Occurrence of Parasites on Fruits and Vegetables in Norway

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ABSTRACT

Between August 1999 and January 2001, samples of various fruits and vegetables obtained within Norway were analyzed by published methods for parasite contamination. Neither Cyclospora oocysts nor Ascaris (or other helminth) eggs were detected on any of the samples examined for these parasites. However, of the 475 samples examined for Cryptosporidium oocysts and Giardia cysts, 29 (6%) were found to be positive. No samples were positive for both parasites. Of the 19 Cryptosporidium-positive samples, 5 (26%) were in lettuce, and 14 (74%) in mung bean sprouts. Of the 10 Giardia-positive samples, 2 (20%) were in dill, 2 (20%) in lettuce, 3 (30%) in mung bean sprouts, 1 (10%) in radish sprouts, and 2 (20%) in strawberries. Mung bean sprouts were significantly more likely to be contaminated with Cryptosporidium oocysts or Giardia cysts than the other fruits and vegetables. Concentrations of Cryptosporidium and Giardia detected were generally low (mean of approximately 3 [oo]cysts per 100 g produce). Although some of the contaminated produce was imported (the majority, if sprouted seeds are excluded), there was no association between imported produce and detection of parasites. Cryptosporidium oocysts and Giardia cysts were also detected in water samples concerned with field irrigation and production of bean sprouts within Norway. This is the first time that parasites have been detected on vegetables and fruit obtained in a highly developed, wealthy country, without there being an outbreak situation. These findings may have important implications for global food safety.

Various fruits and vegetables have been demonstrated to be the vehicle for transmission of a range of parasites. Parasites that have been associated with vegetable- or fruit-borne outbreaks of infection include the protozoan parasites Giardia intestinalis (27, 31, 32), Cryptosporidium parvum (26), and Cyclospora cayetanensis (2, 7, 13, 15, 16), and the helminth parasites Fasciola hepatica (6, 12) and Ascaris lumbricoides or Ascaris suum (34).

In a review (39), the case is made for foodborne infection being a problem which should be of increasing concern. Global trading and increasing numbers of susceptible individuals are key factors. Further, trends in many countries toward eating more raw, or lightly cooked, vegetables to preserve taste and heat-labile nutrients may also increase the likelihood of foodborne infections.

Almost all published surveys of fruits and vegetables for parasites have been conducted in countries where parasitic infection may be considered endemic in some sectors of the population and where socioeconomic conditions may favor parasite transmission, e.g., Brazil (8, 10, 11, 24, 40), Costa Rica (28), Malaysia (5), Peru (30), Philippines (9). These surveys generally indicate a low level, widespread occurrence of parasite transmission stages on fruits and vegetables obtained from commercial sources. Nevertheless, the increasing export of fruits and vegetables from all regions of the world, and the high longevity of the transmission stages of many parasites (especially in the moist microclimate required for export of many fruits and vegetables), indicates that all areas of the world should be concerned about the potential for parasite transmission via contaminated fruit and vegetable produce.

Additionally, as some parasites are zoonotic and thus also occur in animals, even fruits and vegetables produced in countries in which human parasitic infection is not considered widespread should be considered to be potentially a source for human transmission. Cryptosporidium and Giardia have been demonstrated to occur widely in water courses of many industrialized countries, e.g., Australia (42), Canada (35, 43), Germany (14, 19), Netherlands (20), New Zealand (18), Norway (37), Taiwan (17), the United Kingdom (22), the United States (21–23), and may contaminate produce during irrigation and/or processing. Water contamination may be from human or animal sources. Furthermore, infected animals have the potential to contaminate produce, either as a result of fertilization procedures (e.g., slurry spraying) or during handling, transport, or storage of the products in areas in which infected animals may have contaminated the environment (e.g., farm yards, etc.). The increased interest in organic farming may further exacerbate this potential. Pickers, handlers, packers, and other individuals involved in the production and processing of products may also have the potential to contaminate produce.

Herein we describe the results of a survey undertaken between August 1999 and January 2001 to assess the extent of parasitic contamination of various fruits and vegetables available commercially in Norway.
TABLE 1. Fruits and vegetables involved in survey

<table>
<thead>
<tr>
<th>Fruit or vegetable</th>
<th>Country of origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raspberries</td>
<td>Belgium, Chile, Norway</td>
</tr>
<tr>
<td>Strawberries</td>
<td>Belgium, Egypt, Israel, Italy, Norway</td>
</tr>
<tr>
<td>Alfalfa sprouts</td>
<td>Norway</td>
</tr>
<tr>
<td>Dill</td>
<td>Unknown (all imported)</td>
</tr>
<tr>
<td>Lettuce (Chinese leaves, frisee, green lollo, head, iceberg, oakleaf, red lollo)</td>
<td>Belgium, Norway, Spain, Portugal, unknown</td>
</tr>
<tr>
<td>Mung bean sprouts</td>
<td>Norway</td>
</tr>
<tr>
<td>Mushrooms</td>
<td>Netherlands, Norway, unknown</td>
</tr>
<tr>
<td>Parsley</td>
<td>Norway, b unknown</td>
</tr>
<tr>
<td>Precut salad mixes; eight different types, containing mixtures of raw precut vegetables including broccoli, carrot, cabbage (red, green, and white), celery, leek, lettuce (iceberg, rosso, and Chinese leaves), onion, pepper (red, green, and yellow)</td>
<td>Norway, b unknown</td>
</tr>
</tbody>
</table>

Notes:

a Seeds imported.
b Although precut salads were prepared in Norway, the origin of individual components is unknown. It is probable that some components are imported and some grown in Norway.

