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Mini Review

Salmonella contamination in raw vegetables: A review

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ABSTRACT

Raw vegetables that experience increasing demand by consumer due to the healthy nutrients. It is thought consumption of raw vegetables will help in reducing chronic diseases such as hypertension, obesity, cholesterol and diabetes. With the increasing consumption of raw vegetables, several outbreaks linked to the pathogen contamination in these vegetables have been reported worldwide. One of the most common pathogen contamination is *Salmonella*. *Salmonella* have two species which are *S. bongori and S. enterica*. Of these, only *S. enterica* that cause human infection. However, there are roughly 1500 serovars within *S. enterica*. *Salmonella* are ubiquitously present in the environment and easily contaminate food if no proper handling being practices throughout the supply chain. Various vegetables have been implicated with the contamination of *Salmonella*. Thus, this paper review contamination of *Salmonella* in vegetables from various studies and the outbreaks.

Keywords: *Salmonella*, fresh produce, raw vegetables, fruits, food poisoning

INTRODUCTION

Salmonella is a group of the pathogen that may cause foodborne illness to humans. It is a great concern to the field of the health and food industries since Salmonella may affect public health and cause a serious economic risk for the food industry (Doran et al., 2005). It is a rod-shaped, Gram-negative, and facultative intracellular pathogen of the Enterobacteriaceae family.

Salmonella is known as ubiquitous and hardy bacteria. *Salmonella* invades the intestinal to cause gastroenteritis or disseminate to systemic sites and cause sepsis. It can live in a dry environment for several weeks and up to few months in water. *Salmonella* also thrives within the intracellular niche, allowing intrinsic antimicrobial resistance and chronic colonization in rare cases. There are many types of *Salmonella* exist worldwide.

The only two species of *Salmonella* species are *Salmonella bongori* and *Salmonella enterica*. Within these two *Salmonella* species, over 2500 different serotypes or serovars have been identified, and most of the serotypes are under *Salmonella enterica*. According to Crump and Wain (2016), *Salmonella enterica* is divided into six subspecies as listed in Table 1.

Table 1. *Salmonella* type and subspecies

Type	**Subspecies**
enterica	(I)
salamae	(II)
arizonae	(IIIa)
diarizonae	(IIIb)
houtenae	(IV)
indica	(VI)

Source: (Crump & Wain, 2016)

These different types of subspecies act as the indicator in identifying the disease caused by Salmonella infection since different types of bacteria will cause different diseases. Therefore, the disease affected by a group of same bacteria species with the same name and the same host can be easily identified. Salmonella enterica is the pathogen live in an animal such as bird, chicken and some from human intestines. *Salmonella enterica* serotype Enteritidis and *Salmonella enterica* serotype Typhimurium are examples of the most common serotypes of *Salmonella* transmitted from animals to humans which resulting in foodborne illness.

A study by Theron and Lues, (2007) reported that *Salmonella* Typhimurium is the most important microorganisms among the foodborne pathogens. The infection of this *Salmonella* bacteria may cause Salmonellosis. Salmonellosis is an infection that occurs when a person consuming contaminated products comes from raw poultry, unwashed eggs, contaminated soils, and water. Similar to poultry products, the main transmission route of *Salmonella* to vegetables is through fecal contamination, cross-contamination, and food handling (Warriner et al., 2009).

Salmonella is commonly known to come from poultry animals and humans, however, *Salmonella* Dublin and *Salmonella* Choleraesuis species can only be found in one or few species such as in cattle and pigs. Therefore, when these types of serotypes infected in humans, they usually invasive and life-threatening (World Health Organization, 2018).

PREVALENCE OF *SALMONELLA* IN FRESH PRODUCE

Salmonella disease commonly found in the contamination of poultry or bird products. For the last few decades, many cases related to contamination of *Salmonella* in fresh products have been reported. A study by Orue et al. (2013) has reported that the plant extracts are effective in the disinfection of *Salmonella* contamination on vegetables such as cilantro, parsley, and spinach. About 41 plant extracts tested has been tested in this study

where the extracts from oregano leaves and peel and pulp of limes were found to be as effective as chlorine. Therefore, extracts from both leaves can be used as an alternative of chlorine chemicals to reduce the risk of *Salmonella* contamination on leafy vegetables. About 0.4% per 25 g of countable levels of *Salmonella* presented in four packages of fresh produce such as lettuce and arugula were obtained in a study conducted in São Paulo, Brazil (Sant'Ana et al., 2011). *Salmonella* Typhimurium and *Salmonella* enteric subspecies *enterica* were the types of *Salmonella* that detected in the package of lettuce and arugula respectively.

