5.0 Minimally Processed Vegetables Food Safety Risk Assessment

DRAFT

Food Inspection Branch
Food Industry Division
Ontario Ministry of Agriculture and Food

5.0 Minimally Processed Vegetable Food Safety Risk Assessment

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
Pre-Processing ***Facility Location and Design*** This stage considers issues relating to the location and design of a minimally processed vegetable processing facility that contribute to the production of a safe food product.	**Biological** Concern that poorly located and designed processing facility increases the risk of product becoming contaminated with foodborne pathogens (166). Foodborne outbreaks of *E. coli*, *Listeria*, *Salmonella* and *Shigella* have been linked to minimally processed vegetables (MPV) (168, 169, 170, 171, 172). See Appendix A for selected outbreaks and Appendix B for a list of pathogens known to contaminate foods of plant origin. Hazards associated with plant location include proximity to animal agriculture, locations subject to flooding, environmentally contaminated locations, sites prone to infestation of pests and areas where waste is difficult to remove (166). Hazards in facility design include for example; storage of incoming raw product and outgoing finished product in the same area, poor waste and water management, and considerations related to process flow and materials used in construction.	Nglg-Med Although at this stage no product has been received, poor facility location, design and/or construction increase the probability that minimally processed vegetables will become contaminated. Food safety risks related to process flow are discussed at each stage or activity of production. Previous contamination has occurred where the location of a facility is adjacent to animal agriculture (173).	Nglg-Med Although at this stage no product has been received, poor facility location, design and/or construction increase the probability that minimally processed vegetables will become contaminated leading to potential consumer exposure. While many practices to reduce and eliminate potential pathogens are commonly practiced during production of minimally processed vegetables, poor facility location, design and/or construction can impede good practices increasing the probability of consumer exposure.	Low Some foodborne pathogens are easily transmitted directly by person to person, or by the fecal to oral route (9, 10, 21). If infection occurs, secondary spread among humans can also occur (9, 22, 23, 44). While primary exposure may be broadly distributed, secondary spread is expected to be local.

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			Uncertainty of Data	Summary of Risk and Uncertainty	
on human health	economic	environment			
Low-High If infection occurs the impact is variable depending on the pathogen and the individual (9). The young, elderly and immuno-compromised are at greater risk (21). Symptoms are variable from mild diarrhea and upset stomach to extreme cases where death may occur (9, 11, 24, 25, 44).	Low-Med Direct healthcare costs vary with pathogen virulence, individual susceptibility, and size of outbreak (2). If an outbreak is traced back to a specific company or industry, the indirect economic impact could be high (23, 26, 27, 28).	Nglg Although no specific studies are known, the presence of biological hazards in food crops is expected to have negligible impact on the environment.	Low It is known that poor processing facility location, design and construction can lead to an increased probability of product contamination (166, 167, 176).	**Nglg-Med** A large range of risk can be attributed to facility location and design. Where good facility location and design are used the overall risk is expected to be very low, while a poor location and design can lead to significant contamination, consumer exposure and a range of impacts.	To reduce risk: Locate, design and construct the processing facility to minimize the potential for product contamination with foodborne pathogens. Consider existing recommendations, codes of practice and food safety guidelines (5, 166, 167, 175). HACCP Materials used in construction should be durable, easy to maintain, clean and disinfect (166).

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Pre-Processing ***Facility Location and Design*** This stage considers issues relating to the location and design of a minimally processed vegetable processing facility that contribute to the production of a safe food product.	**Chemical** Concern that a poorly located and designed processing facility will increase the risk of food products becoming contaminated with chemicals (166). Previously identified hazards relating to plant location include areas subject to flooding and environmentally contaminated areas (166). Chemical hazards in facility design include improper storage, handling and mixing areas for chemicals and poorly designed ventilation and drainage systems. Concern that if materials used for food contact surfaces are not food grade leaching of chemicals into the food could occur.	Nglg-Low Although at this stage no product has been received, poor choice of location, facility design, or materials used in construction may increase the risk of chemical contamination. Where storage of chemical products is not adequate, o were food contact surfaces are made of non-food grade materials, chemical contamination could occur. Regulations are in place, which govern the use of materials approved for food contact surfaces (64).	Nglg-Low If product becomes contaminated consumer exposure could occur. The probability of significant consumer exposure varies with the toxicity and persistence of the chemical and the individual affected (39, 40, 44). Extensive washing, rinsing and processing of the raw product reduce the probability of consumer exposure.	Nglg Chemicals are not conducive to secondary spread among humans.

Risk Characterization			Risk Summary		Recommendations for Action
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Nglg-Med Chemicals are very rarely found on produce in high enough concentrations to cause acute health effects. Although the effects of long term exposure to many chemicals are not well known, there is evidence that exposure to certain chemicals over a long period of time can cause numerous health effects including cancer (35, 36, 39, 40, 41, 42).	Low Direct healthcare costs vary with the level and extent of contamination and exposure. If contamination is traced back to a specific company or industry the economic impact to that company or industry could be significant (43).	Nglg At the levels at which chemicals are found in seed, the impact on the environment would be negligible.	Low No specific concerns have been noted in minimally processed vegetable products ready for consumption. Chemicals present in food are not usually found at harmful levels (35, 36, 40).	**Nglg-Low** The probability of contamination and exposure are quite low. If exposed, the impact is likely to be mainly low. There is a lack of previous incidences.	To reduce risk: Chemical storage, handling, mixing and usage should be considered in the design and construction of the processing facility. Materials used in construction should be durable, easy to maintain and clean, and all food contact surfaces should be made of food grade material (64, 166). Consult available resources for recommended processing plant design and construction to minimize potential chemical contamination of food products (166, 167).

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Pre-Processing ***Facility Location and Design*** This stage considers issues relating to the location and design of a minimally processed vegetable processing facility that contribute to the production of a safe food product.	**Physical** Concern that a poorly located and designed processing facility will increase the risk of food products becoming contaminated with extraneous physical materials such as metal, wood, glass or plastic etc. Physical hazards in food are known to cause injury (47, 48, 49). See Appendix C for a list of physical material hazards.	Nglg-Low Although expected to be mainly negligible, there is some potential for physical materials to contaminate food products from the use of improper materials in construction and from poor plant design such as unprotected lights above processing and packaging operations. Improperly designed or maintained processing equipment may also lead to physical contamination with pieces of metal or plastic.	Nglg-Low Physical materials are not likely to be incorporated into minimally processed vegetables. Cleaning and rinsing processes prior to and during production reduce the likelihood of contaminated product being packaged and causing consumer exposure. Where metal detection systems are employed potential exposure is minimized. Many minimally processed products are also rinsed prior to consumption further reducing the probability of consumer exposure.	Nglg Physical hazards are not conducive to secondary spread.

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Nglg-Med If contamination occurs the impact is variable depending on the physical hazard and the individual. Physical hazards are known to cause injury (47, 48, 49).	Nglg-Low If contamination and exposure occur, the economic impact is variable but mainly negligible. The impact depends on the type and extent of physical contamination and the product, company and industry involved. When contamination is traced back to a specific company and product the economic impact may be greater for that company or industry.	Nglg Although no specific studies are known, the impact of physical hazards in any food on the environment is considered negligible.	Nglg-Low No specific cases of physical hazards relating to minimally processed vegetables have been previously identified.	**Nglg** The risk of product becoming contaminated and consumer exposure occurring is mainly negligible. The potential impacts of exposure are variable but mainly very low. With few previous incidences known, the overall risk is considered to be mainly negligible. Where a very poor location, plant design and materials are used, the risk is increased.	Materials used in construction should be durable, easy to maintain and clean, and all food contact surfaces should be made of food grade material (64, 166). Consult available resources for recommended processing plant design and construction to minimize potential physical contamination of food products (166, 167, 175).

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Pre-Processing ***Receiving and Storage*** This includes the activities involved in transferring product from the transport vehicle to the processing plant, inspection of incoming product and storage. Incoming product may be raw or previously minimally processed. Once received, product is stored at a temperature and humidity to maintain optimum quality.	**Biological** Concern that incoming vegetable products are contaminated or become contaminated with foodborne pathogens during receiving, inspection and storage. Concern that product becomes contaminated from contact with employees or from the environment where product is received and stored including, surfaces, equipment, pests and air (dust) for example. Foodborne outbreaks of *E. coli*, *Listeria*, *Salmonella* and *Shigella* have been linked to minimally processed vegetables (MPV) (168, 169, 170, 171, 172). A few pathogens such as *Listeria* are able to grow in a storage environment. See Appendix A for selected outbreaks and Appendix B for a list of pathogens known to contaminate foods of plant origin.	Nglg-Low Incoming vegetable products are commonly containerized or packaged which helps to protect them from contact with equipment, surfaces and employees. Minor quantities of product may be contacted during the inspection process. Where bulk product is delivered or reusable containers are used some contact with equipment, surfaces and employees may occur, resulting in potential contamination. Employees can contaminate produce through contact (31, 50, 55). There is minimal opportunity for pests to contact product once in storage.	Nglg-Low If contaminated there is some potential for infiltration and survival of pathogens resulting in potential exposure (7, 55, 145, 153). Vegetables have a pH which supports the growth of pathogenic microorganisms (55, 56). Cold chain management reduces the potential for pathogen growth, and washing, rinsing and processing reduce contamination, minimizing the probability of consumer exposure (7, 19, 55, 66). While most pathogens do not grow well at low temperatures, *Listeria* is able to grow at storage temperatures used for fresh produce.	Low Some foodborne pathogens are easily transmitted directly by person to person, or by the fecal to oral route (9, 10, 21). If infection occurs, secondary spread among humans can also occur (9, 22, 23, 44). While primary exposure may be broadly distributed, secondary spread is expected to be local.

