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A Review on Impacts, Resistance Pattern and Spoilage of Vegetables Associated Microbes

Review Article

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Vegetable spoilage produces various microbes of different origins like parasites, fungi, viruses, and bacteria. This causes infections and diseases in vegetables, and later on, when humans eat these vegetables; diseases induce in humans. So, to prevent human diseases, the symptoms of various infections in vegetables must be known. Moreover, the conditions supporting the infections in vegetables must be understood. So that spoiled vegetable consumption can be prevented. Sometimes spoiled vegetables are regarded as disease free and suitable for consumption. These misconceptions sometimes lead to lethal human diseases, which in history led to major outbreaks. The antimicrobial resistance is faced by microbes which deteriorate the situation and make the cure of diseases.

Keywords: Contamination, Antimicrobial resistance, Microbial growth, etiological agent, causative agent.

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Introduction

The 21st century is a scientific one built on the demand for a healthy diet in which vegetables play a vital role. This type of food is rich in phytochemicals, dietary fibres, minerals, vitamins and controls the spread of infectious diseases [1]. Various food health agencies like French Agency for Food Safety (FAFS), Food & Agricultural Organization (FAO)(EFSA), European Food Safety Authority, and World Health Organization WHO stated specific suggestions regarding this that people should include five vegetable servings each day for appropriate nutrient intake [2]. For more vital eating habits which must be inclusive generally, one should prefer fresh vegetables rather than cooked. Nevertheless, many aspects must be taken into account to reduce microbial contamination relevant to fresh and raw vegetables [3]. The foremost class ready-to-eat vegetables (RTE) are cultured in polluted conditions [4], water with poor quality [5][6], and fertilizable utilizing inorganic contents [7], [8]. All these factors give rise to microorganism contaminants and the spread of harmful diseases, for example, Shigellosis, diarrhoea, and Salmonellosis in humans. Bacteria, according to reports, play a major role in food-borne infections [9].

The food spoilage microbes such as bacteria contribute 66%, whereas the contribution of viruses and parasites is 4%, according to scientists' reports. Since its microbiota outweighs spoiling moulds, bacteria, and yeasts. Vegetable harmful bacteria are Clostridium botulinum, Listeria monocytogenes, Yersinia enterocolitica, Campylobacter spp, Bacillus cereus, Escherichia coli, and Salmonella. In contrast, they also hold some parasites and viruses [10][11][12]. In May 2008, at Oman Royal Hospital, B. cereus hospital acquired occurrence of gastroenteritis infected 58 individuals. In various vegetables, B. cereus and its toxin were recovered [13]. Moreover, a comparative outraging disease resulted in Germany in May–July 2011; Where etiological agent was Shiga toxin producing E. coli O104:H4 in which 2987 gastroenteritis incidents were recorded 855 incidents were of hemolytic-uremic syndrome, reporting 53 death. Later on, Fenugreek sprouts were recovered and contaminated with the etiological agent [14]. Bean sprouts were connected to two endemics in the USA in 2014; one happened in August and had causative agent L. monocytogenes, whereas the other was caused by Salmonella enteritidis; both existed with one month difference. Though opportunistic microbes can lead to lethal diseases in humans, principally in immunocompromised masses, that can result in a positive impact amongst immunocompetent peoples by inducing improvement and readying immune responses [15]. Nonpathogenic microbes connected with vegetables possibly influence the qualitative approach by food spoilage proportion. Vegetables can be the way which can distribute numerous microorganisms to the food formulation domain [16][17][18].

The demand for processed vegetable products is getting higher. It not only allows a lengthy duration acceptable from farm to fork but even opens a new chance for the growth of microorganisms. For instance, endemic strains can spread disease to novel locations and hosts, discovered as unprotected and thus comparatively more supersensitive. Moreover, the use of chemical disinfectants and cold storage techniques provide an ideal environment for resistant or adapted strains of bacteria, which incline and prevail in the food chain and cause existing pathogens to make toxins in vegetable food products. Inside the food market around the globe, it is even more challenging to maintain a hygienic environment within the food chain, which turns on by observing proper farming practices and processing after yield or following Standard Operating Procedures (SOPs) while handling vegetable products . The problems mentioned above necessitate the prospective of biopreservation for the food industry concerned with vegetables. Biopreservation pertain to living cells and/or their antimicrobic products to inhibit food-borne spoilage, pathogenic, or toxinogenic microorganisms [19]. Till now, lactic acid bacteria (LAB) are the most efficient microbial group as they have the potential to replace food-borne pathogens. Since they produce antimicrobials such as reuterin, hydrogen peroxide, acetoin, and organic acids, they potentially show competition for the nutrients and give rise to an exclusive environment [20], [21][22].

