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Quality Maintenance and Food Safety of Fresh-cut Produce in Korea

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ABSTRACT

In Korea, the fresh-cut produce market reached approximately US $1.1 billion in 2006. The increase in consumption of fresh-cut produce was brought about by an expanded number of retail markets over the last 5 years. As retail consumption increases, the Korean fresh-cut industry's challenge to ensure food safety and quality likewise increases. Researches pertaining to fresh-cut processing technology have focused on mainly delaying quality changes and inhibiting microbial activities. Current techniques that retard browning are mainly exposure to low temperature, peeling by hydraulic means, and vacuum packaging. Vacuum packaging induces too high CO_2 and low O_2 levels which may cause off-odor development and growth of anaerobic bacteria during retail distribution. Modified atmosphere (MA) packaging using films with different oxygen transmission rates (OTR), including porous films have just started for application to fresh-cut produce. Chlorine is still widely used as a sanitizer in reducing microbial contamination. However, the Korean fresh-cut industry is not only concerned about searching for more effective sanitizers but also environmental friendly washing methods. Electrolyzed, ozonated, and hot water, or combinations of known washing techniques have been applied to the fresh-cut industry. Further practical research on washing and packaging technology is required to improve quality and food safety of fresh-cut products.

Keywords: fresh-cut market, MA packaging, microbial quality, postharvest technology, sanitizing

Abbreviations: EW, Electrolyzed water; **KFDA**, Korea Food and Drug Administration; **KFPA**, Korea Fresh-cut Produce Association; **MA**, Modified atmosphere; **NHRI**, National Horticultural Research Institute; **OTR**, Oxygen Transmission Rate; **PE**, polyethylene; **TPC**, Total Plate Count

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INTRODUCTION

The fresh-cut fruit and vegetable industry has been growing rapidly since the last decade, due to the freshness and convenience in Korea. Initially, the food service industry for school meals and restaurants was the main user of fresh-cut products, but the consumption has expanded to retail markets since the early 2000s (Kim 2005; KFPA 2006). Fresh-cuts are generally more perishable because they have been subjected to severe physical stress, such as peeling, cutting, slicing, and shredding. Therefore, fresh-cut produce has a shorter shelf-life compared to intact produce. Short shelf-life of fresh-cut produce was not much of a problem in Korea due to its rapid consumption at food service areas. Recently, Korean consumers carefully consider food safety and quality of fresh-cut produce with prime importance. Therefore, the fresh-cut industry is faced with challenges to process and distribute products that are considered fresh, sanitized, and without any defects.

Many Korean fresh-cut processors used conventional technology until late 1990s. Lately, most processors have been adopting better technologies and facilities to produce

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safe products as demanded by consumers. Korea Fresh-cut Produce Association (KFPA) was founded in 2005 as initiated by fresh-cut processors based on mutual interests. The foundation of KFPA promoted adoption of modern technology for fresh-cut processing in terms of technology exchange and acquiring new information.

Fresh-cut processing technology in Korea has focused much on inhibiting quality deterioration such as browning and off-odor development in fresh-cut products. Current industrial techniques that delay browning in fresh-cut produce are low temperature, hydraulic peeling of potato, and vacuum packaging methods. Application of modified atmosphere (MA) packaging technique using different oxygen transmission rate (OTR) film and gas flushing with nitrogen has been used to maintain quality of fresh-cut produce for retail market. Recently, the Korean fresh-cut industry is trying to find a more effective sanitizer tolerable for commercial processing conditions. The industry is also searching for alternative environmental-friendly sanitizing methods to increase market value of fresh-cut produce.

Fresh-cut produce in retail market can be considered as not yet firmly established in Korea although consumers are interested in fresh-cut items. The fresh-cut market is expected to grow continuously in Korea unless products are not considered as doubtful foods by consumers. Therefore, the need to develop acceptable processing techniques for food safety becomes a must in order to come up with a more profitable fresh-cut industry in Korea.