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Low-High If infection occurs the impact is variable depending on the pathogen and the individual (9). The young, elderly and immuno-compromised are at greater risk (21). Symptoms are variable from mild diarrhea and upset stomach to extreme cases where death may occur (9, 11, 24, 25, 44).	Low-Med Direct healthcare costs vary with pathogen virulence, individual susceptibility, and size of outbreak (2). If an outbreak is traced back to a specific company or industry, the indirect economic impact could be high (23, 26, 27, 28).	Nglg Although no specific studies are known, the presence of biological hazards in food crops is expected to have negligible impact on the environment.	Low Although no specific incidences are associated with receiving vegetable product, previous biological contamination of minimally processed vegetables has been documented (168, 169, 170, 171, 172). Although employee handling of product is usually minimal at this stage, a number of outbreaks have been traced back to infectious food handlers as the source of contamination (50).	**Nglg-Low** During the receiving process the probability of contamination is mainly low. With many future steps that reduce or eliminate potential pathogens the probability of consumer exposure is very low. While the impacts are variable and there is some uncertainty the overall risk is expected to be very low.	To reduce risk: Implement GMPs, SOPs and SSOPs (166, 167, 175, 177). Maintain, clean and sanitize all equipment and clean and sanitize all surfaces that may contact the minimally processed vegetables. Test incoming product for contamination. Work with vendors to develop a plan of expected GAPs to be used and set quality and microbial contamination standards for incoming product (167). Consider use of vendor certification programs, letters of "Food Guarantee", or third party audits (167). Ensure incoming product temperature is appropriate and that product is properly containerized to minimize potential contact with surfaces, equipment and employees. Employees should follow and have training in sanitary and hygienic food handling practices (5, 50, 58, 59, 60). Continue "cold chain management" of product. Received product not utilized immediately should be put into storage.

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Pre-Processing ***Receiving and Storage*** This includes the activities involved in transferring product from the transport vehicle to the processing plant, inspection of incoming product and storage. Incoming product may be raw or previously minimally processed. Once received, product is stored at a temperature and humidity to maintain optimum quality.	**Chemical** There is concern that incoming raw or minimally processed products could be chemically contaminated or become contaminated from climate control equipment or from contact with contaminated surfaces or packaging materials. In addition, there is concern about the potential for contamination from chemicals used to clean and sanitize receiving and storage facilities and handling equipment. While testing has shown that the level of chemicals in food is generally quite low, it has been suggested that foods are a source of exposure to chemicals (35, 36).	Nglg There is a very low probability that incoming product is contaminated. Contamination is unlikely during receiving and storage. Incoming product is mainly containerized and protected from contact with receiving equipment or facilities. Any contamination is likely to be limited to surface contamination of the exterior portion of bulk product. Although unlikely, some potential for contamination exists where product is not stored properly or where cooling equipment is not properly maintained. Regulations and business contracts governing the use of chemicals on incoming product aid in minimizing contamination (46, 167).	Nglg No previous issues have been related to receiving and storage. If contamination occurs, the probability of significant consumer exposure varies with the toxicity and persistence of the chemical and the individual (39, 40, 44). Extensive washing, rinsing and processing of the raw product reduce the probability of consumer exposure. Environmental degradation of chemicals (should they exist) will also reduce contamination further limiting exposure during consumption.	Nglg Chemicals are not conducive to secondary spread among humans.

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Nglg-Med Chemicals are very rarely found on produce in high enough concentrations to cause acute health effects. Although the effects of long term exposure to many chemicals are not well known, there is evidence that exposure to certain chemicals over a long period of time can cause numerous health effects including cancer (35, 36, 39, 40, 41, 42).	Low Direct healthcare costs vary with the level and extent of contamination and exposure. If contamination is traced back to a specific company or industry the economic impact to that company or industry could be significant (43).	Nglg At the levels at which chemicals are found in seed, the impact on the environment would be negligible.	Low No specific concerns have been noted from receiving and storage practices. Chemicals present in food are not usually found at harmful levels (35, 36, 40).	**Nglg** The probability of contamination and exposure are negligible. If exposed, the impact is likely to be mainly low. There is a lack of previous incidences. The overall chemical risk is negligible for the receiving stage in the production of minimally processed vegetables.	To reduce risk: Develop, write and implement prerequisite programs with appropriate standard operating procedures (SOPs) for receiving and storing raw materials (167). Follow GMPs and implement SSOPs (166, 167, 175). All chemicals should be received and stored to prevent contamination of incoming food, food contact surfaces and packaging materials (166). Protect incoming raw or minimally processed vegetables from cross contamination. Use only registered and approved chemicals for the use intended. Train employees to properly handle and use chemicals. Ensure cooling facilities are properly maintained.

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Pre-Processing ***Receiving and Storage*** This includes the activities involved in transferring product from the transport vehicle to the processing plant, inspection of incoming product and storage. Incoming product may be raw or previously minimally processed. Once received, product is stored at a temperature and humidity to maintain optimum quality.	**Physical** Concern that during the receiving and storage process extraneous physical materials such as metal, wood, glass or plastic etc. may contaminate the minimally processed vegetables. Physical hazards in food are known to cause injury (47, 48, 49). See Appendix C for a list of physical material hazards.	Nglg No issues have been identified at this stage. Containerized and bulk packaged incoming products are not likely to be contaminated with physical materials during receiving and storage. Should physical materials fall onto the incoming vegetables, they are not likely to become incorporated unless forcefully contacted. The probability of any physical material contaminating the minimally processed vegetables at this stage is negligible.	Nglg Incoming vegetables are not likely to be contaminated with incorporated physical materials. If product is contaminated on the surface during the receiving process, washing and rinsing steps before, during and after processing reduce the probability of consumer exposure. Inline metal detection and elimination systems also reduce the probability of consumer exposure.	Nglg Physical hazards are not conducive to secondary spread.

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Nglg-Med If contamination occurs the impact is variable depending on the physical hazard and the individual. Physical hazards are known to cause injury (47, 48, 49).	Nglg-Low If contamination and exposure occur, the economic impact is variable but mainly negligible. The impact depends on the type and extent of physical contamination and the product, company and industry involved. When contamination is traced back to a specific company and product the economic impact may be greater for that company or industry.	Nglg Although no specific studies are known, the impact of physical hazards in any food on the environment is considered negligible.	Nglg-Low While foods are known to be a source of physical hazards no incidences of physical hazards in MPV are known.	**Nglg** The probability of contamination and exposure are mainly negligible. While there is some uncertainty and there may be some impact if exposure occurs, the overall risk is expected to be negligible.	To reduce risk: Provide information to employees on potential physical material hazards and proper handling practices for receiving and storing incoming product. Use GMPs. Minimize contact with product and movement of product. Ensure all equipment and utensils used for handling minimally processed vegetables are appropriate. Keep cooling equipment in good repair. Protect lights from breakage.

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Pre-Processing ***Product Preparation*** *(Staging)* This includes all steps to prepare the product for processing including activities such as trimming, washing, rinsing and staging of product.	**Biological** Concern that vegetables are contaminated or will become contaminated with foodborne pathogens during preparation for processing from contaminated surfaces, water, air, equipment, pests or employees (167, 181). Incoming raw vegetables are potentially contaminated with a variety of foodborne pathogens. Foodborne outbreaks of *E. coli*, *Listeria*, *Salmonella* and *Shigella* have been linked to minimally processed vegetables (168, 169, 170, 171, 172). See Appendix A for selected outbreaks and Appendix B for a list of pathogens known to contaminate foods of plant origin.	Low-Med Pathogens may exist or be introduced from contaminated equipment, unsanitary food contact surfaces, air, water, soil, employees or pests (31, 40, 50, 55, 98, 126). Contamination could be localized or widespread depending on the source of contamination. Where there is soil on incoming vegetables or wash water is recycled the potential for contamination increases. Also, where wash water is colder than the vegetables, pathogens present in the water may be absorbed (86, 104). Development of biofilms on food contact surfaces, providing a residual source of pathogens for contamination (182). Preparation by hand potentially increases the probability of contamination.	Nglg-Low If contaminated there is some potential for infiltration and survival of pathogens resulting in potential exposure (7, 55, 145, 153). Vegetables, other than the outer rind generally have a pH that supports the growth of pathogenic microorganisms (55, 56). Good cold chain management reduces the potential for pathogen growth, and washing, rinsing and processing reduce the probability of consumer exposure (7, 19, 55, 66). It has been shown that washing cannot completely remove microorganisms in or on vegetables such as lettuce (19, 69).	Low Some foodborne pathogens are easily transmitted directly by person to person, or by the fecal to oral route (9, 10, 21). If infection occurs, secondary spread among humans can also occur (9, 22, 23, 44). While primary exposure may be broadly distributed, secondary spread is expected to be local.

