Cryptosporidium spp.

Cryptosporidium parvum, *C. hominis*
Protozoa, class of Sporozoera

Parasite

anses
French agency for food, environmental and occupational health & safety

Characteristics and sources of *Cryptosporidium* spp.

Main microbial characteristics

Cryptosporidium spp. is the causative agent of cryptosporidiosis. It is a unicellular parasite belonging to the Coccidia subclass of the phylum Apicomplexa. The multiplication cycle includes both sexual and asexual stages, in the epithelium of the intestine, sometimes that of the bile duct or, very exceptionally, that of the respiratory tract. The parasite's asexual multiplication leads to contamination of neighbouring cells in the digestive epithelium and its alteration. Sexual multiplication leads to the formation of oocysts which are shed in faeces and can infect directly.

Five species of *Cryptosporidium* are considered pathogenic, *C. parvum*, *C. hominis*, *C. felis*, *C. meleagridis* and "rabbit genotype" *Cryptosporidium*. The vast majority of cases of cryptosporidiosis in humans (>90%) are due to *C. parvum* (principal animal reservoir: ruminants) or *C. hominis*. The other species are mainly found in immunocompromised subjects.

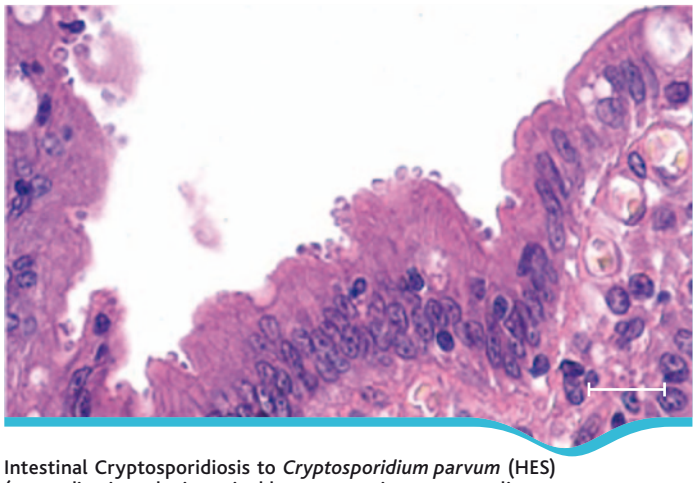
Cryptosporidium oocysts remain viable and infectious in water and in faeces for up to six months at temperatures between 0 and 30°C, and for up to a year in seawater. They cannot multiply in the environment, but can survive for several months in cool, humid conditions.

Sources of the hazard

C. parvum mainly infects newborn ruminants, in which it can cause serious neonatal diarrhoea. Shedding peaks between 5 and 25 days, and this age range is a major source of the hazard. Adult animals can also be reservoirs, but levels of shedding are much lower (asymptomatic carriers are not unknown).

Human faeces are a significant source of *C. hominis*, particularly during the diarrheal phase of the disease.

The consequences for humans of *Cryptosporidium* being carried by wild or domestic vertebrates have not been evaluated. However, the risk of humans being infected with *C. canis* or *C. felis* (from pet dogs or cats) may be considered low in the general population.



Intestinal Cryptosporidiosis to *Cryptosporidium parvum* (HES) (protruding into the intestinal lumen, parasites seem to cling to the apex of enterocytes. J.-F. Pays. (source : ANOFEL)

Transmission routes

Contamination is by faecal matter from an infected host. Transmission can occur by ingestion of oocysts (which can infect directly, once emitted) or by contact with infected hosts. Medical staff and paramedics, farmers and veterinarians are particularly exposed to the hazard.

Water is the principal vector for contamination, but oocysts can also be disseminated by birds, filter-feeding shellfish, insects (flies) or contaminated farm equipment (overalls, boots). The extent to which the different sources or routes contribute to contamination (human-to-human, foodborne, environmental) is unknown. Travel in countries with poor levels of hygiene may be considered a risk factor for contracting cryptosporidiosis.

Data sheet on foodborne biological hazards
January 2011

Recommendations for primary production

- Reinforce hygiene measures when in contact with infected subjects or animals (wear gloves, etc.). Avoid contact between newborn ruminants and sick animals. Inform personnel concerned about cryptosporidiosis and how to prevent it.
- Particular care must be paid to the production of crops grown with spray irrigation, and also to shellfish farming. The *Cryptosporidium* hazard should be taken into account when drawing up vulnerability profiles of shellfish-growing areas to prevent the contamination of these waters. It should also be taken into account when considering applications for authorisation to use drinking water resources, especially where resources are thought to represent a risk.

Human foodborne disease

Nature of the disease (Table 1)

Susceptible population groups(1)**:** immunocompromised subjects (particularly AIDS patients) suffering from affected bile ducts are susceptible to complications. Young children are also susceptible to infection: 18% of cryptosporidiosis cases in France concern children under 4 years old, and 52% of cases in the UK concern children under 9 years old.