The Microbial infections are increasing with the passage of time in all vegetables. Where the number of common bacteria is numerous in certain vegetables during particular or throughout every season. Still, if we conclude, it is not wrong; those medicines found effective to treat vegetable infections previously are now resistant to the same pathogens responsible for the same disease. The microbes, including viruses, bacteria, and fungi, areincreasing day by day on specie specific ground . Th,is study aims to detect how many microbes in certain vegetables are resistant, non-resistant, and going to be resistant in the near future so that we adopt necessary precautions and research to devise plans to handle this problem effectively.for sustainable development

Organisms involved in the spoilage of various vegetables

Ordinarily, spoilage microbes recovered from extensive vegetables were molds, yeasts, and bacteria. The decay caused by bacteria was expressed as a slimy and watery layer. But few rots ,that appeared due to fungi are also watery and delicate, whereas they are distinguished from bacteria based on features like mycelium andspore-forming artifact. Generally, the species of Erwinia genus are involved in causing the most frequent and popular bacterial degradation of vegetables. Nearly all Erwinias species love to grow at refrigerator temperatures though few strains at favorable temperature for growth that is 1°C. These organisms specifically have the potential for fermentation of numerous vegetable alcohols and sugars, which cannot further be used by species other than Erwinia [23]. Moreover, lactic acid bacteria like pseudomonads group species especially; (P. syringae and P. fluorescens), Xanthomonascampestris, and lactic acid bacteria (lactic streptococci, leuconostocs, and lactobacilli) even lead to devastating spoilage of vegetable yield [23], [24][25].

The common molds involved in vegetable degradation are Mycosphaerella, Fusarium, Botrytis, Penicillium, Alternaria, Sclerotinia, Aspergillus, Bremia (mildew) Perenospora, Colletotrichum, Phytophthora, Cladosporium, Rhizoctonia, Geothrichum, Phomopsis, Ceratocystis, and Rhizopus. Substrate specification subsists amongst varied compositions of vegetable yield in accordance with different growth demands of various microbes.

Literature

Many outbreaks of food-borne illness have been reported in recent years. About half of Mexico's "traveller's diarrhoea" incidents were linked with lethal enterotoxigenic E. coli, isolated from raw vegetables. The corresponding organism was even the reason for New England's two outbreaks that happened in 1993 [26]. Raw vegetables were the medium of alone bacterial strain in both happening.E. coli O157:H7 was a reportable agent in 1995, which led to foodborne infections within Maine and Montana. These two outbreaks from two regions were researched, and contaminated lettuce was declared as a source [27], [28]. Similarly, the outbreak of salmonellosis in 1990 in the Midwest was a justification for raw tomatoes (sliced) intake [29]. Another attack, like septicemia caused by food, specifically diverse vegetables (fresh), were associated with Listeria monocytogenes[30], [31]. Shigellosis incidents were traced by isolation of Shigellaflexneriand contaminated scallions and lettuce [32]–[34].

The diverse variety of sprouts was found to be associated with food poisoning cases in the past. According to [35], several incidents occurred, which made history due to vegetable sprouts found infected with Bacillus cereus. The vegetable source, in this case, was contaminated seeds, in which the corresponding bacteria manifold during sprouting and lead to counts above 107 per gram and resulted in disease after some hours of intake (Shaik and Thomas, 2019) [36] were the two researches who recovered cytotoxic Aeromonas strain from vegetables, particularly alfalfa sprouts. Moreover, the same sprouts were responsible for an outbreak within British Columbia and Newport, Oregon, in 1995 that was salmonellosis, whose causative agent was Salmonella enteric serotype. The origin of the illness was contaminated seeds [37]. Whereas another salmonellosis outbreak had a similar origin; alfalfa sprouts from which Salmonella Havana were isolated in 1998 within Arizona and California [38]. Again in 1997, within the United States, the same vegetable source, alfalfa sprouts, were involved in two outbreaks of E. coli O157:H7 [39]. The seeds were the source of its causative agent. Still another outbreak occurred in 2000 in the Netherlands due to bean sprout intake in which Salmonella enteric serotype enteritidis (causative agent)was present. Nevertheless, the seeds which lead to major illnesses were decontaminated, but still, they were hazardous [40].