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Low-High If infection occurs the impact is variable depending on the pathogen and the individual (9). The young, elderly and immuno-compromised are at greater risk (21). Symptoms are variable from mild diarrhea and upset stomach to extreme cases where death may occur (9, 11, 24, 25, 44).	Low-Med Direct healthcare costs vary with pathogen virulence, individual susceptibility, and size of outbreak (2). If an outbreak is traced back to a specific company or industry, the indirect economic impact could be high (23, 26, 27, 28).	Nglg Although no specific studies are known, the presence of biological hazards in food crops is expected to have negligible impact on the environment.	Low Although no specific incidences are associated with product preparation, previous biological contamination of minimally processed vegetables has been documented (168, 169, 170, 171, 172). A number of outbreaks have been traced back to infectious food handlers as the source of contamination (50).	**Low** The probability of contamination and exposure are variable, but mainly low. The impacts of contamination and exposure are mostly low. While there is some uncertainty the overall risk is expected to be low.	To reduce risk: Implement GMPs, HACCP, SOPs and SSOPs (166, 167, 174, 175, 177). Maintain, clean and sanitize all equipment and surfaces that may contact the vegetables. Keep product cool to prolong quality and retard microbial growth. Ensure adequate pest control programs are in place. Employees should follow and have training in sanitary and hygienic food handling practices (5, 50, 58, 59, 60). Where anti microbial treatments are used in wash and or rinse water consider continuous monitoring of the sanitizer to ensure consistent microbial quality of the product (167, 179).

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Pre-Processing ***Product Preparation*** This includes all steps to prepare the product for processing including activities such as trimming, washing, rinsing and staging of product.	**Chemical** Concern that chemical residues from sanitizing, rinsing, handling equipment and food contact surfaces could contaminate the product. While the level of chemicals in food is generally quite low, it has been suggested that foods are a source of exposure to chemicals (35, 36).	Nglg No previous issues have been identified. Chemicals are not normally applied during this stage in the process. Although unlikely, some potential for contamination exists where improper cleaning and sanitation practices are used, where water is contaminated, equipment is not maintained or where food contact surfaces are not made of food grade materials. The probability of chemicals being present at levels higher than allowed is negligible.	Nglg If contamination occurs, the probability of significant consumer exposure varies with the toxicity and persistence of the chemical and the individual (39, 40, 44). Extensive washing, rinsing and processing of the raw product prior to consumption reduces the probability of consumer exposure. Environmental degradation of chemicals (should they exist) will also reduce contamination further limiting exposure during consumption.	Nglg Chemicals are not conducive to secondary spread among humans.

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Nglg-Med Chemicals are very rarely found on produce in high enough concentrations to cause acute health effects. Although the effects of long term exposure to many chemicals are not well known, there is evidence that exposure to certain chemicals over a long period of time can cause numerous health effects including cancer (35, 36, 39, 40, 41, 42).	Low Direct healthcare costs vary with the level and extent of contamination and exposure. If contamination is traced back to a specific company or industry the economic impact to that company or industry could be significant (43).	Nglg At the levels at which chemicals are found in seed, the impact on the environment would be negligible.	Low No specific chemical concerns have been noted during this stage of production of minimally processed vegetable products. Chemicals present in food are not usually found at harmful levels (35, 36, 40).	**Nglg** The probability of contamination and exposure are negligible. If exposed, the impact is likely to be mainly low. There is a lack of previous incidences. The overall chemical risk is negligible for the product preparation stage in the production of minimally processed vegetables.	To reduce risk: Develop, write and implement prerequisite programs with appropriate standard operating procedures (SOPs) for wash water disinfection, equipment maintenance and chemical control (167). Follow GMPs and implement SSOPs (166, 167, 175). All chemicals should be received and stored to prevent any potential cross contamination of incoming vegetables or food contact surfaces (166). Protect incoming raw or minimally processed vegetables from chemical contamination. Use only registered and approved chemicals for their intended use. Train employees to properly handle and use chemicals.

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Pre-Processing ***Product Preparation*** This includes all steps to prepare the product for processing including activities such as trimming, washing, rinsing and staging of product.	**Physical** Concern that extraneous physical materials such as metal, wood, glass, plastic, etc. may contaminate minimally processed vegetables. Physical hazards in food are known to cause injury (47, 48, 49). See Appendix C for a list of physical material hazards.	Nglg No issues have been identified at this stage. Product preparation is designed to reduce physical contamination with washing rinsing and trimming practices. Should physical materials fall onto the vegetables, they are not likely to become incorporated unless forcefully contacted. The probability of any physical material contaminating the minimally processed vegetables at this stage is negligible.	Nglg Vegetables are not likely to be contaminated with incorporated physical materials during preparation. If product is contaminated on the surface during preparation, washing and rinsing steps reduce the probability of consumer exposure. Inline metal detection and elimination systems of finished product also reduce the probability of consumer exposure.	Nglg Physical hazards are not conducive to secondary spread.

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Nglg-Med If contamination occurs the impact is variable depending on the physical hazard and the individual. Physical hazards are known to cause injury (47, 48, 49).	Nglg-Low If contamination and exposure occur, the economic impact is variable but mainly negligible. The impact depends on the type and extent of physical contamination and the product, company and industry involved. When contamination is traced back to a specific company and product the economic impact may be greater for that company or industry.	Nglg Although no specific studies are known, the impact of physical hazards in any food on the environment is considered negligible.	Low While it is known that physical hazards can contaminate food, no previous cases have been identified from minimally processed vegetable production. Knowledge of the preparation process in producing minimally processed vegetables adds certainty to the assessment.	**Nglg** The probability of contamination is very low and the probability of exposure is negligible. While there is some uncertainty and there may be some impact if exposure occurs, the overall risk is expected to be negligible.	To reduce risk: Provide information to employees on potential physical material hazards and proper handling practices for preparing product. Use GMPs. Minimize contact with product and movement of product. Ensure all equipment and utensils used with minimally processed vegetables are appropriate. Protect lights from breakage.

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Processing ***Cutting, Slicing, Shredding, Grinding etc.*** This process changes the product physically to conform to the size, shape and texture requirements desired for the minimally processed vegetable product. While most products are processed mechanically some products may also be processed by hand.	**Biological** Concern that the vegetables will become contaminated with foodborne pathogens during processing from contaminated surfaces, water, air, equipment, pests, or employees (167, 181). Foodborne outbreaks of *E. coli*, *Listeria*, *Salmonella* and *Shigella* have been linked to MPV (168, 169, 170, 171, 172). Incoming raw vegetables are potentially contaminated with a variety of foodborne pathogens, which may be difficult to eliminate during product preparation and processing. See Appendix A for selected outbreaks and Appendix B for a list of pathogens known to contaminate foods of plant origin.	Low-Med There is some possibility for foodborne pathogens to be introduced from contaminated equipment, unsanitary food contact surfaces, air, water, employees or pests (31, 40, 50, 55, 98, 126). Contamination could be localized o widespread depending on the source of contamination. Where water used in the process is colder than the product pathogens present in the water may be absorbed (86, 104). Once cell walls of product are ruptured cellular contents leak out providing an entry and nutrient source for pathogens (167, 175, 178). Biofilms on food contact surfaces may provide a residual source of pathogens (182). Processing by hand potentially increases the probability of contamination.	Nglg-Low If contaminated there is some potential for infiltration and survival of pathogens resulting in potential exposure (7, 55, 145, 153). Vegetables, in particular the internal parts have a pH that supports the growth of pathogenic microorganisms (55, 56). Good cold chain management of the product reduces the potential for pathogen growth, and washing and rinsing reduce the probability of consumer exposure (7, 19, 55, 66). Although, it has been shown that washing cannot completely remove microorganisms in or on vegetables such as lettuce (19, 69). If not properly washed pathogens normally found on the surface of vegetables can be transferred through processing to the MPV product (5, 6, 7, 11 check).	Low Some foodborne pathogens are easily transmitted directly by person to person, or by the fecal to oral route (9, 10, 21). If infection occurs, secondary spread among humans can also occur (9, 22, 23, 44). While primary exposure may be broadly distributed, secondary spread is expected to be local.

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Low-High If infection occurs the impact is variable depending on the pathogen and the individual (9). The young, elderly and immuno-compromised are at greater risk (21). Symptoms are variable from mild diarrhea and upset stomach to extreme cases where death may occur (9, 11, 24, 25, 44).	Low-Med Direct healthcare costs vary with pathogen virulence, individual susceptibility, and size of outbreak (2). If an outbreak is traced back to a specific company or industry, the indirect economic impact could be high (23, 26, 27, 28).	Nglg Although no specific studies are known, the presence of biological hazards in food crops is expected to have negligible impact on the environment.	Low Although no specific incidences are associated with processing of the product, previous biological contamination of minimally processed vegetables has been documented (168, 169, 170, 171, 172).	**Low** The probability of contamination and exposure are mainly low and the impacts are mostly low. While there is some uncertainty, where treatments are applied following processing to reduce or eliminate pathogens the overall risk is expected to be quite low.	To reduce risk: SSOPs, SOPs, HACCP, GMPs (166, 167, 174, 175, 177) Maintain, clean and sanitize all equipment and surfaces that may contact the MPV. Employees should follow and have training in sanitary and hygienic food handling practices (5, 50, 58, 59, 60). Keep product cool at all times to prolong quality and retard microbial growth. Washing product immediately after cutting removes nutrients at the cut surfaces that favour microbial growth. Cut cells take up water, therefore continuous and strict water disinfection is necessary (167). Ensure adequate pest control programs are in place.

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		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
Processing ***Cutting, Slicing, Shredding, Grinding etc.*** This process changes the product physically to conform to the size, shape and texture requirements desired for the minimally processed vegetable product. While most products are processed mechanically some products may also be processed by hand.	**Chemical** Concern that chemical contamination could occur from food contact surfaces, equipment and cleaning or sanitizing products. While the level of chemicals in food is generally quite low, it has been suggested that foods are a source of exposure to chemicals (35, 36).	Nglg No previous issues have been identified. Chemicals are not normally applied during this stage in the process. The probability of chemicals being present at levels higher than allowed is very low. Although unlikely, some potential for contamination exists where improper cleaning and sanitation practices are used, where water is contaminated, equipment is not maintained or where food contact surfaces are not made of food grade materials.	Nglg If contamination occurs, the probability of significant consumer exposure varies with the toxicity and persistence of the chemical and the individual (39, 40, 44). Extensive washing and rinsing of the product following this processing stage reduces the probability of future consumer exposure. Environmental degradation of chemicals (should they exist) will also reduce contamination further limiting exposure during consumption.	Nglg Chemicals are not conducive to secondary spread among humans.