Dose-effect(2) and dose-response(3) relationships

A 50% infectious dose (ID_{50}(4)) of *C. parvum* for healthy volunteers varies from <10 to >2,000 oocysts, depending on the strain. For *C. hominis*, one study estimated it at between 10 and 83 oocysts. In im-munocompromised subjects, the ID_{50} is not known, but it is between 1 and 5 oocysts in immunosuppressed animals. The LD_{50} is not known. A dose-response relationship has been determined for the water matrix (AFSSA, 2002).

Epidemiology

Surveillance system

In France, only clustered cases of foodborne cryptosporidiosis are subject to mandatory notification as foodborne illness outbreaks. Since 2006, 38 hospital parasitology laboratories have been notifying cases to the ANOFEL *Cryptosporidium* network, which collects and genotypes the isolates, in the absence of a dedicated National Centre of Reference. The European Centre for Disease prevention and Control (ECDC) centralises epidemiological data for cryptosporidiosis from 30 European countries. In the United States, FoodNet (CDC) has been collecting confirmed cases since 1997.

Prevalence

Cryptosporidiosis is found throughout the world. Rates of infection vary from 0.6 to 2% in industrialised countries and from 4% to 32% elsewhere. Higher rates have been observed in AIDS patients with chronic diarrhoea. In France, from 2006 to 2009, 407 cases (54.2% *C. parvum*, 36.4% *C. hominis*, 9.4% other species) were notified to the ANOFEL *Cryptosporidium* network, with a peak in late summer and early autumn. Of these cases, 18% were observed in children and 38% in AIDS sufferers.

In Europe, more than half of countries provide incomplete or no information on prevalence. In 2007, 6220 cases were notified: children under 5 were the most seriously affected. Here too, a peak was observed in late summer and early autumn.

Outbreaks

Several epidemics have been reported (mostly in the United States and the United Kingdom), mainly related to the consumption of drinking water (Milwaukee in 1993 with 403,000 cases and, in France, Sète in 1998, Dracy-le-Fort in 2001, Divonne-les-Bains in 2003), or ingestion of bathing water in swimming pools or leisure centres (main cause of epidemics in the USA and the UK).

The principal non-waterborne outbreaks were due to the consumption of unpasteurised cider or cow's milk.

Role of food

Main foods to consider

Water is the principal vector for food contamination, especially water from public distribution systems. Fruit and vegetables (lettuce, carrots, radishes, etc.) can be contaminated with infectious oocysts from the soil or water (untreated water used for irrigation). Milk and, more rarely, meat can become contaminated by direct contact with the faeces of shedding animals or their environment. If these foods are not washed carefully, or pasteurised or cooked, they can contain oocysts.

Filter-feeding shellfish (oysters, mussels, clams), if raw or insufficiently cooked, can retain oocysts, which remain infectious in seawater. In France, the risk of shellfish being contaminated is higher when they come from an area where shellfish gathering is not authorised. However, no epidemic related to the consumption of these products has so far been reported.

(1) Susceptible population group: people with a higher than average probability of developing symptoms of the disease, or severe forms of the disease, after exposure to a foodborne hazard [in the case of the ANSES data sheets].

(2) Relationship between the dose (the quantity of microbial cells ingested during a meal) and the effect on an individual.

(3) For a given effect, the relationship between the dose and the response, i.e. the probability of this effect appearing, in the population.

(4) ID_{50} is the dose causing the onset of infection in 50% of individuals exposed, while LD_{50} is the dose causing the death of 50% of individuals exposed.

Table 1. **Characteristics of the disease**

Mean incubation period	Target population	Main symptoms	Duration of symptoms	Duration of infectious period (shedding)	Complications	Asymptomatic forms
7 days	Cosmopolitan All ages M/F ratio: variable, depending on studies	Diarrhoea (98%), watery (81%) Abdominal pain (60-96%) Weight loss (50-75%) Nausea (35%) Vomiting (49-65%) Fever (36-59%)	11-13 days (mean)	From onset of symptoms up to several weeks after disappearance of symptoms (subclinical infection).	Immunocompromised subjects: Severe and prolonged diarrhoea, gall bladder affected in about 30% of cases. Very rarely located out-side the digestive tract. Lethality can be very high among very immunocompromised subjects. Nutritional impact on children in developing countries. Possible extra-digestive consequences: joint or ocular pain, apparently more frequent in cases of infection by *C. hominis*. Lethality: increased in children malnourished or suffering from AIDS, and in AIDS patients (50% in 1 year during the Las Vegas epidemic in 1994).	Yes: Frequency unclear. Estimated at 1.3% of children attending day-care centres in the UK.

Inactivation treatments in industrial environments

Retention treatments

Flocculation, sedimentation and membrane filtration are the most reliable procedures. Ultrafiltration or microfiltration can obtain five decimal reductions in the initial load. Slow biological filtration results in four decimal reductions.

