THE UNIVERSITY OF MELBOURNE

FOOD20006

Food Microbiology & Safety

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Food-borne viral diseases

Ray and Bhunia Ch 2, 24, 28, 29

Intended learning outcomes

- Describe the characteristics of viruses that enable them to be transmitted in food and/or water
- Describe how some viruses can persist in food commodities

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Viruses

‘Small infectious agent that replicates only inside living cells of an organism.’

- Viruses infect all types of life forms
- Very basic structure:
  - Genome (DNA or RNA, ss or ds, linear, segmented, +ve or –ve sense)
  - Protein coat (capsid)
  - Enveloped or unenveloped
    - Lipid bilayer (cell membrane)
    - Glycoproteins (different functions)
    - Sensitive to desiccation, heat, detergents
    - Limited survival outside the host.

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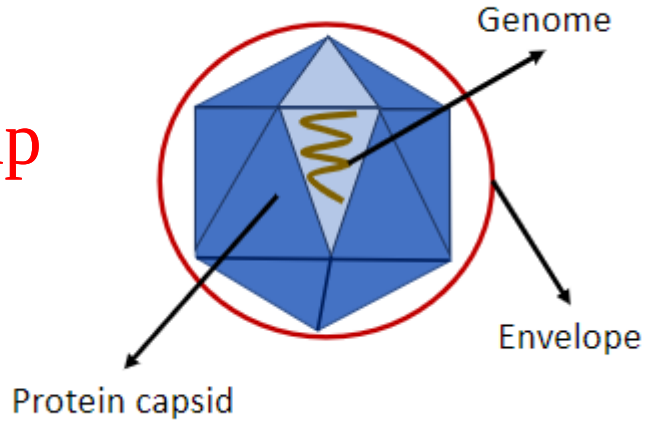

Most common food-borne viruses

- Norovirus (*Caliciviridae*) – non-enveloped, ssRNA
- Hepatitis A virus (*Picornaviridae*) – non-enveloped, ssRNA
- Hepatitis E virus (*Hepeviridae*) – non-enveloped, ssRNA
- Human rotavirus (*Reoviridae*) – non-enveloped, segmented RNA
- Other viruses (Adenovirus, Astrovirus, Sapovirus, Enterovirus, Parvovirus, Aichi virus)
- Emerging viruses (Nipahvirus, SARS-Coronavirus, Flavivirus[TBE], Avian influenza virus H5N1)

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Clinical syndromes

Gastroenteritis (diarrhoea, vomiting)

Norovirus, human Rotavirus (Adenovirus, Astrovirus, Sapovirus)

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Enterically transmitted hepatitis

Hepatitis A and E

Viruses and food

Viruses do not replicate in food

Viruses do not cause deterioration of food

Viruses are hardy and persist in the environment

Food hygiene guidelines which are optimised for controlling bacteria are not always effective against viruses

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Transmission

Faecal-oral route

Person-to-person (NoV and HAV) – secondary spread

Contaminated water, food, infected food handler

Very low infectious dose (1-100 virions)

Very high levels of viral shedding in infected individuals (10^7 virions per gram of stools)

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Transmission

Human sewage and faeces

- Contamination of bivalve molluscs
- Pre-harvest contamination of fresh-produce (irrigation, washing, fertiliser)
- Potential for contamination with multiple viruses
- Conducive to viral evolution and emergence of new virus strains
- Recombination (NoV) or reassortment (HRV)

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Table 2
Estimates of anti-HAV seroprevalence by age group and world region, 1990 and 2005.