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			Uncertainty of Data	Summary of Risk and Uncertainty	
on human health	economic	environment			
Nglg-Med Chemicals are very rarely found on produce in high enough concentrations to cause acute health effects. Although the effects of long term exposure to many chemicals are not well known, there is evidence that exposure to certain chemicals over a long period of time can cause numerous health effects including cancer (35, 36, 39, 40, 41, 42).	Low Direct healthcare costs vary with the level and extent of contamination and exposure. If contamination is traced back to a specific company or industry the economic impact to that company or industry could be significant (43).	Nglg At the levels at which chemicals are found in seed, the impact on the environment would be negligible.	Low No specific chemical concerns have been noted during this stage in the production of minimally processed vegetables. Chemicals present in food are not usually found at harmful levels (35, 36, 40).	**Nglg** The probability of contamination and exposure are negligible. If exposed, the impact is likely to be mainly low. There is a lack of previous incidences. The overall chemical risk is negligible for the processing stage in the production of minimally processed vegetables.	To reduce risk: Develop, write and implement prerequisite programs with appropriate standard operating procedures (SOPs) for equipment maintenance, disinfection and chemical control (167). Follow GMPs and implement SSOPs (166, 167, 175). All chemicals should be received and stored to prevent any potential cross contamination of incoming vegetables or food contact surfaces (166). Protect incoming raw or minimally processed vegetables from chemical contamination. Use only registered and approved chemicals for their intended use. Train employees to properly handle and use chemicals.

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
Processing ***Cutting, Slicing, Shredding, Grinding etc.*** This process changes the product physically to conform to the size, shape and texture requirements desired for the minimally processed vegetable product. While most products are processed mechanically some products may also be processed by hand.	**Physical** Concern that extraneous physical materials such as metal, wood, glass, plastic, etc. may contaminate the minimally processed vegetables. Physical hazards in food are known to cause injury (47, 48, 49). See Appendix C for a list of physical material hazards.	Nglg-Low Although quite low, there is some likelihood of physical contamination from the cutting, slicing, grinding shredding etc. during processing. Should physical materials fall onto the vegetables during processing, they are not likely to become incorporated unless fthe vegetables are forcefully contacted. Contamination is likely to be mainly surface contamination.	Nglg No previous issue with minimally processed vegetable products is known. If product is contaminated on the surface during processing, washing or rinsing steps after processing reduce the probability of consumer exposure. Inline metal detection and elimination systems of finished product also reduce the probability of consumer exposure. Many minimally processed products are also rinsed prior to consumption further reducing the probability of consumer exposure.	Nglg Physical hazards are not conducive to secondary spread among humans.

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			**Uncertainty of Data**	**Summary of Risk and Uncertainty**	
on human health	economic	environment			
Nglg-Med If contamination occurs the impact is variable depending on the physical hazard and the individual. Physical hazards are known to cause injury (47, 48, 49).	Nglg-Low If contamination and exposure occur, the economic impact is variable but mainly negligible. The impact depends on the type and extent of physical contamination and the product, company and industry involved. When contamination is traced back to a specific company and product the economic impact may be greater for that company or industry.	Nglg Although no specific studies are known, the impact of physical hazards in any food on the environment is considered negligible.	Low While it is known that physical hazards can contaminate food, no previous cases have been identified from minimally processed vegetable production. Knowledge of the processing of minimally processed vegetables adds certainty to the assessment.	**Nglg** The probability of contamination is low and the probability of exposure is negligible. While there is some uncertainty and there may be some impact if exposure occurs, the overall risk is expected to be negligible.	To reduce risk: Provide information to employees on potential physical material hazards and proper handling practices for processing product. Use GMPs. Minimize contact with product and movement of product. Ensure all equipment and utensils used with minimally processed vegetables are appropriate. Protect lights from breakage.

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
Processing ***Washing, Rinsing, Drying, Blending*** After processing product is immediately washed and/or rinsed, often cooled and then dried to remove excess moisture. While centrifugation is most commonly used for drying, vibration screens and forced air tunnels are also used. Water is usually disinfected and anti-microbial treatments may be applied during this process. A number of processed products are often combined to produce blended MPV products.	**Biological** Concern that the MPV will become contaminated with foodborne pathogens during the washing, rinsing, drying or blending processes from contaminated surfaces, water, air, equipment, pests, or employees. Foodborne outbreaks of *E. coli*, *Listeria*, *Salmonella* and *Shigella* have been linked to MPV (168, 169, 170, 171, 172). See Appendix A for selected outbreaks and Appendix B for a list of pathogens known to contaminate foods of plant origin.	Nglg-Low Foodborne pathogens may be introduced from contaminated equipment, unsanitary food contact surfaces including biofilms, air, water, employees or pests (31, 40, 50, 55, 98, 126, 182). Contamination could be localized or widespread depending on the source of contamination. Where water used is colder than the product pathogens present in the water may be absorbed (86, 104). Once cell walls of product are ruptured cellular contents leak out providing an entry and nutrient source for pathogens (167, 175). This process step is partially designed to help minimize contamination prior to packaging.	Low-Med If product is contaminated leaving this stage of production, there is some potential for survival of pathogens resulting in consumer exposure (7, 145, 153). During washing and rinsing there is potential for existing pathogens to infiltrate product. Generally, MPV have a pH that supports the growth of pathogenic microorganisms (55, 56). Good cold chain management reduces the potential for pathogen growth (7, 19, 55, 66). It has been shown that washing cannot completely remove microorganisms in or on vegetables such as lettuce (19, 69). If sanitizers in wash or rinse water are not effective in reducing or eliminating pathogens the potential for consumer exposure is increased since some MPVs are not washed prior to consumption.	Low Some foodborne pathogens are easily transmitted directly by person to person, or by the fecal to oral route (9, 10, 21). If infection occurs, secondary spread among humans can also occur (9, 22, 23, 44). While primary exposure may be broadly distributed, secondary spread is expected to be local.

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			**Uncertainty of Data**	**Summary of Risk and Uncertainty**	
on human health	economic	environment			
Low-High If infection occurs the impact is variable depending on the pathogen and the individual (9). The young, elderly and immuno-compromised are at greater risk (21). Symptoms are variable from mild diarrhea and upset stomach to extreme cases where death may occur (9, 11, 24, 25, 44).	Low-Med Direct healthcare costs vary with pathogen virulence, individual susceptibility, and size of outbreak (2). If an outbreak is traced back to a specific company or industry, the indirect economic impact could be high (23, 26, 27, 28).	Nglg Although no specific studies are known, the presence of biological hazards in food crops is expected to have negligible impact on the environment.	Low Although no specific incidences are associated with this stage of production, previous biological contamination of minimally processed vegetables has been documented (168, 169, 170, 171, 172).	**Low** Although the probability of contamination during this stage of processing is quite low, no subsequent treatments are normally applied to reduce or eliminate existing contamination. If product is contaminated leaving this stage of production consumer exposure could occur. The impacts of exposure are variable but mainly low. While there is some uncertainty the overall risk is expected to be mainly low.	To reduce risk: Implement SSOPs, SOPs, HACCP, GMPs (166, 167, 174, 175, 177) Maintain, clean and sanitize all equipment and surfaces that may contact the MPV. Employees should follow and have training in sanitary and hygienic food handling practices (5, 50, 58, 59, 60, 179). Keep product cool at all times to prolong quality and retard microbial growth. Washing product immediately after cutting removes nutrients at the cut surfaces that favour microbial growth. Cut cells take up water, therefore continuous and strict water disinfection is necessary. Moisture increases microbial growth, therefore remove excess water from product after washing or rinsing. Light desiccation of minimally processed lettuce may favour longer shelf-life. Ensure adequate pest control programs are in place.

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
Processing ***Washing, Rinsing, Drying, Blending*** After processing product is immediately washed and/or rinsed, often cooled and then dried to remove excess moisture. While centrifugation is most commonly used for drying, vibration screens and forced air tunnels are also used. Water is usually disinfected and anti-microbial treatments may be applied during this process. A number of processed products are often combined to produce blended MPV products.	**Chemical** Concern that chemical contamination could occur from food contact surfaces, contaminated water, equipment and cleaning or sanitizing products where they are not properly rinsed off. While the level of chemicals in food is generally quite low, it has been suggested that foods are a source of exposure to chemicals (35, 36).	Nglg-Low No previous issues have been identified. Chemical products to sanitize water or minimize microbial growth may be applied. The probability of chemicals being present at levels higher than allowed is very low. Although unlikely, some potential for contamination could occur where improper chemical application rates or practices are followed for cleaning and sanitation. Contamination could also occur where water is contaminated, equipment is not maintained or where food contact surfaces are not made of food grade materials.	Low If contamination occurs, the probability of significant consumer exposure varies with the toxicity and persistence of the chemical and the individual (39, 40, 44). While washing, rinsing and drying steps at this stage should aid in reducing chemical contamination and future consumer exposure, if contamination does occur during this step in the process consumer exposure is possible. There is some opportunity for environmental degradation of chemicals should they exist. Many minimally processed products are also washed or rinsed prior to consumption further reducing the probability of consumer exposure.	Nglg Chemicals are not conducive to secondary spread among humans.

