment, but the hygiene of pickers is still important.
- Transportation. Vehicles and containers used for this need to be kept clean and should not be used to transport other items (for example dirty items, agricultural equipment or animals).

These issues may be of reduced importance if the plant or crop is to be cooked before consumption. The cooking process is usually effective at eliminating potentially pathogenic organisms, making the food safe to eat. However, much fresh produce (salad crops and fruits) are eaten in a raw state, and here the presence of contaminating micro-organisms, particularly pathogens, could cause problems for the consumer.

Microbiology

Fresh produce will always have its own natural microflora. It would not be unusual to find total viable counts on ready to eat fresh produce of over 10^6/g. This is perfectly acceptable.

These types of organisms will generally include fluorescent pseudomonads, Enterobacter spp., Klebsiella spp. Serratia spp., Flavobacterium spp., Xanthomonas spp., Chromobacterium spp., Alcaligenes spp. and Leuconostoc spp., and yeast and mould species, including Cryptococcus, Candida, Rhodotorula, Sporobolomyces, Cladosporium, Aureobasidium, Aspergillus, Penicillium, Phoma, Botrytis, Fusarium, Epicoccum and Geotrichum. It should be noted that Enterobacteriaceae form part of the normal flora of plants and their presence on fresh produce should not be looked upon in the same negative way as a high Enterobacteriaceae count on, for example, a ready to eat meat product. The natural flora of fresh produce are an essential part of the plant, indeed some researchers hypothesese that the presence of high levels of generally harmless organisms could help to inhibit the development of possible spoilage organisms or even human pathogens.

Of course, no discussion on fresh produce microbiology would be complete without some discussion of the role of pathogens in these materials.

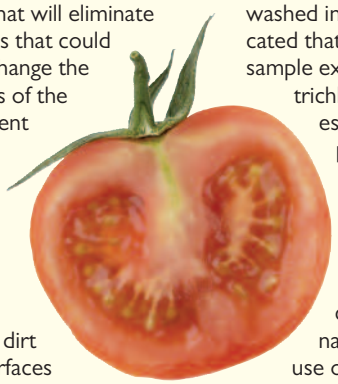
The range and types of pathogens that can be found on fresh produce (see Nguyen-the and Carlin, 2000) include bacterial pathogens: Listeria monocytogenes, Clostridium botulinum, Shigella, E. coli O157:H7, Salmonella, Staphylococcus aureus, Bacillus cereus, Vibrio cholerae, Campylobacter; viral pathogens: Hepatitis A and Norovirus; and Protozoan pathogens: Cryptosporidium parvum, Giardia, Cyclospora cayetanesis. In addition to contamination of the growing plant, seeds may also be contaminated with human pathogens. This can be an issue if the seed is to be eaten directly, or made into a ready to

eat product (for example there have been salmonella contamination issues linked to sesame seed products and to germinated alfalfa seeds).

There have been several well documented outbreaks of illness throughout the world, linked to consumption of raw fruits and vegetables. These include salmonella from lettuce, tomatoes, bean sprouts and melons; E. coli O157:H7 from spinach, radish sprouts and fresh unpasteurised apple juice; listeria and shigella from lettuce; and Clostridium botulinum from vegetable juice.

The conditions in or on some foods would appear to be antagonistic to microbial growth, but survival and consumption of a pathogen is sufficient to cause illness in many cases. Other types of fresh produce offer conditions that allow microbial growth, and this can be a particular problem. Such products require care in setting shelf life, processing and storage conditions.

In the production of ready to eat, raw produce there is no step that will eliminate pathogens. Any process that could do this would usually change the organoleptic properties of the product to such an extent that it would become unacceptable to the consumer. The only way to reduce the microbial load of raw fresh produce is by washing.



Washing will remove dirt and debris from the surfaces of produce, and has some effect at removing surface microflora. Most producers of ready to eat fresh produce add sanitisers to the water used for washing. This reduces microbial load and helps to decrease the risk of pathogen presence in these products. Over recent years there has been much discussion on the use of chlorine in vegetable washing, which has led to considerable research into this and alternative ways of removing microflora from fresh fruits and vegetables.