	Region	Year	1–4	5–9	10–14	15–19	20–24	25–34	35–44	45–54	55–64	65–74	75–84	85+
1	High-income Asia Pacific	1990	4	9	14	18	23	32	46	61	78	98	100	100
		2005	6	12	19	25	32	42	56	70	84	99	100	100
2	Central Asia	1990	35	46	57	68	76	87	98	100	100	100	100	100
		2005	47	56	65	73	80	88	98	100	100	100	100	100
3	East Asia	1990	0	3	13	23	35	53	70	88	100	100	100	100
		2005	17	31	44	53	65	77	88	95	100	100	100	100
4	South Asia	1990	73	87	95	98	99	100	100	100	100	100	100	100
		2005	93	98	99	100	100	100	100	100	100	100	100	100
5	Southeast Asia	1990	0	5	17	28	38	56	73	88	96	100	100	100
		2005	20	35	35	56	67	79	88	96	100	100	100	100
6	Australasia	1990	2	7	11	15	18	22	31	41	52	63	75	88
		2005	2	7	13	19	24	32	41	52	63	75	88	100
7	Caribbean	1990	2	10	40	52	60	70	80	91	97	99	100	100
		2005	2	10	40	52	60	70	80	91	97	99	100	100
8	Central Europe	1990	14	20	28	35	43	52	61	72	80	86	90	94
		2005	35	43	47	52	58	64	72	80	86	90	94	99
9	Eastern Europe	1990	27	31	36	42	47	57	69	83	97	100	100	100
		2005	35	43	51	57	65	74	83	93	99	100	100	100
10	Western Europe	1990	0	3	13	23	36	52	66	79	88	92	99	100
		2005	1	7	18	28	37	50	63	73	83	92	99	100
11	Andean Latin America	1990	48	58	69	80	90	96	100	100	100	100	100	100
		2005	84	90	94	96	98	100	100	100	100	100	100	100
12	Central Latin America	1990	45	56	66	74	82	90	96	98	100	100	100	100
		2005	56	69	82	90	96	97	98	99	100	100	100	100
13	Southern Latin America	1990	29	48	59	68	78	89	96	100	100	100	100	100
		2005	29	64	81	89	96	98	100	100	100	100	100	100
14	Tropical Latin America	1990	33	46	60	72	81	92	100	100	100	100	100	100
		2005	65	71	76	82	86	91	100	100	100	100	100	100
15	North Africa/Middle East	1990	29	45	59	72	82	92	97	100	100	100	100	100
		2005	68	75	81	87	92	98	100	100	100	100	100	100
16	High-income North America	1990	0	0	2	4	7	11	20	29	37	47	56	68
		2005	0	0	5	11	16	22	29	37	47	56	68	79
17	Oceania	1990	9	33	56	74	88	98	100	100	100	100	100	100
		2005	41	54	66	78	88	98	100	100	100	100	100	100
18	Central sub-Saharan Africa	1990	98	99	100	100	100	100	100	100	100	100	100	100
		2005	98	99	100	100	100	100	100	100	100	100	100	100
19	East sub-Saharan Africa	1990	90	95	98	100	100	100	100	100	100	100	100	100
		2005	98	100	100	100	100	100	100	100	100	100	100	100
20	South sub-Saharan Africa	1990	83	92	94	95	96	97	98	99	100	100	100	100
		2005	83	92	94	95	96	97	98	99	100	100	100	100
21	West sub-Saharan Africa	1990	72	90	94	95	96	97	98	99	100	100	100	100
		2005	72	90	94	95	96	97	98	99	100	100	100	100

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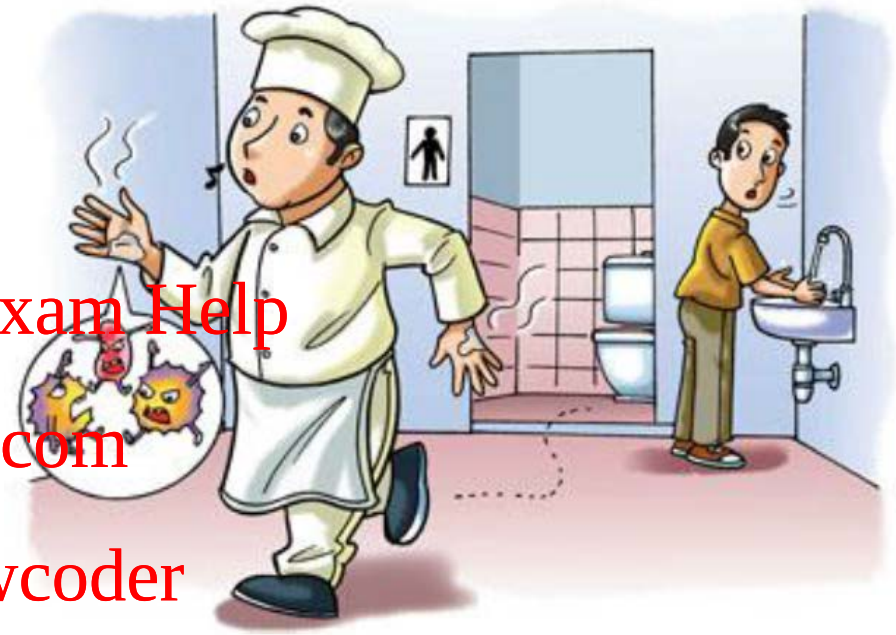
Jocobsen and Wiersma (2010). *Vaccine* 28: 6653-7