A study in Malaysia tested a total of 43 samples of vegetable samples such as selom *(Oenanthe stolonifera),* pegaga *(Centella Asiatica),* kangkung *(Ipomoea Aquatica)* and kesum *(Polygonum minus)* for the presence of *Salmonella* spp. and found 31 detections of *Salmonella* in four local salad vegetables can be potential health hazards to the consumers (Awang et al., 2003). Besides, a study in the United State has found that the rates of *Salmonella* prevalence in cilantro ranged has increased from 0% to 0.34% (Amrutha et al, 2017).

Recently, in Kampar, Perak, Malaysia, a few samples of vegetables have been studied to determine the prevalence of *Salmonella* in fresh produce such as cabbages, lettuce, tomatoes, carrots, and cucumbers, from three different hypermarkets and a wet market. Most of the vegetables showed no contamination of *Salmonella* spp., *S. enterica* serovar Enteritidis and *S. enterica* serovar Typhimurium. However, the presence of *Salmonella* was detected in cabbage and cucumber (Saw et al., 2019).

Outbreaks of *Salmonella*

Salmonella are known to live in the intestines of people, animals, and birds. However, consumption of fresh produce that received minimum processing such as cutting, slicing, or peeling may damage the vegetable tissue which releases nutrients and facilitates microorganisms' growth (Harris et al., 2003), which may be potentially hazardous to human health. Therefore, it is a great concern to Malaysia's public about the presence of the foodborne pathogen, *Salmonella* in the raw vegetables other than the poultry products.

For the past ten years, many *Salmonella* outbreaks have been associated with fresh fruits and vegetables. Though fresh produce is implicated less frequently, several outbreaks of *Salmonella* have been linked to fresh fruits and vegetables (Awang et al., 2003). Olaimat & Holley (2012) reported that pathogens of greatest current concern from 2005 to 2011 are due to *Salmonella* contamination which is found in tomatoes, seed sprouts, and spices as listed in Table 2.

According to CDC (2015), an outbreak of *Salmonella* in cucumber in the United State has been studied which resulted in 204 ill people were hospitalized, and six deaths were recorded from Arizona, California, Oklahoma, and Texas. A study reported on the occurrence of *norovirus* and *Salmonella* outbreaks associated with salads and berries consumption in the United States and European Union (Callejón et al., 2015) also prove that *Salmonella* outbreak becomes uncontrollable if decontamination method of the *Salmonella* is not being identified.

Besides, there are three cases linked to *Salmonella* outbreaks that have been reported involving fresh produce such as papaya, melon, and cut fruit this year in Mexico and the United States (CDC, 2019).

Illness Caused by *Salmonella* Infection

Salmonella is divided into two main groups which are typhoid and non-typhoid *Salmonella.* Typhoid *Salmonella* is a group of bacterial strains that cause typhoid fever or paratyphoid fever, including *Salmonella* Typhi, Paratyphi A, Paratyphi B, and Paratyphi C while non-typhoid *Salmonella* is a group of other *Salmonella* strains usually because of the gastrointestinal disease called acute gastroenteritis. Including diarrhea and abdominal cramps. Non-typhoid *Salmonella* also known as salmonellosis is the common foodborne illness affected by a human.

Table 2. *Salmonella* outbreaks linked to fresh produce from 2005 to 2011.

Location	Year	Pathogen	Produce	Cases (Death)
Canada	2005	*Salmonella*	Mung bean sprouts	592
USA	2005	*Salmonella*	Tomatoes	459
Australia	2006	*Salmonella*	Alfalfa sprouts	125
USA, Canada	2006	*Salmonella*	Fruit salad	41
USA	2006	*Salmonella*	Tomatoes	183
Australia	2006	*Salmonella*	Cantaloupe	115
Europe	2007	*Salmonella*	Baby spinach	354
North America, Europe	2007	*Salmonella*	Basil	51
Europe	2007	*Salmonella*	Alfalfa sprouts	45
USA, Canada	2008	*Salmonella*	Peppers	1442 (2)
UK	2008	*Salmonella*	Basil	32
USA	2008	*Salmonella*	Cantaloupe	51
USA, Canada	2008	*Salmonella*	Peanut butter	714 (9)
USA	2009	*Salmonella*	Alfalfa sprouts	235
USA	2010	*Salmonella*	Alfalfa sprouts	44
USA	2011	*Salmonella*	Alfalfa and mixed sprouts	140

Source: (Olaimat and Holley, 2012)

Symptoms of salmonellosis are diarrhea, typically occur between 12 and 72 hr after exposure and ingestion of *Salmonella*. The symptoms usually last up to 4 to 7 days. Symptoms of the salmonellosis are included diarrhea, which may become bloody, abdominal cramps, fever, headache, loss of appetite, nausea, and loss of appetite (Joseph, 2015). Most patients infected by salmonellosis can recover without outside treatment. It usually can be recovered by taking some rest and stay hydrated. However, some of the *Salmonella* infection may become aggressive and resulting in complications to the affected area outside the digestive system such as bloodstream, bones, joints, a central nervous system which may affect the brain and other internal organs. These symptoms usually due to the infection of typhoid *Salmonella* pathogen.