Washing with chlorine

Until recently, chlorinated water was the most common wash agent used to reduce the microbial load of fresh produce. Sodium hypochlorite, for example, reacts in water to form sodium hydroxide and hypochlorous acid. It is the hypochlorous acid (free chlorine) that is the active biocide and the amount formed is pH-dependent – more hypochlorous acid remains in solution at pH 5 than at pH 7. Too much acid can corrode the washing tanks and so it is best practice to control chlorine solutions at pH 7, where 78% of the hypochlorous acid remains in solution and achieves a good decontamination effect. Some free chlorine can bind with organic matter, rendering it inactive.

It is thought that most of the biocidal activity occurs within the first few minutes of washing and increasing concentration above a few hundred ppm does not increase the biocidal effect. Washing fresh produce in chlorinated water can reduce microbial levels by 10 to 100-fold, as long as the washing is carefully controlled. Washing studies at CCFRA have shown that a 10-fold (1-log) reduction in salmonella, E. coli and listeria levels can be achieved by washing inoculated lettuce in water containing 100ppm free chlorine for five minutes.

Safety of chlorine

Over the last decade there has been increasing concern about the potential formation of harmful by-products such as organochlorine, when fresh produce is washed in chlorinated water. Recently, however, study by the Fresh Prepared Salads Producers Group evaluated the presence of disinfectant by-products on fresh produce washed in chlorinated water. Results indicated that of all the tests done only one sample exceeded the US standard for trichloroacetic acid. The group also estimated intake levels of these compounds based on average and extreme salad consumption and concluded that a 150g bag of salad contains less chlorine compounds than a 250ml glass of tap water and is no cause for concern. Irrespective of this, chlorinated washes are not permitted for use on organic produce and are not permitted for use in certain countries such as Germany and Denmark.

Alternatives to chlorine

Chlorine dioxide is considered a useful alternative to hypochlorite as it is not affected by pH and does not react with organic matter to the same degree as hypochlorite. It can be unstable, however, and requires on-site generation (although liquid forms are now commercially available). Recent studies undertaken by CCFRA have demonstrated that a mean log reduction of 0.9cfu/g and 1.3cfu/g could be achieved when iceberg lettuce or spinach was washed for two minutes in water containing 2-3ppm chlorine dioxide. This reduction was similar to that achieved with a two minute wash in water containing 20ppm free chlorine.

There is also a trend towards the use of organic acids in washing fresh produce. Studies at CCFRA evaluated the efficacy of lactic and acetic acid for the reduction of salmonella on inoculated iceberg lettuce. Washing in lactic acid gave a similar log reduction to that of chlorine washing, with acetic acid giving a slightly higher microbial kill.

Some commercially available wash agents containing mixes of organic acids are currently used to wash fresh produce. Some of these mixes, such as Citrox, Fresh Produce Wash (Drywite), Anti-bac and Aqua-a live are permitted for use on organic produce.

Other techniques being investigated as potential alternatives to chlorine include UV, ultrasound, ozone, irradiation, electrolysed water, peracetic acid, hot water, bio control agents and natural compounds like essential oils. With many of these it is too early to say whether widespread commercial use will ever occur. Sequential washing (washing produce a number of times with the same or different wash agents) is also being studied and may have some added benefits to microbial reduction in some cases.

With any washing system, it is important to ensure proper validation of the method before it is used commercially and that, once adopted, it is properly monitored and controlled. In most cases, with ready to eat fresh produce, the washing step is the only point in the production process where the level of micro-organisms can be controlled and, as such, it is of the greatest importance.

Conclusions

There is no doubt that the consumption of fresh fruits and vegetables is good for a healthy diet. We should understand that, as raw products generally grown in an outside environment, fruits and vegetables will have a large and varied microflora on their outer surfaces and some of these organisms may, on occasion, be human pathogens.

Good agricultural practices should help reduce instances of pathogen contamination on fresh produce and this, combined with good washing practices and appropriate chilled storage, will result in the production of a healthy, nutritious and safe product. ■

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