Transmission

Infected food handlers

- >10^7 viral particles per gram of faeces
- Viral shedding as early as 12hr after exposure (before clinical symptoms)
- Shedding for several weeks (after recovery)
- Asymptomatic infections and shedding (5.2-19% NoV; Netherlands)
- Direct contamination of food or equipment
- At any stage of the farm-to-fork chain
- Vomitus – widespread contamination



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Transmission

Zoonotic transmission

- Animal faeces
  - HEV in pig faeces
  - SARS-coronavirus
  - Nipah in fruit
- Raw meat
  - HEV in liver and meat of deer or wild boar
  - HEV in pig meat and organs

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Epidemiology

Susceptibility varies depending on aetiological agent:

- NoV - all ages
- HAV - asymptomatic in children
- HRV - in children and infants
- HEV - severe in pregnant women

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Determining incidence is difficult (person-to person transmission)

Control measures different to those used for bacterial food-borne pathogens

Priority virus-commodity combinations

1. NoV and HAV – Bivalve molluscan shellfish (oysters, clams, cockles and mussels)

- Faecal contamination of harvesting areas
- Persistence for 8-10 weeks in contaminated live shellfish
- Molluscs can actively accumulate and concentrate viruses
- Light cooking does not completely inactivate the viruses

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Priority virus-commodity combinations

2. NoV and HAV – Fresh produce

- Sewage-contaminated water
- Infected food handler
- Pre-or post-harvest
- 20M Ha agricultural land irrigated with raw, treated or partially diluted wastewater
- Global market

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Priority virus-commodity combinations

3. NoV and HAV – Prepared foods

- Infected food handlers
- Poor personal hygiene
- Outbreaks with hundreds of cases
- Foods that do not receive terminal heating before consumption
- Deli, bakery, salads, ready to eat foods

4. HRV – water for food preparation

5. Emerging viruses and associated commodities

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Risk assessment for NoV and HAV