Besides, it may show the symptoms by causing the patient a sustained fever ranges up to 39°C to 40°C known as typhoid fever followed by other symptoms similar to non-typhoid infection such as headache and loss of appetite. In this case, particularly in children, elderly patients, and those with an impaired immune system may result in life-threatening. There are some cases, *Salmonella* infection may spread from the intestine to the bloodstream and other body areas and resulting in death.

FRESH PRODUCE

Public awareness of healthy eating styles has been increasing in these recent years which resulted in higher demand for fresh produce worldwide (Olaimat & Holley, 2012) including in Malaysia. Fresh produce is a term

for fruits and vegetables that have not been processed in any manner. This term cannot be applied to dried fruits and vegetables, any kind of nuts, processed products from fruits and vegetables, meats, and seafood. Pathogens usually contaminate on the surface of the produce. Therefore, by washing the fresh produce properly, it will be safe to eat. But if the produce is not washed properly or becomes contaminated after washing, it can become infected with foodborne illnesses by the pathogen (Molen, 2019).

Fresh produce usually has short shelf life. However, minimal processing treatment, quality factors such as appearance, texture, and flavor may influence the product deterioration process to happen rapidly. Even with refrigeration, the produce still has a minimal shelf life. This is because hazardous bacteria can grow at refrigerator temperature, however, it can slow down the process of the deterioration. Microbial growth in fresh produces is the main issue in the produce industry. Most of the pre-cutting and packaging fresh produce in the wet market does not have pre-treatment such as blanching or freezing which can inhibit the growth of the microorganisms. Therefore, it might be one of the sources that lead to the contamination of the pathogens.

Microorganism in Fresh Produce

Consumption of raw vegetables has become consumer's choices nowadays since it is easier to prepare, ready-to-eat, and a healthy diet to be practice. A lot of nutrients can be obtained from the vegetables including potassium, dietary fiber, folate (folic acid), vitamin A, and vitamin C. Howev[e]r, fresh vegetables including cucumber and tomato has become one source of foodborne illness nowadays due to the contamination of potential pathogen bacteria such as *Salmonella, Listeria,* and *E. coli.* In the last two decades foodborne illness outbreaks and cases associated with fresh produce have rapidly increased (Warriner et al., 2009).

Pathogen contaminants in food products exposing public health and a serious economic risk for the food industry (Doran et al., 2005). Fresh produce is considered to be vehicles that easily transmit microorganisms into the consumer, especially when eaten raw or without peeling. *Listeria* and *Salmonella* are the most common pathogen involved in worldwide foodborne illnesses caused by gastroenteritis and other chronic infections. Recent outbreaks of foodborne illness related to vegetables indicate that the increased consumption of fresh produce may present new challenges to food safety in the future. Espigol et al., (2018) reported that *E. coli* and *Salmonella* were detected in fresh produce as shown in Table 4.

Table 4. Coliform count and detection of *Escherichia coli* and *Salmonella* spp. on fresh produce.

Sample	**Total Coliform (cfu/g)**		***Escherichia coli* (cfu/g)**		***Salmonella* spp.**	
	O	C	O	C	O	C
Broccoli	50	150	0	0	-	-
Cabbage	30	590	0	0	-	-
Celery	45	985	0	70	-	+
Green Ice Lettuce	250	955	0	345	-	-
Romaine Lettuce	60	35	0	0	+	-
Strawberry	140	115	0	0	-	+

O - Organic; C - conventional; (-) -not detected; (+) -presence of *Salmonella* spp. detected
Source: (Espigol et al., 2018).

CONCLUSION

The study revealed that though fresh produce such as fruits and vegetables provide healthy nutrients, they are possible source of foodborne pathogen if the production are not following the hygienic practices. *Salmonella* have been reported to contaminate fresh produce in several studies and some cause food poisoning outbreaks. With the increase in consumption of fruits and vegetables, it is important ensure the supply chain follow the guidelines to prevent contamination of *Salmonella.*

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