Moreover, not only bacteria but protozoa, for instance, Cryptosporidium parvum,Cyclosporacayetanensis and Giardia lambliaand infective Cryptococcus and Candidaandviruses (Norwalk and hepatitis virus) were the lethal cause of major outbreaks in the past. In Kentucky (1988), hepatitis A virus illness was caused by contaminated green salad intake [41]. Still, other illnesses due to the same virus occurred in 1994 where the virus was derived from tomatoes [42]. Gastroenteritis caused by the Norwalk virus was created by intake of green salad celery [43], [44].

The origin of nearly all parasitic-based illnesses was contaminated water. Still, some food-borne infections due to parasites were derived from fresh vegetables. In 1997 United States was infected with Cyclosporacaye tennis relevant illness. The vegetable source (lettuce) was the origin of the parasite [45]. A related disease in Peru occurred within the same year derived from raw vegetables [39]. Whereas in 1995 (United States) and 1997 (Peru), regions were contaminated with Cryptosporidium parvum illness [46], [47]. The medium of this parasite was a mixed salad containing celery and heterogeneous vegetables correspondingly. Again in 1992, the United States was associated with food-borne illness through raw vegetable intake by the presence of Giardia lamblia [48]. Growth of poisonous fungi upon stored vegetables, for instance, Penicillium, Fusarium, and Alternariaspp are liable to produce mycotoxins. The diacetoxy stiripentol was found on potato tubers when contaminated with Fusarium sambucinum [49]; Whereas [50] reported deoxynivalenol presence within potatoes contaminated with F. coeruleum and F.sambucinum [51]. A. alliaceous was associated with ochratoxin [52], [53], a yield through P. allii was connected with Meleagris and C. roquefortine yield [54] still, past research had not proven toxins presence in naturally contaminated garlic onions and. Alternations derived from Alternaria were found in tomatoes [55].

Mycotoxins vitality was dedicated to a variety of diseases posed to human health. Their relevancy of attributes pertains to neurotoxicity, carcinogenicity, mutagenicity, and acute or chronic toxicity. Nearly all these substances are heat stable; thus, they did not lose their activity after heat treatment of varied food products. Different spoilage fungi are opportunistic infective agents that lead to health risks for immunocompromised patients.

Other fungi-relevant substances were the stress metabolites derived from plants, jointly termed phytoalexins are released in case fungi inoculated plants [56]–[58]. For instance, phytoalexins were psoralens in celery, alkaloids, coumarins, terpenes, phenolicssolanidine derivatives in white potato tuber, pisatin in peas, batatic acid, terpenes, and coumarins in sweet potatoes, hydroxyphaseolin and phaseolin existed in beans which were found contaminated with Sclerotinia sclerotiorum [59]–[61]. Psoralens were associated with skin lesions and blisters appearing in human individuals [62]

Table 1: Vegetables-related microbes and their prevention

Vegetable	Microbe involved	Preventative methods	Citation
Lettuce	Coliform (fecal)	Vinegar founded washing	[6]
	Parasite-based Helminth infections	Washing by hand with running water	[6]

	Escherichia coli (O157:H7)		[12]
(RTE) Ready to eat vegetables and salads	Escherichia coli	Distinguishing and eradicating possible rootage of contamination. Modified atmospheric refrigeration and storage to enhance shelf-life	[3] [63] [64]
	Listeria monocytogenes		
	Salmonella		
Carrot	EnterotoxigenicE.coli	**General recommendations discussed** 1. Rinsing and washing and disinfectants and sanitizers usage 2. Chemical seed treatments for seed (sprout) involving chlorine compounds (sodium and calcium hypochlorite), ethanol etc 3. Thermotherapy (exposing seeds to temperature of 57 to 60 °C for short periods i.e. 10 min 4. Ionizing radiation usage 5. Testing (seed)	[12]
Cauliflower	Aeromonas		
	Salmonella		
Cabbage	Clostridium botulinum		
	Salmonella		
Tomato	Listeria monocytogenes		
	Salmonella		
Cucumber	Bacillus cereus		
	Listeria monocytogenes		
Spinach	Salmonella		