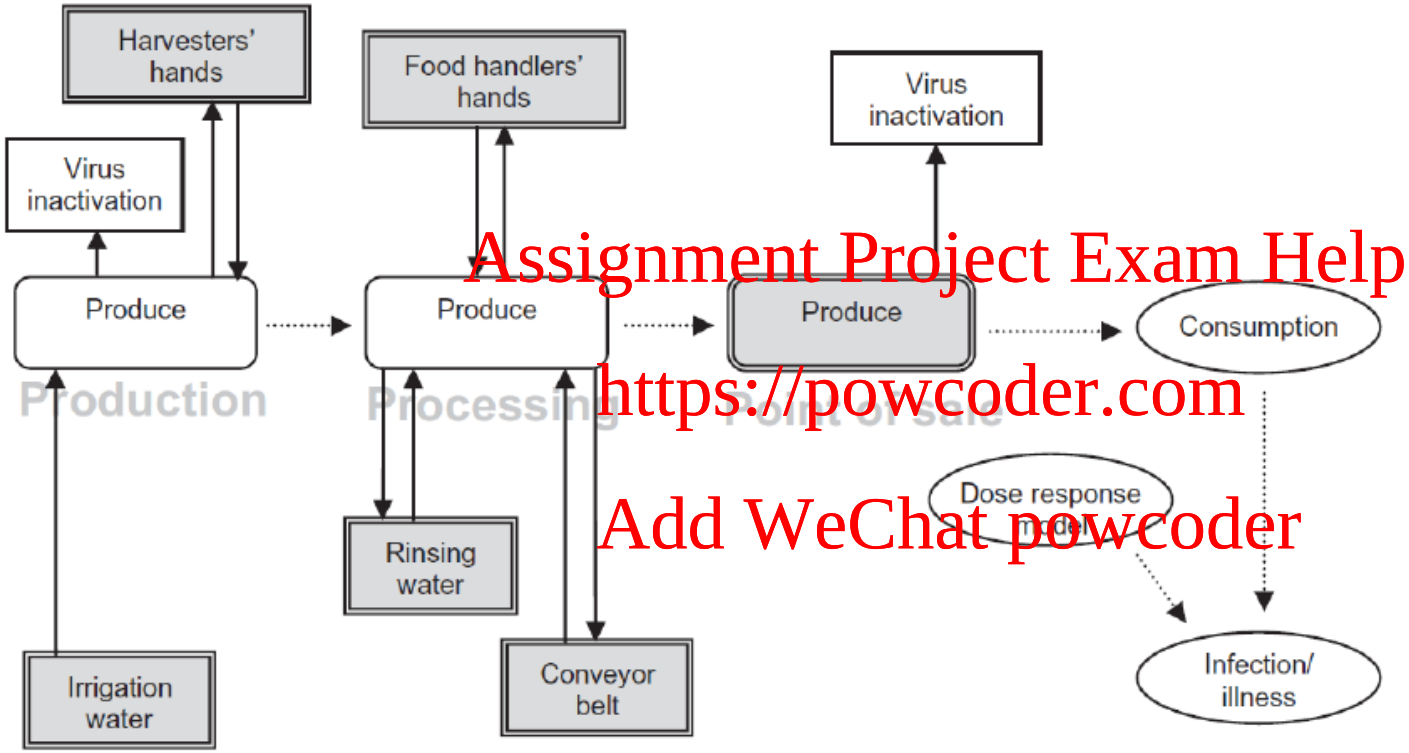

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Fig. 1. Full conceptual model of the soft fruit and leafy green vegetable production chains. Each box represents a module. The actual models differ per production chain based on the practice applied in that chain. Double-lined, shaded boxes indicate where samples were collected in the monitoring. Ovals indicate processes that occur in the consumer phase.

Bouwknegtet al (2015). Quantitative farm-to-fork risk assessment model for norovirus and hepatitis A virus in European leafy green vegetable and berry fruit supply chains. *Int J Food Micro* 198: 50-58.

Detection of the aetiological agents

Foodborne viruses cannot readily be enriched by culture methods

Molecular methods to detect viral nucleic acid

- Low numbers of organisms – sampling and testing large volumes of food
- Need to extract and concentrate viruses prior to detection
- Need for extracts to be free of inhibitors of detection methods
- Does not indicate presence of viable virus

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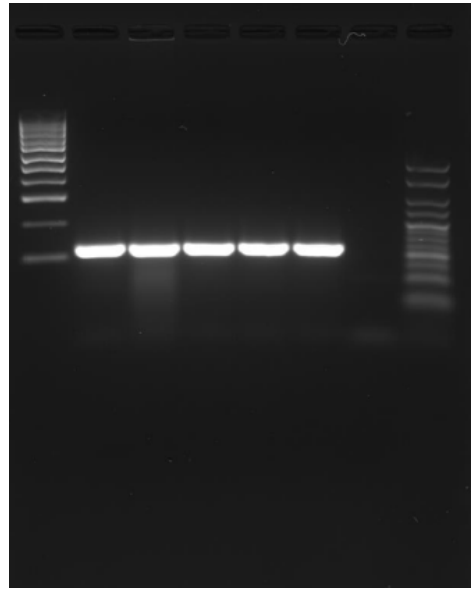
Large variety and complexity of foods

- Food handler or irrigation water – surface contamination
- Bivalve molluscs – internal

High degree of genetic variability

Complex task and costly

Model organisms – limitations!



Considerations for control

Persistence of foodborne viruses

HRV – 9 days at 20°C

Low humidity favours Adenovirus (35 days), HAV and HRV

High humidity favours for Enterovirus

Weeks or months in shellfish

Longer than shelf-life in fresh produce

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Considerations for control

Stability during processing

Survive prolonged periods at low (3-4) or high (9-10) pH

Variable depending on process and substrate

Standard milk pasteurisation – inactivate HAV

Much longer process to inactivate HAV in bivalve molluscs

Resistant to ionising radiation

Refrigeration and freezing normally help preserve viruses

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CONTROL MUST FOCUS ON PREVENTION OF CONTAMINATION

Control

Decontamination of hands

Hand washing, streaming water and towel drying

Hand sanitisers not as effective (only 1-2 $\log_{10}$ reduction)

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Decontamination of surfaces

Viruses easily transferred from hands to surfaces, and vice-versa

Common chemical disinfectants do not effectively inactivate HAV

Difficult to know if measures were effective

Control by prevention

For molluscs and fresh produce – no realistic post-harvest risk management measures (except cooking)

Bivalve molluscs

Growing areas versus sewage

Collaboration (public health authorities, food safety authorities, wastewater treatment authorities, producers)

Monitoring virus occurrence in production areas – appropriate analytical methods

Depuration is not effective

Batch testing of food not recommended

No aquaculture operations in areas susceptible to sewage contamination

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Control by prevention

Fresh produce

Good quality water for irrigation, fertilisation, harvest and packing

Water quality guidelines

Adequate sanitary facilities available

Personal hygiene of manual harvesters

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Handling

Management of ill employees and return to work guidelines

Personal hygiene – **hand washing**

Education of handlers and supervisors

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