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			Uncertainty of Data	Summary of Risk and Uncertainty	
on human health	economic	environment			
Nglg-Med Chemicals are very rarely found on produce in high enough concentrations to cause acute health effects. Although the effects of long term exposure to many chemicals are not well known, there is evidence that exposure to certain chemicals over a long period of time can cause numerous health effects including cancer (35, 36, 39, 40, 41, 42).	Low Direct healthcare costs vary with the level and extent of contamination and exposure. If contamination is traced back to a specific company or industry the economic impact to that company or industry could be significant (43).	Nglg At the levels at which chemicals are found in seed, the impact on the environment would be negligible.	Low No specific chemical concerns have been noted during this stage in the production of minimally processed vegetables. Chemicals present in food are not usually found at harmful levels (35, 36, 40).	**Nglg-Low** The probability of contamination and exposure are very low. If exposed, the impact is likely to be mainly low. There is a lack of previous incidences. The overall chemical risk is negligible for this stage in the production of minimally processed vegetables.	To reduce risk: Develop, write and implement prerequisite programs with appropriate standard operating procedures (SOPs) for equipment maintenance, wash water disinfection and chemical control (167). Follow GMPs and implement SSOPs (166, 167, 175). All chemicals should be received and stored to prevent any potential chemical contamination of processed vegetables or food contact surfaces (166). Use only registered and approved chemicals for their intended use. Ensure all contact surfaces are made of approved food grade materials. Train employees to properly handle and use chemicals.

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
Processing ***Washing, Rinsing, Drying, Blending*** After processing product is immediately washed and/or rinsed, often cooled and then dried to remove excess moisture. While centrifugation is most commonly used for drying, vibration screens and forced air tunnels are also used. Water is usually disinfected and anti-microbial treatments may be applied during this process. A number of processed products are often combined to produce blended MPV products.	**Physical** Concern that extraneous physical materials such as metal, wood, glass, plastic, etc. may contaminate the minimally processed vegetables. Physical hazards in food are known to cause injury (47, 48, 49). See Appendix C for a list of physical material hazards.	Nglg-Low Although the probability of contamination is very low, there is some chance of physical contamination during this processing stage. Should physical materials fall onto or mix with the processed vegetables at this stage they can become incorporated into the final product. The washing, rinsing and drying steps at this stage are designed to reduce and eliminate foreign material from the product, reducing the probability of contamination.	Nglg-Low While unlikely, if product is contaminated during this step in production consumer exposure is possible. Inline metal detection and elimination systems of finished product help to reduce the probability of consumer exposure. Many minimally processed products are also rinsed prior to consumption further reducing the probability of consumer exposure.	Nglg Physical hazards are not conducive to secondary spread.

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			Uncertainty of Data	Summary of Risk and Uncertainty	
on human health	economic	environment			
Nglg-Med If contamination occurs the impact is variable depending on the physical hazard and the individual. Physical hazards are known to cause injury (47, 48, 49).	Nglg-Low If contamination and exposure occur, the economic impact is variable but mainly negligible. The impact depends on the type and extent of physical contamination and the product, company and industry involved. When contamination is traced back to a specific company and product the economic impact may be greater for that company or industry.	Nglg Although no specific studies are known, the impact of physical hazards in any food on the environment is considered negligible.	Low While it is known that physical hazards can contaminate food, no previous cases have been identified from minimally processed vegetable production. Knowledge of the processing of minimally processed vegetables adds certainty to the assessment.	**Nglg** The probability of contamination is very low and the probability of exposure is negligible. While there is some uncertainty and there may be some impact if exposure occurs, the overall risk is expected to be negligible.	To reduce risk: Provide information to employees on potential physical material hazards and proper handling practices. Use GMPs. Minimize contact with product and movement of product. Ensure all equipment and utensils used with minimally processed vegetables are appropriate. Protect lights from breakage.

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
Post Processing ***Packaging*** Product is conveyed from the processing area and may be air or water-cooled and dried prior to packaging. MPV products are most often packed on a form-fill-seal machine into various types and sizes of roll stock or vacuum packed into preformed bags. Packaged product is conveyed through a metal detector and grouped into larger master containers or boxes and palletized. To prolong quality and shelf life products may be packed in modified atmosphere packaging (MAP) and/or flushed with nitrogen gas during packaging to replace the oxygen content, reducing the rate of respiration. Although packaging is mainly done mechanically, some MPV products are packaged by hand.	**Biological** Concern that MPVs will become contaminated with foodborne pathogens during packaging from contaminated surfaces, water, air, equipment, pests, or employees. Foodborne outbreaks of *E. coli*, *Listeria*, *Salmonella* and *Shigella* have been previously linked to MPV (168, 169, 170, 171, 172). See Appendix A for selected outbreaks and Appendix B for a list of pathogens known to contaminate foods of plant origin.	Nglg-Low There is some possibility for foodborne pathogens to be introduced from contaminated equipment, unsanitary food contact surfaces including biofilms, air, water, employees or pests (31, 40, 50, 55, 98, 126). Contamination could be localized or widespread depending on the source of contamination. Where packaging equipment is not properly cleaned and sanitized on a regular basis there is increased opportunity for biofilms to develop leading to product contamination (182). Where products are packaged by hand there is an increase in the probability of contamination.	Low-Med If contaminated there is some potential for infiltration and survival of pathogens resulting in potential exposure (7, 55, 145, 153). The probability of exposure varies with the pathogen and the individual (40, 44). Vegetables have a pH that supports the growth of pathogenic microorganisms (55, 56). Good cold chain management reduces the potential for pathogen growth. Although MAP and nitrogen flushing may add shelf life to the product they may not aid in controlling potential pathogens. Where they exist, biofilms on food contact surfaces can be difficult to remove (182). Once packaged no further treatments are commonly applied that can completely eliminate pathogens prior to consumption.	Low Some foodborne pathogens are easily transmitted directly by person to person, or by the fecal to oral route (9, 10, 21). If infection occurs, secondary spread among humans can also occur (9, 22, 23, 44). While primary exposure may be broadly distributed, secondary spread is expected to be local.

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			Uncertainty of Data	Summary of Risk and Uncertainty	
on human health	economic	environment			
Low-High If infection occurs the impact is variable depending on the pathogen and the individual (9). The young, elderly and immuno-compromised are at greater risk (21). Symptoms are variable from mild diarrhea and upset stomach to extreme cases where death may occur (9, 11, 24, 25, 44).	Low-Med Direct healthcare costs vary with pathogen virulence, individual susceptibility, and size of outbreak (2). If an outbreak is traced back to a specific company or industry, the indirect economic impact could be high (23, 26, 27, 28).	Nglg Although no specific studies are known, the presence of biological hazards in food crops is expected to have negligible impact on the environment.	Low Although no specific incidences are associated with packaging product, previous biological contamination of minimally processed vegetables has been documented (168, 169, 170, 171, 172). A number of outbreaks have been traced back to infectious food handlers as the source of contamination (50).	**Low** Although the probability of contamination during this stage of production is quite low, no subsequent treatments are normally applied to reduce or eliminate existing contamination. If product is contaminated during packaging consumer exposure could occur. The impacts of exposure are variable but mainly low. While there is some uncertainty the overall risk is expected to be mainly low.	To reduce risk: SSOPs, SOPs, HACCP, GMPs (166, 167, 174, 175, 177) Maintain, clean and sanitize all equipment and surfaces that may contact the MPV. Employees should follow and have training in sanitary and hygienic food handling practices (5, 50, 58, 59, 60). Keep product cool to prolong quality and retard microbial growth. Handle product with care. Ensure adequate pest control programs are in place. Where modified atmosphere packaging is used the gas composition should be established for each commodity, taking into account the risk of pathogen growth.

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
Post Processing ***Packaging*** Product is conveyed from the processing area and may be air or water-cooled and dried prior to packaging. MPV products are most often packed on a form-fill-seal machine into various types and sizes of roll stock or vacuum packed into preformed bags. Packaged product is conveyed through a metal detector and grouped into larger master containers or boxes and palletized. To prolong quality and shelf life products may be packed in modified atmosphere packaging (MAP) and/or flushed with nitrogen gas during packaging to replace the oxygen content, reducing the rate of respiration. Although packaging is mainly done mechanically, some MPV products are packaged by hand.	**Chemical** Concern that chemical contamination could occur from food contact surfaces, equipment, packaging materials and cleaning or sanitizing products. While the level of chemicals in food is generally quite low, it has been suggested that foods are a source of exposure to chemicals (35, 36).	Nglg No previous issues have been identified. Other than some use of gases in modified atmosphere packaging, chemicals are not generally applied during the packing process. Although unlikely, some potential for contamination exists where improper sanitation practices are used, equipment is not maintained, or where food contact surfaces are not made of food grade materials.	Nglg-Low If contamination occurs, the probability of significant consumer exposure varies with the toxicity and persistence of the chemical and the individual (39, 40, 44). Packaging aids in protecting the product from future contamination. While unlikely, if minimally processed vegetables are contaminated during packaging consumer exposure could occur. Although there may be only a short time interval until consumption there is some potential for environmental degradation of chemicals should they exist. Many minimally processed products are also washed or rinsed prior to consumption further reducing the probability of consumer exposure.	Nglg Chemicals are not conducive to secondary spread among humans.