Table 2: Negative impacting microbes from plants

Type of Microbes in vegetables	Example of negative impacting microbes in vegetables
Bacteria	Corynebacterium sepedonicum.
	Erwiniacarotovora
	Pseudomonas marginalis.
	Erwiniacarotovora
Fungi	Colletotrichumerumpens.
	Alternaria tenuis,
Viruses	Tomato mosaic virus
	Potato leafroll virus (PLRV)
Parasites	Cyclosporacayetanensis
	Cryptosporidium parvum

Table 3: Positive impacting microbes from plants

S. No	Autochthonous positive impacting microorganisms	References
1.	Lactobacillus pentosus (CF2- 10 N)	[65]
2.	Saccharomyces cerevisiae (15A)	[66]
3.	Pichia guilliermondii (25A)	[66]
4.	Candida norvegica (7A)	[66]
5.	Pichia anomala (CL 30-29)	[67], [68]
6.	S. cerevisiae (Sc24)	[69]
7.	Candida boidinii (Cb60)	[69]
8.	Enterococcus faecalis (UP-11)	[70]
9.	Wickerhamomycesanomalus (QAUWA03)	[71]
10.	Kazachstaniahumilis (G23Y)	[72]

Table 4: Human illness related to plants

Pathogen	Examples of pathogen	Vegetable	Illness	Reference
Bacteria	Listeria monocytogenes	Cabbage	Listeriosis	[73]
	E.coli O157:H7 Enterotoxigenic strain	Lettuce	E.coli illness	
	E.coli (ETEC) strain	Carrots	ETEC illness	
	Salmonella species	Sprouts, Tomatoes,	Salmonellosis	
	Shigella	Lettuce	Shigellosis	
	Clostridium botulinum	Garlic (chopped)	Botulism	
	Bacillus cereus	sprouts	Bacillus cereus illness	
Viruses	Hepatitis A	Lettuce	Infectious hepatitis disease	

	Norwalk and Norwalk like a virus	Green salad celery		

Infections causate in vegetables

Before we discuss infections due to various microbes, including bacteria, yeast & molds; a known fact about some is that they are weak plant pathogens because they are involved in causing disease in plants before harvest. Some of the diseases caused by various pathogens in different plants are demonstrated in table 1, 2, 3, 4, and 5.

Table 5: Pathogens in different vegetables

Pathogen Type	Species of microbe	Type of infection	Vegetables having infection
Bacterial	Corynebacterium michiganense	fruit spot and Canker	Tomatoes etc
	C. sepedonicum	Tuber rot	Potatoes (white)
	Erwiniacarotovora	Bacterial soft rot	lettuce, beets, endives, Leafy crucifers, parsley,onions, celery, carrots,cucumbers garlic, tomatoes, peppers,
	Pseudomonas chicorii	zonate spot (Bacterial)	Lettuce and cabbage
	P. marginalis group	Vegetables (Soft rot)	Lettuce, etc
	P. morsprunorumgroup	Halo (blight)	Beans
	P. tomato group	Specks (bacterial)	Tomatoes
	P. syringaegrou	Soybeans (diseases)	Soybeans
	Xanthomonascampestris	Rot (black)	cauliflower and Cabbage
Fungi	Alternaria tenuis	Rot (Alternaria)	peppers, Tomatoes, cucurbits
	Alternariabrassicola	Rot (Alternaria)	Leafy crucifers
	Aspergillus alliaceus	Rot (black)	Garlic and onions
	Botrytis allii	Rot (Neck)	Onions
	B. cinerea	Rot (grey mould)	lettuce, Garlic, onions, leafy crucifers,asparagus,celery,sweet potatoes, pumpkin, squash, carrots, etc
	Bremialactucae	Mildew (downy)	Lettuce
	Ceratocystis fimbriata	Rot (black)	Sweet potatoes
	Cladosporiumcumerinum	Scab	Pumpkin and cucumber
	Colletotrichumcoccodesand other Colletotrichum species.	Anthracnose	Anthracnose
	Diaporthebatatis		Sweet potato
	D. vexans		Eggplant
	Fusarium species.	Rot (dry)	Potatoes
	Geotrichumcandidum	Sour rot	Asparagus, onions, garlic, parsnips, beans, carrots, parsley, globe artichokes crucifers, lettuce, endives, tomatoes,
	Mucor		Different vegetables
	Mycosphaerella		Cucurbits
	Rhizopusstoloniferand other Rhizopus species.	soft rot (Rhizopus)	Potatoes, sweet potatoes, crucifers, cucumber, beans, cauliflower, pumpkin, squash, tomatoes and cabbage
	Sclerotiniasclerotiorum	Soft rot (watery)	Carrots, beans and peas
	Rhizoctoniaspecies.	brown rot (slimy)	Different vegetables