Chemical treatments

The oocysts are resistant to the majority of chemical substances at doses generally used for water treatment. While prolonged exposure to high concentrations can lower the initial quantity of *Cryptosporidium* by two decimal reductions, it leads to the formation of undesirable secondary compounds and is therefore incompatible with use for foodstuffs. Certain products have been cited as being effective against oocysts for other foods: gaseous ammonia from 50%, formaldehyde at 10% and hydrogen peroxide at 3%. Oocysts cease to be infectious after exposure to ozone (1.11 $mg.L^{-1}$ for 6 min).

Physical treatments

Table 2. **Physical treatments**

Treatments	Efficacy	Recommended conditions
Heat	Destruction or lowered infectivity of the oocysts	≥ 5 sec at ≥ 72°C
Freezing	80% of inactivation	5 days at –20°C
Ultraviolet radiation	Lowered by 3 $\log_{10}$ reduction*	400 J/m2
Solar radiation	Lowered infectivity of the oocysts	10 h at 830 W/m^2
Ionisation	Transient lowering by 2 $\log_{10}$ reduction	10 kGy
High pressure (artificially contaminated fruit juice)	> 5 $\log_{10}$ reduction	1 min at 550 MPa
High pressure (oysters)	> 90% of inactivation	3 min at 550 MPa
Drying	Total inactivation	Not specified

* Under conditions of use specified by the manufacturer.

Monitoring in food

In Europe, there are no regulations governing the detection of *Cryptosporidium* in food matrices, and in particular for water, except in the United Kingdom, where the regulations stipulate that water pro-duced must not contain more than 1 cyst/10 litres.

Screening in water: there are four methods for counting oocysts whose structures appear intact, No.1623 by the US EPA, that of the UK's Drinking Water Inspectorate (2005), ISO 15553 (2006) and the French NF T90-455 (2001). They provide no information on the viability, infectivity or species of the parasites.

Screening in solid foods: no standardised procedure.

Recommendations to operators

- ***Cryptosporidium*** **should be taken into account in the hazard analysis by operators concerned with foods that are immersed in or spray-irrigated by potentially contaminated water. Appropriate control measures should be taken.**
- **This hazard should be taken into account in the context of any request for authorisation to use a resource for drinking water, especially for resources thought to represent a risk.**
- **Kitchen staff or anyone else involved in handling foods, especially those intended to be consumed raw or partly cooked, should be made aware of the risk of faecal-oral transmission and the need to observe strict hygiene measures (washing hands thoroughly).**

Domestic hygiene

Recommendations to consumers

- **Observe hygiene rules including thorough washing of hands (after using the toilet, after changing nappies and after contact with animals or their excreta), plus the thorough washing of cooking utensils and work surfaces, especially before handling food.**
- **Thoroughly wash foods that may be contaminated with *Cryptosporidium* oocysts: lettuce, radishes, carrots, strawberries, etc. Cook food if it cannot be washed normally through a lack of drinking water.**
- **Other important recommendations, especially for immunocompromised people and young children, and in countries with poor hygiene levels: do not drink untreated surface water or water from wells or sources that have not been analysed; avoid unpasteurised fruit juice, ice if you are uncertain where it came from or how it was prepared, or raw shellfish, if not taken from an authorised or inspected growing area.**
- **Avoid contact with droppings and infected animals (farm visits, etc.).**

Moreover, it should be remembered that swimming in natural waters (lakes, rivers) or artificial bathing pools (AFSSET Report, 2009) may represent a risk (by ingestion).

References and links

General references

- AFSSA. *Rapport d'expertise sur les infections à protozoaires liées aux aliments et à l'eau : évaluation scientifique des risques associés à Cryptosporidium sp.* [Report of collective expert appraisal of infections by food- and water-borne protozoa: a scientific assessment of the risks associated with *Cryptosporidium* sp.] AFSSA, September 2002, 185 pp.
- EHC *Cryptosporidium*, Draft 2.1, WHO Guidelines for Drinking Water Quality. *Cryptosporidium* 02 January 2006, 138 pp. http://www.who.int/water_sanitation_health/gdwqrevision/cryptodraft2.pdf
- The ANOFEL *Cryptosporidium* National Network. Laboratory-based surveillance for *Cryptosporidium* in France, 2006–2009. Euro Surveill. 2010;15(33):pii=19642. http://www.eurosurveillance.org/ViewArticle.aspx?ArticleId=19642
- Annual report of the ECDC: http://www.ecdc.europa.eu/en/publications/Publications/0910_SUR_Annual_Epidemiological_Report_on_Communicable_Diseases_in_Europe.pdf#page=102
- WHO (2009), Risk assessment of Cryptosporidiosis in drinking water.
- Technical document for public comment "Enteric Protozoa: Giardia and *Cryptosporidium*" from Health Canada, 2010. http://clf2-nsi2.hc-sc.gc.ca/ewh-semt/alt_formats/hecs-sesc/pdf/consult/_2010/giardia-cryptosporidium/giardia-cryptosporidium-eng.pdf

Useful links

- ANOFEL *Cryptosporidium* laboratory network (coordinator: francis.derouin@sls.aphp.fr)
- http://www.cdc.gov/crypto/
- http://www.wales.nhs.uk/sites3/page.cfm?orgid=457&pid=48350