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			**Uncertainty of Data**	**Summary of Risk and Uncertainty**	
on human health	economic	environment			
Nglg-Med Chemicals are very rarely found on produce in high enough concentrations to cause acute health effects. Although the effects of long term exposure to many chemicals are not well known, there is evidence that exposure to certain chemicals over a long period of time can cause numerous health effects including cancer (35, 36, 39, 40, 41, 42).	Low Direct healthcare costs vary with the level and extent of contamination and exposure. If contamination is traced back to a specific company or industry the economic impact to that company or industry could be significant (43).	Nglg At the levels at which chemicals are found in seed, the impact on the environment would be negligible.	Low No specific chemical concerns have been noted relating to packaging of minimally processed vegetable products. Chemicals present in food are not usually found at harmful levels (35, 36, 40).	**Nglg** The probability of contamination and exposure are very low. If exposed, the impact is likely to be mainly low. There is a lack of previous incidences. The overall chemical risk is negligible for this stage in the production of minimally processed vegetables.	To reduce risk: Develop, write and implement prerequisite programs with appropriate standard operating procedures (SOPs) for equipment maintenance, product coding and traceability and chemical control (167). Follow GMPs and implement SSOPs (166, 167, 175). All chemicals should be received and stored to prevent any potential chemical contamination of processed vegetables or food contact surfaces (166). Use only registered and approved chemicals for their intended use. Ensure all packaging and contact surfaces are made of approved food grade materials. Train employees to properly handle and use chemicals.

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
Post Processing ***Packaging*** Product is conveyed from the processing area and may be air or water-cooled and dried prior to packaging. MPV products are most often packed on a form-fill-seal machine into various types and sizes of roll stock or vacuum packed into preformed bags. Packaged product is conveyed through a metal detector and grouped into larger master containers or boxes and palletized. To prolong quality and shelf life products may be packed in modified atmosphere packaging (MAP) and/or flushed with nitrogen gas during packaging to replace the oxygen content, reducing the rate of respiration. Although packaging is mainly done mechanically, some MPV products are packaged by hand.	**Physical** Concern that extraneous physical materials such as metal, wood, glass, plastic, etc. may contaminate the minimally processed vegetables. Physical hazards in food are known to cause injury (47, 48, 49). See Appendix C for a list of physical material hazards.	Nglg-Low Although the probability of contamination is very low, there is some chance of physical contamination during the packaging process. Should physical materials fall onto or mix with the processed vegetables at this stage they are likely to become incorporated into the packaged product.	Nglg-Low If product is contaminated during the packing process consumer exposure is possible. Inline metal detection and elimination systems of finished product reduce the probability of consumer exposure. Many minimally processed products are also rinsed prior to consumption further reducing the probability of consumer exposure.	Nglg Physical hazards are not conducive to secondary spread.

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			**Uncertainty of Data**	**Summary of Risk and Uncertainty**	
on human health	economic	environment			
Nglg-Med If contamination occurs the impact is variable depending on the physical hazard and the individual. Physical hazards are known to cause injury (47, 48, 49).	Nglg-Low If contamination and exposure occur, the economic impact is variable but mainly negligible. The impact depends on the type and extent of physical contamination and the product, company and industry involved. When contamination is traced back to a specific company and product the economic impact may be greater for that company or industry.	Nglg Although no specific studies are known, the impact of physical hazards in any food on the environment is considered negligible.	Low While it is known that physical hazards can contaminate food, no previous cases have been identified from minimally processed vegetable production. Knowledge of the packaging of minimally processed vegetables adds certainty to the assessment.	**Nglg** The probability of contamination and exposure is very low. While there is some uncertainty and there may be some impact if exposure occurs, the overall risk is expected to be mainly negligible.	To reduce risk: Provide information to employees on potential physical material hazards and proper handling practices for packaging product. Use GMPs. Minimize contact with product and movement of product. Ensure all equipment and utensils used with minimally processed vegetables are appropriate. Protect lights from breakage.

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
Post Processing ***Storage*** Packaged product is moved form the packaging area into cold storage prior to transportation and distribution. Where possible the finished product storage area is separate from the storage of incoming product. Product is stored in a cold environment as part of good "cold chain management" to maintain optimum quality prior to sale.	**Biological** Concern that the MPV will become contaminated with foodborne pathogens during storage from contaminated surfaces, water, air, equipment, pests, or employees. Foodborne outbreaks of *E. coli*, *Listeria*, *Salmonella* and *Shigella* have been linked to MPV (168, 169, 170, 171, 172). See Appendix A for selected outbreaks and Appendix B for a list of pathogens known to contaminate foods of plant origin.	Nglg Packaged product is well-protected product from contamination during storage. It is expected that if any contamination occurred that it would be localized. There is minimal opportunity for pests to contact product in storage If temperatures are not properly maintained existing pathogens could grow and multiply increasing the level of contamination (7, 19, 55, 66). Packaged product ready for distribution is not normally stored in areas used for incoming raw product.	Low-Med If contaminated there is some potential for infiltration and survival of pathogens resulting in potential exposure (7, 55, 145, 153). The probability of exposure varies with the pathogen and the individual (40, 44). Vegetables have a pH that supports the growth of pathogenic microorganisms (55, 56). Good cold chain management reduces the potential for pathogen growth. Once packaged no further treatments are commonly applied that can completely eliminate pathogens prior to consumption. Therefore, although contamination is unlikely during storage, contamination could result in consumer exposure.	Low Some foodborne pathogens are easily transmitted directly by person to person, or by the fecal to oral route (9, 10, 21). If infection occurs, secondary spread among humans can also occur (9, 22, 23, 44). While primary exposure may be broadly distributed, secondary spread is expected to be local.

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			Uncertainty of Data	Summary of Risk and Uncertainty	
on human health	economic	environment			
Low-High If infection occurs the impact is variable depending on the pathogen and the individual (9). The young, elderly and immuno-compromised are at greater risk (21). Symptoms are variable from mild diarrhea and upset stomach to extreme cases where death may occur (9, 11, 24, 25, 44).	Low-Med Direct healthcare costs vary with pathogen virulence, individual susceptibility, and size of outbreak (2). If an outbreak is traced back to a specific company or industry, the indirect economic impact could be high (23, 26, 27, 28).	Nglg Although no specific studies are known, the presence of biological hazards in food crops is expected to have negligible impact on the environment.	Low Although no specific incidences are associated with stored product, previous biological contamination of minimally processed vegetables has been documented (168, 169, 170, 171, 172).	**Nglg-Low** The probability of contamination is negligible and the probability of exposure is mainly low. If exposure occurs the impacts are mostly low. While there is some uncertainty the overall risk is expected to be very low.	To reduce risk: Use clean transport vehicles, pallets, master containers and packaging (166, 167, 174, 175, 177). Maintain a log of previous transport vehicle uses. Consider the potential for foodborne pathogens on other products shipped in the same vehicle. Maintain temperatures below 4 C during transport when possible and keep the length of time in transport as short as possible. Handle product with care. Ensure proper rotation of stock in distribution facilities. Ensure adequate pest control programs are in place. Employees involved in transportation and distribution should follow and have training in sanitary and hygienic food handling practices (5, 50, 58, 59, 60).

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
Post Processing ***Storage*** Packaged product is moved form the packaging area into cold storage prior to transportation and distribution. Where possible the finished product storage area is separate from the storage of incoming product. Product is stored in a cold environment as part of good "cold chain management" to maintain optimum quality prior to sale.	**Chemical** Concern that chemical residue from cooling equipment or from contamination with non-food grade packaging materials could contaminate the product. While the level of chemicals in food is generally quite low, it has been suggested that foods are a source of exposure to chemicals (35, 36).	Nglg No previous issues have been identified. No chemicals are applied during storage of the product. Packed product is put into master containers then palletized. Thus, pre-packaged minimally processed vegetables are usually well protected from contamination. There is a very low probability of contamination from movement of chemicals in packaging material into product.	Nglg-Low If contamination occurs, the probability of significant consumer exposure varies with the toxicity and persistence of the chemical and the individual (39, 40, 44). While very unlikely, if product is contaminated during storage consumer exposure is possible. Although there may be only a short time interval until consumption there is some potential for environmental degradation of chemicals should they exist. Many minimally processed products are also washed or rinsed prior to consumption further reducing the probability of consumer exposure.	Nglg Chemicals are not conducive to secondary spread among humans.

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			Uncertainty of Data	Summary of Risk and Uncertainty	
on human health	economic	environment			
Nglg-Med Chemicals are very rarely found on produce in high enough concentrations to cause acute health effects. Although the effects of long term exposure to many chemicals are not well known, there is evidence that exposure to certain chemicals over a long period of time can cause numerous health effects including cancer (35, 36, 39, 40, 41, 42).	Low Direct healthcare costs vary with the level and extent of contamination and exposure. If contamination is traced back to a specific company or industry the economic impact to that company or industry could be significant (43).	Nglg At the levels at which chemicals are found in seed, the impact on the environment would be negligible.	Low No specific chemical concerns have been noted from the storage of minimally processed vegetable products. Chemicals present in food are not usually found at harmful levels (35, 36, 40).	**Nglg** The probability of contamination and exposure are very low. If exposed, the impact is likely to be mainly low. There is a lack of previous incidences. The overall chemical risk is negligible for this stage in the production of minimally processed vegetables.	To reduce risk: Develop, write and implement prerequisite programs with appropriate standard operating procedures (SOPs) for equipment maintenance, product coding and traceability and chemical control (167). Follow GMPs and implement SSOPs (166, 167, 175). All chemicals should be received and stored to prevent any potential chemical contamination of processed vegetables or food contact surfaces (166). Use only registered and approved chemicals for their intended use. Ensure all contact surfaces are made of approved food grade materials. Train employees to properly handle and use chemicals. Ensure cooling facilities are properly maintained.