FRESH-CUT MARKET AND INDUSTRY

In Korea, the fresh-cut produce market reached approximately $1.1 billion in 2006, up from $ 530 million in 2003 (KFPA 2006). Fresh-cut vegetable which is a major item made up to 75.4 % of the total processing amount in 2005. Although consumption of salads made from iceberg lettuce, cabbage, etc. increased, ready-to-cook vegetables such as onion, garlic, and potato are the more popular fresh-cut products in Korea (**Table 1**).

Fresh-cut vegetables continue to dominate other fresh-cut items in the fresh-cut produce category. However, the fresh-cut fruit sector is likewise growing fast just like in the USA, UK, and Japan (Kim and Jung 2006). There were 102 companies involved in processing of fresh-cut produce in Korea according to 2006 survey. Out of 102, 85 companies were producing fresh-cut vegetables, including wild vegetables, while the other 17 were producing fresh-cut fruits and mushrooms (KFPA 2006).

At present, Korea has fast growing fresh-cut markets with a wide variety of products in the retail segment. The fresh-cut fruit industry has enjoyed double digit growth rates since the second millennium. Fresh-cut vegetable market has also expanded a lot since Korean consumers enjoy salads at their table. It is expected that growth in terms of consumption of fresh-cut produce will continue to flourish in the near future in Korea. However, Korean fresh-cut industry cannot depend on past successes to continue growth because of new challenges.

QUALITY MAINTENANCE OF FRESH-CUT PRODUCE

Postharvest technology of law materials for fresh-cut produce

Quality of fresh-cut produce depends mainly on the quality of the intact product and its maintenance between harvest and preparation of the fresh-cut products, processing method, and subsequent handling conditions (Vilas-Boas and Kader 2001). Korean fresh-cut processors have just recognized the importance of postharvest technology of raw materials. They are aware that raw materials affect shelf-life of fresh-cut produce. Some of them have used pre-cooling system to ensure freshness of intact leafy vegetables (Kim 2007b). In general, leafy vegetables senesce rapidly compared to fruit vegetables and root vegetables (Able *et al*. 2003). Fresh-cut processing of leafy vegetables presents unique postharvest problems due to the detachment of leaf from the whole plant. Therefore, leafy vegetable used for fresh-cut produce is handled with more postharvest care compared to other intact vegetables which are used for fresh-cut produce.

Study on effect of intact materials on the shelf-life of fresh-cut iceberg lettuce was carried out to investigate cultivation method and harvest season on the shelf-life of fresh-cut iceberg lettuce (**Table 2**). Iceberg lettuce as fresh-cut product resulted in different length (2-6 days) in shelf-life among different intact materials cultivated under different environment and harvested in different seasons (Kim 2007c). Iceberg lettuce (cultivar; *Sacramento*) harvested in winter has less respiration rate compared to lettuce harvested in summer and fall (cultivar; *U-lake*). Therefore, different MA packaging films are needed for fresh-cut iceberg lettuces based on the respiration rate and postharvest physiology of raw materials. Respiration rate of mushroom (*Agaricus bisporus* Sing.) harvested in summer and autumn was lower than mushrooms picked in spring and winter. Summer-harvest mushrooms and mushrooms kept at 2°C for more than 7 days after harvest were unsuitable for fresh-cut processing due to rapid browning (Lim *et al*. 2004).

Technologies to delay browning of fresh-cut produce

One of the major defects of fresh-cut produce is the browning of cut pieces. Peeled and cubed fresh-cut potato is one of the major ready-to-cook fresh-cut products in Korea though it is very sensitive to browning after mechanical wounding. Heat treatment as physical means to inhibit browning has been studied since Korean consumers have

Table 1 Proportion of fresh-cut produce category based on processing amount of raw materials for fresh-cut processing in Korea in 2005.