Cruciferous Vegetables

Cruciferae family Cruciferous vegetables are cabbage, mustard greens, Chinese cabbage, collards, cauliflower, watercress, kale, broccoli, Brussels sprouts. The organic chemistry and constitution of these plants are alike; , they face common decomposition by

,similar microbes, which act as a source of disease with similar symptoms. For this ground, they are considered as groups. The chief spoiling microbes of crucifers include Erwiniacarotovora, Sclerotiniasclerotiorum, Mycosphaerellabrassicicola, Pseudomonas cichorii, Rhizopusstolonifer, Xanthomonascampestris, Pseudomonas maculicola, Botrytis cinerea, Peronosporaparasitica, A. oleraceaandAlternariabrassicae. Soft rot is a plant bacterial disease that infects vegetables (cruciferous) caused by Erwiniacarotovora. This microbe comes in the vegetables with injured curds and leaves. Symptoms of Erwinia make a water-soaked appearance in the infected tissue, and in the advanced stage, the product is changed into a slimy mass [74]. Pseudomonas maculicolamove into the leaves pores spots on cauliflower and broccol. Whereas in broccoli, the disease leave (about 1 mm diameter) small purplish-gray to black spots appear on leaves, florets, stems, and petioles. While in cauliflower, the decay is apparent as small, dark-centered, water-soaked spots on leaves and brown, gray, or black on cauliflower curds. It has been noticed that P. cichorii move into leaves through injury and initiate zonate spots in cabbage due to bacteria. This spoilage appears as buff to brown, dark-rimmed, and dark-centered, dry spots roughly 2 to 15 mm in diameter. Yet one other microorganism causing spoiling is Xanthomonascampestrisof leafy crucifers. This particular organism produces black rot, which is relevant to the blackening of the leaf veins. X. campestrispenetration starts within the field and acts as a source of different bacteria-borne diseases [74].

Alternariabrassicae chooses crucifers on which Alternaria leaf spot appears. This illness causes the manifestation of grey-brown to black spots of diameter (25 mm). These fungi become a source of disease in the field and incur rapid progression during storage and transport, particularly when temperature conditions of the product are well-kept above 10°C. Alternariabrassicae even lead to brown rot in cauliflower. This condition appear as brown to greenish black lesions of different textures and sizes. The parts of the plant having the disease are the curds; in which brown rot is produced in conditions of high humidity and temperatures of 2°C [74].

The source of grey mould rot is Botrytis cinerea. This causative agent is involved in diseases of cauliflower, Brussels sprouts, cabbage, and broccoli. The spoilage can appear at 0°C, but it gets deteriorated at higher temperatures. The fungus gets into wounds and appears greenish-brown to graybrown, water-soaked spots on leaves. Peronosporaparasitica is a causative agent of downy mildew amongst leafy cruciferous vegetables, whereas it gets its worst stage in cauliflower and cabbage. The illness produces white, downy spots upon leaves. Cauliflower and stems, and curds are also attacked. The decay initiates in the field,, which progresses even in the refrigerator at temperatures above 5°C. Rhizoctoniasolani is an infectious agent causing rhizoctonia head to rot in cabbage. The disease is initiated in contaminated soil; appearing as dry brown spots with mycelium and sclerotia visible. The spoilage increases rapidly within high humid conditions [74].