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
Post Processing ***Storage*** Packaged product is moved form the packaging area into cold storage prior to transportation and distribution. Where possible the finished product storage area is separate from the storage of incoming product. Product is stored in a cold environment as part of good "cold chain management" to maintain optimum quality prior to sale.	**Physical** Concern that extraneous physical materials such as metal, wood, glass, plastic, etc. may contaminate the minimally processed vegetables. Physical hazards in food are known to cause injury (47, 48, 49). See Appendix C for a list of physical material hazards.	Nglg Pre-packaged minimally processed vegetables are usually well protected from contamination. Product is packaged, put into master containers then palletized. The probability of product contamination with physical materials during storage is negligible. Any potential contamination is likely to affect minimal product.	Nglg-Low If product is contaminated during storage consumer exposure is possible. Many minimally processed products are also rinsed prior to consumption further reducing the probability of consumer exposure. Any large physical materials may be visible or felt by consumers prior to consumption and eliminated. Any exposure would be very local.	Nglg Physical hazards are not conducive to secondary spread.

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			**Uncertainty of Data**	**Summary of Risk and Uncertainty**	
on human health	economic	environment			
Nglg-Med If contamination occurs the impact is variable depending on the physical hazard and the individual. Physical hazards are known to cause injury (47, 48, 49).	Nglg-Low If contamination and exposure occur, the economic impact is variable but mainly negligible. The impact depends on the type and extent of physical contamination and the product, company and industry involved. When contamination is traced back to a specific company and product the economic impact may be greater for that company or industry.	Nglg Although no specific studies are known, the impact of physical hazards in any food on the environment is considered negligible.	Nglg-Low While it is known that physical hazards can contaminate food, no previous cases have been identified from minimally processed vegetable production. Knowledge of the storage of minimally processed vegetables adds certainty to the assessment.	**Nglg** The probability of contamination is negligible and the probability of exposure is very low. While there is some uncertainty and there may be some localized impact if exposure occurs, the overall risk is expected to be negligible.	To reduce risk: Provide information to employees on potential physical material hazards and proper handling and storage practices. Use GMPs. Minimize contact with product and movement of product. Ensure all equipment used with minimally processed vegetables are appropriate. Protect lights from breakage. Keep all transportation and cooling equipment in good repair.

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
Post Processing ***Shipping, Transportation and Distribution*** This includes all practices involved in moving packaged product from storage into transportation vehicles and transportation and delivery of product to wholesale distribution and retail outlets. Optimally, product is kept cold through good "cold chain management" from the processor through to delivery at retail.	**Biological** Concern that the MPV will become contaminated with foodborne pathogens during shipping, transportation and distribution from contaminated surfaces, water, air, equipment, pests, or employees. Foodborne outbreaks of *E. coli*, *Listeria*, *Salmonella* and *Shigella* have been linked to MPV (168, 169, 170, 171, 172). See Appendix A for selected outbreaks and Appendix B for a list of pathogens known to contaminate foods of plant origin.	Nglg Packaged product is well-protected product from contamination during shipping, transportation and distribution. If contamination occurred it is expected that it would be local and affect only a limited quantity of product. Pests are not likely to contact product that is protected by multiple packaging barriers. Similarly, product is not likely to be contaminated by unhygienic surfaces, equipment or employees. If temperatures are not properly maintained any existing pathogens should they exist, could grow and multiply increasing contamination.	Low-Med If contaminated there is some potential for infiltration and survival of pathogens resulting in potential exposure (7, 55, 145, 153). The probability of exposure varies with the pathogen and the individual (40, 44). Vegetables have a pH that supports the growth of pathogenic microorganisms (55, 56). Good cold chain management reduces the potential for pathogen growth. Once packaged no treatments are commonly applied that completely eliminate pathogens prior to consumption.	Low Some foodborne pathogens are easily transmitted directly by person to person, or by the fecal to oral route (9, 10, 21). If infection occurs, secondary spread among humans can also occur (9, 22, 23, 44). While primary exposure may be broadly distributed, secondary spread is expected to be local.

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			Uncertainty of Data	Summary of Risk and Uncertainty	
on human health	economic	environment			
Low-High If infection occurs the impact is variable depending on the pathogen and the individual (9). The young, elderly and immuno-compromised are at greater risk (21). Symptoms are variable from mild diarrhea and upset stomach to extreme cases where death may occur (9, 11, 24, 25, 44).	Low-Med Direct healthcare costs vary with pathogen virulence, individual susceptibility, and size of outbreak (2). If an outbreak is traced back to a specific company or industry, the indirect economic impact could be high (23, 26, 27, 28).	Nglg Although no specific studies are known, the presence of biological hazards in food crops is expected to have negligible impact on the environment.	Low Although no specific incidences are associated with stored product, previous biological contamination of minimally processed vegetables has been documented (168, 169, 170, 171, 172).	**Nglg-Low** The probability of contamination is negligible. If contamination of the product does occur exposure may follow. If exposure occurs the impacts are variable although, they are expected to be mainly low. While there is some uncertainty the overall risk is expected to be very low.	To reduce risk: Handle product with care. Ensure proper rotation of stock in shipping and distribution facilities. Employees involved in shipping, transportation and distribution should follow and have training in sanitary and hygienic food handling practices (5, 50, 58, 59, 60). Regularly maintain, clean and sanitize all handling and transport equipment (166, 167, 174, 175). Ensure enclosed refrigerated docks and pre cooled trailers are used. Maintain a log of previous transport vehicle uses and consider the potential for cross contamination from foodborne pathogens on other products shipped in the same vehicle. Ensure adequate pest control programs are in place. Maintain product temperatures below 4 C during shipping, transport and distribution and minimize time in transport.

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
Post Processing ***Shipping, Transportation and Distribution*** This includes all practices involved in moving packaged product from storage into transportation vehicles and transportation and delivery of product to wholesale distribution and retail outlets. Optimally, product is kept cold through good "cold chain management" from the processor through to delivery at retail.	**Chemical** Concern that chemical residue from cooling equipment or from contamination with surfaces and non-food grade materials could contaminate the product. While the level of chemicals in food is generally quite low, it has been suggested that foods are a source of exposure to chemicals (35, 36).	Nglg No previous issues have been identified. While surfaces in the shipping, transportation and distribution system are commonly cleaned and sanitized with chemical products, pre-packaged, boxed and palletized product are well protected from contamination. There is a very low probability of contamination from movement of chemicals in packaging material into product.	Nglg-Low If contamination occurs, the probability of significant consumer exposure varies with the toxicity and persistence of the chemical and the individual (39, 40, 44). While very unlikely, if product is contaminated during Shipping, transportation and distribution consumer exposure is possible. Although there may be only a short time interval until consumption there is some potential for environmental degradation of chemicals should they exist. Many minimally processed products are also washed or rinsed prior to consumption further reducing the probability of consumer exposure. Any exposure is expected to have a local distribution.	Nglg Chemicals are not conducive to secondary spread among humans.

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			Uncertainty of Data	Summary of Risk and Uncertainty	
on human health	economic	environment			
Nglg-Med Chemicals are very rarely found on produce in high enough concentrations to cause acute health effects. Although the effects of long term exposure to many chemicals are not well known, there is evidence that exposure to certain chemicals over a long period of time can cause numerous health effects including cancer (35, 36, 39, 40, 41, 42).	Low Direct healthcare costs vary with the level and extent of contamination and exposure. If contamination is traced back to a specific company or industry the economic impact to that company or industry could be significant (43).	Nglg At the levels at which chemicals are found in seed, the impact on the environment would be negligible.	Low No specific chemical concerns have been noted from the shipping, transportation or distribution of minimally processed vegetable products.. Chemicals present in food are not usually found at harmful levels (35, 36, 40).	**Nglg** The probability of contamination and exposure are very low. If exposed, the impact is likely to be mainly low. There is a lack of previous incidences. The overall chemical risk is negligible for the shipping, transportation and distribution stage.	To reduce risk: Employees involved in shipping, transportation and distribution should follow and have training in sanitary and hygienic food handling practices (50, 58, 59, 60). Use clean transport vehicles. Maintain a log of previous transport vehicle uses and consider the potential for cross contamination from other products shipped in the same vehicle. Regularly maintain, clean and sanitize all handling and transport equipment. Use only products registered for cleaning and sanitizing and follow label recommendations. Employees should be trained to handle and use chemicals. Ensure cooling facilities are properly maintained.

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
Post Processing ***Shipping, Transportation and Distribution*** This includes all practices involved in moving packaged product from storage into transportation vehicles and transportation and delivery of product to wholesale distribution and retail outlets. Optimally, product is kept cold through good "cold chain management" from the processor through to delivery at retail.	**Physical** Concern that extraneous physical materials such as metal, wood, glass, plastic, etc. may contaminate the minimally processed vegetables. Physical hazards in food are known to cause injury (47, 48, 49). See Appendix C for a list of physical material hazards.	Nglg Pre-packaged minimally processed vegetables are mainly well protected from contamination. Transported product is packaged inside master containers, which are commonly palletized. The probability of contaminating product during this stage is negligible. Any contamination is likely to affect minimal product.	Nglg-Low If product is contaminated during this stage consumer exposure is possible. Many minimally processed products are also rinsed prior to consumption further reducing the probability of consumer exposure. Any large physical materials may be visible or felt by consumers prior to consumption and eliminated. Any exposure would be very localized.	Nglg Physical hazards are not conducive to secondary spread.