Total	Vegetables			Fruits	Wild vegetables	Mushroom
(%)	Sub total	Salad	Ready to cook			
100	75.4	33.3	42.1	15.6	8.7	0.3

From KFPA (2006)

Table 2 Microbial population and shelf-life of fresh-cut iceberg lettuce processed from various raw materials, packaged in 80 µm Ny/PE film and stored at 5°C.

Harvest time	Cultivar	Cultivation	Total plate count (Log CFU/g)		Deterioration factors	Shelf-life (days)
			Day 0	Day 8		
April 8	Sacramento	Green house	3.7	5.0	Off-odor	12
June 10	U-lake	Green house	3.8	5.4	Off-odor	10
July 7	U-lake	Field	4.0	5.9	Off-odor	8
August 18	U-lake	Field	4.5	6.0	Off-odor	8
Oct. 12	Sacramento	Field	4.1	5.7	Off-odor	8
Jan. 8	Sacramento	Green house	3.2	5.2	Browning	6

Data from KFPA (2006)

Table 3 Effect of heat treatment (30°C for 1 day) before peeling on gas composition and quality of peeled potato stored at 28°C for 24 hours.

Treatment	Gas composition (kPa)		Color		Off-odor
	O_2	CO_2	Redness (a)	Yellowness (b)	
Control	0.67 b	34.7 a	- 2.14 a	14.2 a	3.2 a
Heat treatment	2.74 a	16.8 b	- 2.44 a	14.4 a	1.7 b

[z] 0 = none, 1 = slight, 2 = moderate, 3 = severe, 4 = strong
Data from KFPA (2006)

Table 4 Proportion of sanitizers based on the number of fresh-cut processing company used for fresh-cut industry in Korea in 2007.

Total (%)	Chlorine (Cl)	Electrolyzed water	Ozonated water (O_3)	Combination of Cl and O_3	No sanitizer	Others
100	56.2	15.6	9.4	3.1	9.4	6.3

Data from KFPA (2006)

Table 5 Gas composition and quality of fresh-cut iceberg lettuce washed in different sanitizers and stored at 10°C for 6 days.

Treatment	Gas composition (kPa)		Total plate count (Log CFU/g)	Off-odor[z]	Discoloration[z]
	O_2	CO_2			
Sodium hypochlorite	0	25.8 b	7.0 a	3.3 b	0.5 b
Weak alkaline EW	0	31.2 a	7.3 a	3.8 a	1.8 a
Strong acidic EW	0	23.8 b	7.1 a	2.7 c	0.7 b

[z] 0 = none, 1 = slight, 2 = moderate, 3 = severe, 4 = strong
Data from KFPA (2006)

preference for non chemical methods. Potato (cv. 'Jopung') placed at 30°C condition for 1 day before peeling was beneficial in reducing CO_2 concentration resulting in less off-odor accumulation in peeled potato when vacuum packed (**Table 3**). Lim *et al*. (2005) also reported that mild heat treatment of potato (cv. 'Sumi') cubes that was dipped in water at 55°C for 45 seconds after cutting showed positive effect on browning inhibition and quality improvement of cubed fresh-cut potatoes. Korean fresh-cut potato industry has been adopting heat treatments. In onions, the quality of fresh-cut products is influenced by hot water treatment. Hong *et al*. (2004) reported that peeled onion (*Allium cepa* L.) dipped in hot water at 60°C for 1 min maintained good visual quality with a higher sensorial score.

Technologies on natural anti-browning treatments have been studied to delay browning of fresh-cut produce. Natural licorice extracts with ascorbic acid were effective anti-browning agents for maintaining quality of fresh-cut potatoes (Hwang and Moon 2006). Various natural materials were treated to investigate the effect as browning inhibitors. Ryu *et al*. (2003) reported that asparagi radix and cassia extracts could be alternatives to preventing browning on fresh-cut mushrooms instead of chemical browning inhibitors containing 1% cystene or 1% ascorbic acid. However, natural anti-browning agents are still not used in the Korean fresh-cut industry.