Rhizopus soft rot in brussels sprouts, cabbage, and cauliflower is caused by Rhizopusstolonifer. In this spoilage, the resulted part shows mushy appearance. Incorporated by coarse mycelium having dark sporangial structures. The optimal requirements for the specific spoilage are temperatures above 13°C and high humidity. Moreover, another microbe, specifically fungi named Sclerotiniasclerotiorum, is involved in the causate of the cabbage's watery soft rot and appears as water-soaked spots draped with white mycelium, while; Mycosphaerellabrassicicolais, a causative agent of ring spot of cauliflower. The last mentioned spoilage appears as greenish-yellow spots having water-soaked borders incorporated with black fruiting bodies during the mature stage. Both types of spoilage involve high humidity conditions [74]. But this spoilage can be lowered with careful storage at near 0°C, handling, and sorting.

Asparagus

The list of post-harvest spoilage list of asparagus is bacterial phyrophthora rot, fusarium rot, and soft rot. The causative agent of bacterial soft rot is Erwiniacarotovorawhich is referred to as asparagus common market disease [23], [74]. The bacterial entrance into the tissue happens by injury, and a watery softening condition appears with a foul smell. This is a lazy deterioration at temperatures below 2°C,thus; this condition is further stopped or reduced by maintaining asparagus spears at 2°C and trimming the damaged areas. The causative agent of fusarium rot is Fusariumspecies, manifested by white, fluffy mycelium upon the spears. The spoiled tissue appears soft and discoloured. The asparagus harvested must be kept at low temperatures (about 2°C) to inhibit this disease. Phytophthoraspecies is the cause of Phytophthora rot. Wet lesions manifest this disease upon the spears in between the area of the butt ends and the bottom of the tips. Greyish-white mycelium is seldom noticed. but proper refrigeration attempt leads to the control of the disease. More microbes associated with asparagus are Botrytis cinerea and Penicillium spp.In ref [5]it is noticed that for increased periods; holding the asparagus spear in the market progressive Penicillium spoilage and [23] was reportable of asparagus spoilage through Botrytis cinerea.

Onions and Garlic

Onions and garlic are the most commonly used vegetables in Pakistan but unfortunately; there are a varity of illnesses associated with them like Fusarium bulb rot, blue mould rot, Botrytis neck black mould rot, and bacterial soft rot. Bacterial soft rot is a specific disease of onions having a causative agent of Erwiniacarotovora; it moves into the onion bulbs by injury. This decay manifests as watery decay and putrid within a humid and warm situation. Aspergillus alliaceusand A. nigerare the causative agents of onion's black mould rot. This specific disease manifestsin conidial masses with black powdery deposits. Illness arises from the field, and contaminant travel from bulb to bulb and causes deterioration at a faster rate while in storage [75]–[77].Botrytis spp is the causative agent of (grey mould rot) Neck rot occurring in onions and garlic. Illness initiates from the neck, and the spoilage progresses to the scales base. The diseased tissue possesses greyish-brown colouration because of spores [73].

The most frequent Penicilliumspecies cause of spoilage in garlic is P. allii. [78] known to cause a disease termed "blue mould rot." This disease includes light yellow spots on the garlic cloves; but as the spoilage advances, blue spore masses appear. At the same time, the causative agents inhabiting onions are P. glabrum and P. albocoremium [79]. Bacterial decays follow onions bulb rots having a causative agent of Fusarium spp[75]. Disease arises from the base of the bulb, and as the illness advances, white to pinkish mycelium are visible. Fusarium appears as watery decay spoiling the whole bulb after some time. Humidity and high temperature increase the rate of decay. This disease is inhibited by carefully storing garlic and onions at 0°C, cullingdamaged and injured areas, and proper curing [73].