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			**Uncertainty of Data**	**Summary of Risk and Uncertainty**	
on human health	economic	environment			
Nglg-Med If contamination occurs the impact is variable depending on the physical hazard and the individual. Physical hazards are known to cause injury (47, 48, 49).	Nglg-Low If contamination and exposure occur, the economic impact is variable but mainly negligible. The impact depends on the type and extent of physical contamination and the product, company and industry involved. When contamination is traced back to a specific company and product the economic impact may be greater for that company or industry.	Nglg Although no specific studies are known, the impact of physical hazards in any food on the environment is considered negligible.	Nglg-Low While it is known that physical hazards can contaminate food, no previous cases have been identified from minimally processed vegetable production. Knowledge of the steps involved in shipping, transportation and distribution of minimally processed vegetables adds certainty to the assessment.	**Nglg** The probability of contamination is negligible and the probability of exposure is very low. While there is some uncertainty and there may be some localized impact if exposure occurs, the overall risk is expected to be negligible.	To reduce risk: Provide information to employees on potential physical material hazards and proper handling practices. Use GMPs. Minimize contact with product and movement of product. Ensure all equipment used with minimally processed vegetables are appropriate. Protect lights from breakage. Keep all transportation and cooling equipment in good repair. Enclosed refrigerated docks.

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
Post Processing ***Retail*** This includes storage, handling, display and sale at retail outlets. Minimally processed vegetables (MPV) are usually sold pre-packaged and refrigerated. In some retail establishments bulk packages are opened and sold to consumers from self-serve displays.	**Biological** Concern that MPV will become contaminated by store personnel, customers, unsanitary food surfaces, water, air or by flies and other pests that may harbour and transmit foodborne pathogens (50, 55). Foodborne outbreaks of *E. coli*, *Listeria*, *Salmonella* and *Shigella* have been linked to MPV (168, 169, 170, 171, 172). See Appendix A for selected outbreaks and Appendix B for a list of pathogens known to contaminate foods of plant origin.	Nglg-Low Although data indicates that people and pests can contaminate produce (31, 50, 55), minimally processed vegetables normally arrive pre-packed at retail, protecting the product from pest or employee and customer contact. Where bulk packages are opened at retail and sold through self-serve displays, the likelihood of contamination from employees, consumers or from unclean surfaces and utensils increases. Any contamination is likely to be localized.	Low-Med Although unlikely, if contamination does occur at the retail level of trade there infiltration and survival of pathogens could occur resulting in potential exposure (7, 55, 145, 153). The probability of exposure varies with the pathogen and individual (40, 44). The short time interval to consumption increases the probability of exposure. Any contamination is likely to be localized and not cause widespread exposure. While no treatments are applied which can eliminate all pathogens once product is contaminated, good cold chain management and rinsing MPVs prior to consumption may reduce contamination and subsequent exposure.	Low Some foodborne pathogens are easily transmitted directly by person to person, or by the fecal to oral route (9, 10, 21). If infection occurs, secondary spread among humans can also occur (9, 22, 23, 44). While primary exposure may be broadly distributed, secondary spread is expected to be local.

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			Uncertainty of Data	Summary of Risk and Uncertainty	
on human health	economic	environment			
Low-High If infection occurs the impact is variable depending on the pathogen and the individual (9). The young, elderly and immuno-compromised are at greater risk (21). Symptoms are variable from mild diarrhea and upset stomach to extreme cases where death may occur (9, 11, 24, 25, 44).	Low-Med Direct healthcare costs vary with pathogen virulence, individual susceptibility, and size of outbreak (2). If an outbreak is traced back to a specific company or industry, the indirect economic impact could be high (23, 26, 27, 28).	Nglg Although no specific studies are known, the presence of biological hazards in food crops is expected to have negligible impact on the environment.	Low Although no specific incidences are associated minimally processed products sold at retail, previous biological contamination of minimally processed vegetables has been documented (168, 169, 170, 171, 172). A number of outbreaks have been traced back to infectious food handlers as the source of contamination and surfaces previously contaminated by meat (50).	**Nglg-Low** Where MPV are pre-packaged the probability of contamination and subsequent consumer exposure is negligible. Contamination and localized exposure could occur where MPV are sold self-serve from bulk displays. The impacts of exposure are variable, but mainly low. While there is some uncertainty the overall risk is expected to be very low.	To reduce risk: Follow GMPs for retail establishments (50). Employees at retail should follow and have training in sanitary and hygienic food handling practices (5, 50, 58, 59, 60). Employees who are ill must not be allowed to contact food. Any packaging materials used at retail should be stored and handled according to GMPs and should be of food grade materials (64, 166, 167). Ensure proper rotation of stock and maintain appropriate temperatures in storage and display areas. Use sneeze guards and regularly sanitize utensils where product is sold in bulk. Ensure a pest control program is in place.

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
Post Processing ***Retail*** This includes storage, handling, display and sale at retail outlets. Minimally processed vegetables (MPV) are usually sold pre-packaged and refrigerated. In some retail establishments bulk packages are opened and sold to consumers from self-serve displays.	**Chemical** Concern that chemical contamination could occur from food contact surfaces, equipment, packaging materials and cleaning or sanitizing products. While the level of chemicals in food is generally quite low, it has been suggested that foods are a source of exposure to chemicals (35, 36).	Nglg No previous issues have been identified. Although unlikely, some potential for contamination exists where improper cleaning sanitation practices are used, equipment is not maintained or where food contact surfaces are not made of food grade materials. Most MPV are sold in packages, which aids in protecting the product from contamination. A greater potential for contamination exists where product is sold from bulk displays. No chemicals are applied to product at this stage and the probability of chemicals being present at levels higher than allowed is negligible.	Nglg-Low If contamination occurs, the probability of significant consumer exposure varies with the toxicity and persistence of the chemical and the individual (39, 40, 44). While very unlikely, if minimally processed vegetables are contaminated in the retail environment consumer exposure could occur. Although there may be only a short time interval until consumption there is some potential for environmental degradation of chemicals should they exist. Many minimally processed products are also washed or rinsed prior to consumption further reducing the probability of consumer exposure. Any exposure is expected to have a local distribution.	Nglg Chemicals are not conducive to secondary spread among humans.

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			**Uncertainty of Data**	**Summary of Risk and Uncertainty**	
on human health	economic	environment			
Nglg-Med Chemicals are very rarely found on produce in high enough concentrations to cause acute health effects. Although the effects of long term exposure to many chemicals are not well known, there is evidence that exposure to certain chemicals over a long period of time can cause numerous health effects including cancer (35, 36, 39, 40, 41, 42).	Low Direct healthcare costs vary with the level and extent of contamination and exposure. If contamination is traced back to a specific company or industry the economic impact to that company or industry could be significant (43).	Nglg At the levels at which chemicals are found in seed, the impact on the environment would be negligible.	Low No specific chemical concerns have been noted with minimally processed vegetables at retail. Chemicals present in food are not usually found at harmful levels (35, 36, 40).	**Nglg** The probability of contamination and exposure are very low. If exposed, the impact is likely to be mainly low. There is a lack of previous incidences. The overall chemical risk is negligible for the retail stage.	To reduce risk: Regularly maintain, clean and sanitize all equipment and food contact surfaces. Use only products registered for cleaning and sanitizing and follow label recommendations. Employees should be trained to handle and use chemicals. Ensure all contact surfaces are made of approved food grade materials. Ensure cooling facilities are maintained properly.

Activity	Hazard/ Concern	Risk Characterization		
		Probability (Likelihood of Going Wrong)		
		of contamination	of consumer exposure	of secondary spread among humans
Post Processing ***Retail*** This includes storage, handling, display and sale at retail outlets. Minimally processed vegetables (MPV) are usually sold pre-packaged and refrigerated. In some retail establishments bulk packages are opened and sold to consumers from self-serve displays.	**Physical** Concern that extraneous physical materials such as metal, wood, glass, plastic, etc. may contaminate the minimally processed vegetables. Physical hazards in food are known to cause injury (47, 48, 49). See Appendix C for a list of physical material hazards.	Nglg-Low Pre-packaged product is mainly protected from contamination with physical materials. Where product is sold from open bulk self-serve displays the probability of contamination increases. Any contamination at retail would involve minimal product.	Nglg-Low While unlikely, If product is contaminated at the retail level of trade consumer exposure is possible. Product purchased from bulk displays is normally washed or rinsed prior to consumption reducing the probability of consumer exposure. In addition, large physical materials may be visible or felt by consumers prior to consumption and eliminated. Any exposure would be very local.	Nglg Physical hazards are not conducive to secondary spread.

Risk Characterization			Risk Summary		Recommendations for Action
Impact (Consequences of Going Wrong)			**Uncertainty of Data**	**Summary of Risk and Uncertainty**	
on human health	economic	environment			
Nglg-Med If contamination occurs the impact is variable depending on the physical hazard and the individual. Physical hazards are known to cause injury (47, 48, 49).	Nglg-Low If contamination and exposure occur, the economic impact is variable but mainly negligible. The impact depends on the type and extent of physical contamination and the product, company and industry involved. When contamination is traced back to a specific company and product the economic impact may be greater for that company or industry.	Nglg Although no specific studies are known, the impact of physical hazards in any food on the environment is considered negligible.	Low While it is known that physical hazards can contaminate food, no previous cases have been identified from minimally processed vegetable production. Knowledge of the retailing of minimally processed vegetables adds certainty to the assessment.	**Nglg** The probability of contamination and exposure are very low. While there is some uncertainty and there may be some localized impact if exposure occurs, the overall risk is expected to be mainly negligible.	To reduce risk: Provide information to employees on potential physical material hazards and proper handling, display and storage practices. Minimize contact with product and movement of product. Practice GMPs for retail establishments. If packaging at retail or selling in bulk, ensure all utensils used for handling minimally processed vegetables are appropriate, use sneeze guards and protect all lights from breakage.