Korean fresh-cut potato industry has started to use new equipment called hydraulic peeler, recently developed in Korea. The equipment is effective in delaying quality changes of fresh-cut potatoes. Potatoes are peeled by knives installed inside the peeling machine as potatoes are immersed in rotating water. Peeling potatoes under water delayed time to browning compared to peeling potatoes under normal conditions (Kim 2007b).

SANITIZING TECHNOLOGY

Sanitizers in the Korean fresh-cut industry

In Korea, chlorine is the most popular sanitizer that control microbial contamination of fresh-cut produce. About 56% of fresh-cut processing companies use chlorine (Kim 2007a) and popular initial chlorine concentration is 50-100 mg/L (KFPA 2006). Electrolyzed, ozonated, and hot water, or the combination of those sanitizing methods has been applied to the fresh-cut industry. Electrolyzed water (EW) is the second most popular sanitizer in Korea. About 16% of fresh-cut companies are using EW in Korea (**Table 4**).

Ozone is one of potent sanitizer that can be used in fresh-cut industry. Ozonated water is effective against the majority of microorganisms tested by many experiments. Fresh-cut carrots washed for 20 min in ozonated water (initial ozone concentration; 2 ppm) had better vegetable quality and smaller microbial counts compared to samples washed in chlorine water (Kim *et al*. 2007b). Ozonated water or the combination of ozone and chlorine has been used by some fresh-cut processors to reduce microbial contamination. However, ozonated water does not affect microbial decontamination compared to EW or chlorine in Korean industry because ozone concentration that the fresh-cut processors use is too low to affect disinfection of fresh-cut produce. Using EW to sanitize fresh-cut produce appears to be more potent than ozonated water. Although the use of EW has increased, there is a contrasting opinion on the efficiency of EW among Korean fresh-cut processors.

Electrolyzed water (EW)

Strong acidic EW (pH 2.7) and weak acidic EW (pH 5-6.5), which were generated by electrolysis of NaCl solution and HCl, respectively have been used as disinfectant in Korean fresh-cut industry. Weak alkaline EW (pH 7.5-8) from non-diaphragm EW generator, recently developed in Korea is getting popular among three types of EW.

In general, strong acidic EW had stronger bactericidal effect compared to alkaline EW which has very high pH levels. However, strong acidic EW can cause tissue damage in some fresh-cut produce during storage or distribution. Little information exists on the efficacy of weak alkaline EW on quality and microbial reduction in fresh-cut produce.

The effect of strong acidic and weak alkaline EW containing 80 ppm available chlorine as well as sodium hypochlorite on storage quality and microbial growth of fresh-cut iceberg lettuce has been studied (**Table 5**). The effectiveness of strong acidic EW on microbial reduction was greater than weak alkaline EW at initial storage. However, strong acidic EW affected quality deterioration due to texture damage after 6 days at 10°C. Weak alkaline EW reduced off-odor development and was as effective as chlorine in inhibiting total aerobic bacterial and coliform group on fresh-cut iceberg lettuces (cultivar; *U-lake*). Fresh-cut sesame leaves washed in weak alkaline and neutral EW had less total plate counts and better sensorial quality compared to samples washed in control and acidic EW (Jeong *et al*. 2005). Jeong *et al*. (2006) also reported that acid EW (pH 2.53, 80 ppm HClO) and weak alkaline EW (pH 8.37, 105 ppm HClO) were effective in maintaining quality of washed strawberries (harvested in Buyeo) compared to chlorine (pH 10.9, 105 ppm HClO). On the contrary, Kim *et al*. (2007a) reported that microbial quality of strawberry (cultivar;

Maehyang) washed in weak alkaline EW (pH 8.0, 80 ppm HClO) was inferior compared to samples washed in chlorine (pH 6.5, 80 ppm HClO). These results indicated that EW does not affect quality maintenance and microbial safety of all fresh-cut products. However, weak alkaline EW could be an effective alternative to chlorine for washing fresh-cut leafy vegetables. Using weak alkaline EW to disinfect fresh-cut produce appears to be more potent than strong acidic EW.