Table 6: Antimicrobial Resistance by vegetable-borne microbes

Bacterial species/ serotypes	Vegetable names	Antimicrobials having resistance	Antimicrobials not resistant	Resistance testing method	Countr y	Citation
Listeria ivanovii, Listeria grayi, Listeria welshimeri, Listeria monocytogenes	Salads ready to eat	Ampicillin, gentamicin, vancomycin, cefotaxime, Tetracyclin, chloramphenicol, erythromycin, penicillin, cephalothin, Amikacin, neomycin,	None	disk diffusion	Turkey	[80]

		clindamycin, oxacillin and streptomycin				
L. monocytogenes	Vegetables (frozen and fresh)	Tetracycline	Norfloxacin, ciprofloxacin, ampicillin, trimethoprim, minocycline, gentamicin, chloramphenicol, amoxicillin, erythromycin, rifampicin, vancomycin, and sulfamethoxazole	E-test, microdilution	Poland	[81]
Campylobacter jejuni	(ulam) vegetables of salad style	Gentamicin, erythromycin, enrofloxacin and ciproflfloxacin	Penicillin G, Ampicillin, tetracycline, amikacin, vancomycin and norfloxacin,		Malaysia	[82]
Salmonella Cubana, also 50 others	Cantaloupes, cilantro, green onions, alfalfa lettuce, celery, hot peppers, parsley, spinach, tomatoes and sprouts	NARMS panel of gram negative	Chloramphenicol, amoxicillin, streptomycin, sulfamethoxazole kanamycin, ampicillin, nalidixic acid, cefoxitin, cephalothin, sulfisoxazole, Tetracycline and trimethoprim	Sensitive, microdilution	United States	[83]
Salmonella SalmonellaAgona, Weltevreden, others	Autochthonous vegetables	None	Ampicillin, erythromycin, cefotaxime, tetracycline, streptomycin, chloramphenicol, gentamicin, trimethoprim–sulfamethoxazole ceftriaxone, and nalidixic acid	Disk diffusion	Malaysia	[84]
S. enterica subsp.enterica—serovar not specified	Tomato, cucumber, cantaloupe,carrot, spinach, and radish	Aztreonam, cefoxitin, gatifloxacin, netilmicin, gentamicin, ciprofloxacin, meropenem, moxifloxacin, cefixime, imipenem, nalidixic acid, kanamycin, tobramycin,	Amikacin,ampicillin, amoxicillin–clavulanic acid, cotrimoxazole, azithromycin, chloramphenicol, colistin, tetracycline, streptomycindoxycycline and erythromycin	disk diffusion	India	[85]

		norfloxacin, piperacillin, ofloxacin, polymyxin B and sparfloxacin,				
B. cereus	Fermented soybean products	Erythromycin, ciprofloxacin, imipenem, clindamycin, trimethoprim, tetracycline, vancomycin, chloramphenicol, and gentamicin	Cefepime, Ampicillin, sulfamethoxazol, penicillin, oxacillin, and cefotetan	Disk diffusion	Korea	[86]

Antimicrobial Resistance

Against various microbes, antimicrobial resistance is encountered. In table 06, there are a few microbes with antimicrobials having resistance against them. These names are mentioned to create awareness and understanding that agents when given against certain microbe isolated from certain vegetables are ineffective because that particular antimicrobial agent has developed antimicrobial resistance against the microbe and is no more sensitive and effective.

CONCLUSION

The common vegetables of Pakistan having common fungal and bacterial diseases are found in vegetables in all four seasons at different times. Bacterial soft rot caused by Erwiniacarotovoraignite a watery decay and putrid, within a humid and warm situation and Aspergillus alliaceusand nigerare the causative agents of onion's black mould rot, which is of fungal origin. They are forming black powdery deposits in both onion and garlic. But the most frequent fungus Penicilliumspecies is a cause of spoilage in garlic known as P. alliiknown to cause a disease termed "blue mould rot." This disease includes light yellow spots appearing on the garlic cloves.

Moreover, rot dry is also a common disease on dry potatoes by Fusarium. Xanthomonascampestris forming Rot (black) on cauliflower and Cabbage. Specks (bacterial) on tomatoes having caused by p tomato group of bacteria.P. morsprunorumgroup causing Halo (blight) on beans. Therefore not only fungus is prevalent in vegetables in Pakistan but bacteria is dominant too because of the favorable environment offered in particular regions of Pakistan at various seasons.

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