Natural antimicrobial agents

Additions to EW, natural antimicrobial agents derived from fruit, herb, and shell have been investigated as preservatives. No fresh-cut company have used natural antimicrobial agent to wash or preserve fresh-cut produce in Korea due to less effects than chemical sanitizers and non-economic efficiency. However, natural agents are good candidate in Korea to replace tap-water washing because these agents have more potency against microorganisms. Natural agents can be used for washing microgreens and organic fresh-cut produce which are sold at a higher price.

Two natural antimicrobial agents, 0.2% Japanese apricot extract compound and 0.15% calcined calcium have been tested in fresh-cut produce. The Japanese apricot extract applied on fresh-cut melon and iceberg lettuce reduced total microbial counts by 0.5 and 0.9 logs, respectively on initial day as compared to tap water. Calcined calcium agent applied on fresh-cut melon reduced total microbial counts by 0.3 and 0.6 log CFU/g on initial day as compared to tap water and unwashed samples, respectively (Kim 2007b). In Japan, Izumi (2007) also reported that 0.05% calcined calcium agent (91% of calcium) on fresh-cut cucumber reduced the microbial counts by 0.3 to 1.5 log CFU/g as compared to water dipped control. Further studies are needed to determine the effectiveness of natural antimicrobial agents to control microbial quality of microgreens which are getting popular among fresh-cut items in Korea.

PACKAGING TECHNOLOGY

Packaging materials and problems

Flexible packaging film is still widely used to pack fresh-cut produce for food services in Korea (KFPA 2006). In general, fresh-cut produce for food service such as restaurants and school meals are vacuum-packed in Korea. Even vacuum packaging with low OTR film has also been used to pack fresh-cut produce for retail market. However, some quality problems have been found in fresh-cut produce when vacuum packed and distributed in the retail market.

Vacuum packaging is still the most popular packaging method for ready-to-cook vegetables such as peeled potato and onion slice (KFPA 2006). Vacuum packaging creates high CO_2 and low O_2 levels to control browning of fresh-cut produce, however, these conditions may induce accumulation of watery substance and may develop off-odor during distribution. In Korea, peeled potato is vacuum packed to delay browning. However, strong off-odor is often detected as consumers open the bag especially during summer (Kim *et al.* 2006).

MA packaging and rigid containers

MA packaging using different OTR film and micro-perforated film has started to be applied to fresh-cut produce in Korea. Proper MA package design that provides optimum range of O_2 and CO_2 partial pressures is one of the major challenges that should be given considerable attention since they found information that different fruits and vegetables have unique tolerance limits to low O_2 and high CO_2. Studies that investigate optimum MA packaging for fresh-cut leafy vegetables with the influence of initial O_2 concentration, OTR of different package films, and delayed packaging time have been conducted. Results that low initial headspace O_2 concentrations may not always be optimal (Kim *et al.* 2005b) and delayed MA packaging can be an alternative method to reduce off-odor of fresh-cut lettuce (Kim *et al.* 2005a) have been adopted to the industry. Studies on optimum packaging film of fresh-cut green onion were carried out. Hong *et al.* (2000) reported that visual sensory quality of fresh-cut green onion (10 cm cut) was better in polyethylene (PE) film bags of 63 μm thickness (600 O_2 ml/day·m^2·atm; 2,500 CO_2 ml/day·m^2·atm) than in other low thickness films. Better PE packaging film for fresh-cut green onion cut into 0.8 cm length was 50 μm thick film (Kim *et al.* 2006c).

There is also a demand for convenient packaging of fresh-cut produce. Rigid fresh-cut produce container for retail market has increased since the packaging provides excellent protection from physical damage during transport. About 81% of fresh-cut salads, 22% of ready-to-cook vegetables, and 47% of fresh-cut fruits are packaged in rigid tray containers (Kim 2007a). Rigid tray used as actual serving vessel for the consumer is increasing in Korea. Rigid tray with flexible lid to wrap or seal fresh-cut produce is more and more gaining popularity as packaging method utilized by many Korean fresh-cut producers. Further practical research on packaging techniques is required to develop optimum MA packaging for individual fresh-cut products.

MONITORING OF MICROBIAL CONTAMINATIONS

Environmental monitoring

Well-designed and operated processing facilities can contribute to the reduction of microbial contamination of fresh-cut produce. A few fresh-cut processors have started to have environmental monitoring program to detect areas of pathogen harborage and to verify the effectiveness of cleaning and sanitizing programs in preventing cross-contamination. They perform environmental sampling on both food contact and non-food contact surfaces (e.g., floors, drains, doors, employee break rooms, bathrooms, etc) periodically. The monitoring program is designed to detect areas of pathogen harborage and to verify the effectiveness of cleaning and sanitizing programs in preventing cross-contamination. Fresh-cut processors regularly inspect tools for cutting, slicing, and shredding for damage that could impair sanitizing. They also consider ensuring sanitation of components such as packaging materials and containers that are necessary for safe finished product. Airborne microorganisms in fresh-cut processing plant were evaluated. Total plate counts (TPC) for floating, falling, and equipments such as cutting board and conveyors were 10^2-10^3 CFU/m^3, ~10^1 CFU/plate, and ~10^4 CFU/cm^2, respectively (Seo *et al.* 2007).

Monitoring of raw materials and processing steps

Microbial population of intact and fresh-cut produce was monitored to assess microbial safety throughout the year in Korea. In general, population of aerobic bacteria in intact iceberg lettuce was 1.5-6.7 log CFU/g (Kim 2007d). There was a difference in TPC between field and greenhouse culture or among harvest seasons. The initial TPC and coliform/*E. coli* counts in fresh-cut iceberg lettuce were 1.2-3.6 and 0.5-1.8 log CFU/g, respectively. TPC and coliform/*E. coli* counts of fresh-cut produce stored for 9 days at 5°C increased up to 4.2-6.3 log CFU/g.

Appropriate processing step without microbial risk helps minimize microbial hazards of fresh-cut produce. Some fresh-cut produce processors have started to find the cause of microbial hazards in the processing steps. They have programs that monitor microbial population of their fresh-cut produce at each processing step.

Two fresh-cut processors monitored total plate count and coliform group in intact and fresh-cut iceberg lettuce in terms of processing stage (**Fig. 1**). Microbial populations dramatically increased at stage 3, after 1st washing and at

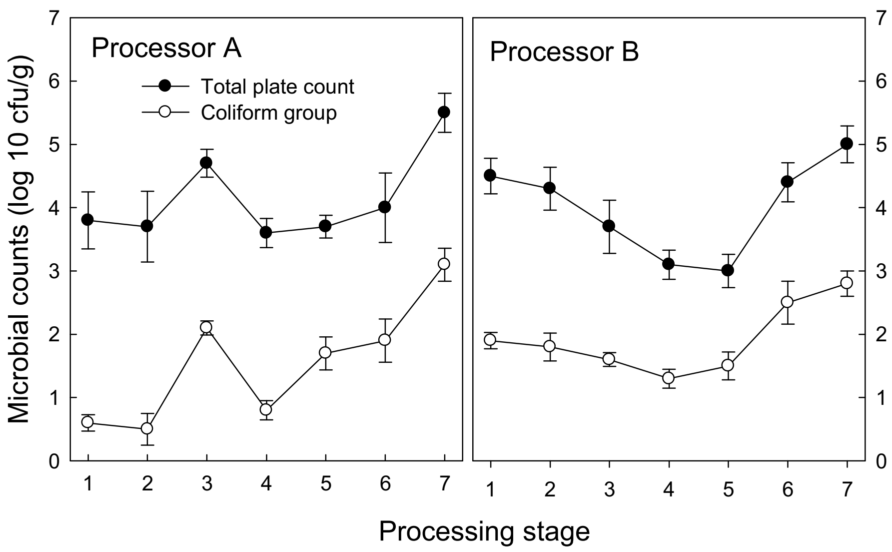

Fig. 1 Example of monitoring on microbial counts of intact and fresh-cut iceberg lettuce processed and distributed by two fresh-cut processors. The processing stage is as follows; 1 = raw material, 2 = cutting, 3 = 1st washing, 4 = 2nd washing (sanitation with chlorine), 5 = 3rd washing, 6 = centrifugal dehydration, and 7 = 1 day after packaging. Data from KFPA 2006.

Table 6 Limits for the microbiological quality of ready-to-eat fresh-cut salads in Korea.

Microorganism	***E. coli***	***S. aureus***	***Salmonella* spp.**	***Vibrio para-haemolyticus***	***Bacillus cereus***
Microbiological limits (cfu/g)	Not detected	< 100	Not detected	Not detected	< 1,000

[z] 0 = none, 1 = slight, 2 = moderate, 3 = severe, 4 = strong
Data from KFPA 2006.

stage 7, 1 day after packaging in samples processed in processor A. The cause of elevated microbial population at stage 3 was attributed to microbial contamination of processing water from underground source. Microbial population increased dramatically at stage 7 because required temperature was unstable while fresh-cut produce was distributed. Processor B had no serious problem with their processing step until stage 5. But, at stage 6 after centrifugal dehydration microbial population of the samples increased dramatically. The cause was due to contaminated centrifugal dryer. The company could reduce microbes after cleaning and sanitizing the dryer.

PROGRAMS FOR QUALITY AND FOOD SAFETY

Programs for growth of fresh-cut industry

The definition and scope of fresh-cut produce was determined through the cooperation with the National Horticultural Research Institute (NHRI) and the Korea Fresh-cut Produce Association (KFPA) to meet new circumstances in 2006. NHRI and KFPA are planning to establish standard manuals as guide to improve food quality and safety of fresh-cut produce. National research projects on shelf-life determination, standard food safety guide, rapid detection of microorganism, etc that involve cooperation with fresh-cut industry, university, and research institute are being conducted.

Food safety has become a big issue with an increasing fresh-cut consumption in retail market in Korea. Education program on fresh-cut processing technology to industrial processors/members has been established by KFPA. In Korea, there are mainly two consumer groups. One is willing to consume fresh-cut produce. But, the other does not buy fresh-cut produce because they think fresh-cut is not safe. Even some of the former group wash or rinse the fresh-cut produce at home after they buy. Consumers are demanding completely safe fresh-cut produce with high quality. They want distinguished fresh-cut products that are safe and good for health from other products which may be unsafe. KFPA is considering a certification program that gives recognition to high quality and safe fresh-cut produce in the near future.

Microbiological limits for fresh-cut produce

In Korea, there is heightened awareness of food safety as well as in USA and Europe. Food safety of fresh-cut produce is inspected while it is being sold by the Korea Food and Drug Administration (KFDA) or consumer associations at retail outlets in Korea. Safety concern was brought about by the detection of microorganisms that may cause food poisoning in fresh-cut produce. In order to meet growing consumer's demand for food safety, KFDA notified microbiological safety limits for ready-to-eat fresh-cut produce in 2007 and it has been being practiced starting 2008. According to the notification, fresh-cut produce should be free from *E. coli*, *Vibrio parahaemolyticus*, and *Salmonella* (**Table 6**). Level of microbial limit on *E. coli* which is acceptable level in ready-to-eat fresh-cut produce is 20-100/g in UK (Gilbert 2000) and Hong Kong (Food and Environmental Hygiene Department 2003). There is an opinion that microbial quality standard requiring a zero level of *E. coli* is unattainable and too strict to follow. NHRI and KFPA are planning to set up guidelines that include determining acceptable limits for mesophilic aerobic bacteria in ready-to-cook fresh-cut produce to control microbiological quality. Guidelines can be applied to determine microbiological quality limits before the stage of shipping until final distribution.

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