MATERIALS AND METHODS

Vegetables and fruits. Fruits and vegetables that are frequently eaten raw (Table 1) were analyzed for Cryptosporidium oocysts, Giardia cysts, Cyclospora oocysts, and Ascaris and other helminth eggs. Not all samples were analyzed for all parasites. Numbers of samples of produce analyzed for the various parasites are described in Tables 2 (Cyclospora), 3 (helminths), and 4 (Cryptosporidium and Giardia).

All produce were obtained within Norway, but some were imported and some grown locally (Table 1). All produce, whether locally grown or imported, was delivered to the laboratory by commercial fruit and vegetable distributors, with the exception of nine raspberry samples and nine strawberry samples that were bought at local retailers.

Irrigation and processing water. Eleven samples of water from a river used for lettuce crop irrigation in southern Norway were analyzed for Cryptosporidium and Giardia. The samples were collected from three locations on four occasions between early July and early September 2000.

Three water samples associated with irrigation of bean sprouts within Norway were also analyzed for Cryptosporidium and Giardia. Two of these water samples were rinse water that had been used in irrigation, and one sample was water taken directly from the source, before contact with the sprouting seeds.

Analysis of fruit or vegetable samples for Ascaris and other helminths, Cryptosporidium, Giardia, and Cyclospora. Development of the methods used in this survey is described in detail elsewhere (36, 38). In brief, portions of fruits and vegetables were weighed into homogenizer bags containing a central filter (BagPage, Breveté, France & Etranger) and processed. Sample weights were usually 50 g for alfalfa, mung bean, and radish sprouts, between 10 and 80 g for parsley, between 15 and 60 g for dill, and approximately 100 g for all other items (range = 23 to 121 g; mean ± standard deviation [SD] = 97 ± 15 g; median = 100 g).

Sample processing was divided into four distinct stages: (i) elution of material from the sample matter into aqueous suspension, (ii) concentration of the suspension, (iii) separation of the parasites in the suspension from other debris (for samples analyzed for Cryptosporidium and Giardia and/or Cyclospora) using paramagnetic beads, and (iv) screening by microscopy. These four sections are briefly outlined below. Further details can be found in Robertson and Gjerde (36, 38).

Elution. The samples were washed twice in a sealed homogenizer bag by a repeated washing (in a rotating drum) and sonication process in a detergent solution containing membrane-filter elution buffer (1). After each washing and sonicating cycle the washings were collected.

Concentration. The combined elution fluid was concentrated by centrifugation. The final pellet was brought to 10, 20, or 30 ml with distilled water and mixed thoroughly using a vortex mixer. Final volume was dependent on the analyses being conducted on a particular sample. All samples were analyzed for Cryptosporidium and Giardia (requiring 10 ml suspension), but if helminth analysis or Cyclospora analysis was also being conducted, the pellet was brought to 20 ml. If all analyses (Cryptosporidium and Giardia, helminths and Cyclospora) were being conducted the pellet was brought to 30 ml.

Ten milliliters was removed by calibrated pipette for immunomagnetic separation (IMS) for Giardia and Cryptosporidium analysis (see below), and 10 ml removed by calibrated pipette for Cyclospora analysis (see below). The remaining 10 ml was again concentrated by centrifugation, giving a final pellet of between 0.5 and 1.5 ml, depending upon sample type.

Separation of Cryptosporidium oocysts and Giardia cysts. IMS of 10 ml of the centrifugation concentrate was conducted using a commercially available kit (Dynal GC Combo; Dynal Microbiology R&D, Dynal) for Cryptosporidium and Giardia (3, 36). The combined elution fluid was concentrated by centrifugation. The final pellet was brought to 10, 20, or 30 ml with distilled water and mixed thoroughly using a vortex mixer. Final volume was dependent on the analyses being conducted on a particular sample. All samples were analyzed for Cryptosporidium and Giardia (requiring 10 ml suspension), but if helminth analysis or Cyclospora analysis was also being conducted, the pellet was brought to 20 ml. If all analyses (Cryptosporidium and Giardia, helminths and Cyclospora) were being conducted the pellet was brought to 30 ml.

Ten milliliters was removed by calibrated pipette for immunomagnetic separation (IMS) for Giardia and Cryptosporidium analysis (see below), and 10 ml removed by calibrated pipette for Cyclospora analysis (see below). The remaining 10 ml was again concentrated by centrifugation, giving a final pellet of between 0.5 and 1.5 ml, depending upon sample type.

Separation for Cryptosporidium oocysts and Giardia cysts. IMS of 10 ml of the centrifugation concentrate was conducted using a commercially available kit (Dynal GC Combo; Dynal A.S., Oslo, Norway). Complete details of the procedure are given in the kit package insert. Separation is in a specially designed magnetic holder.

Separation for Cyclospora. The procedure was based upon the method described for IMS for Cryptosporidium oocysts and Giardia cysts and has been published elsewhere (38). Wheat germ agglutinin-coated paramagnetic beads (D245/4; Dynal Microbiology R&D, Dynal) were used for capture.

Screening. The final concentrate from the centrifugation was screened by brightfield microscopy at ×100 using a Whitlock counting chamber. All parasites were sought at this screening, with emphasis on helminth eggs, particularly Ascaris.

The final concentrate from the IMS (approximately 50 μl) was fixed to microscope slides, labeled with fluorescent monoclonal antibody for Giardia and Cryptosporidium (Aquaglo GiC direct, Waterborne Inc., New Orleans, La.), and 4’6-diamidino-2-phenylindole, and screened using a fluorescence microscope as described elsewhere (3, 36). Positive samples were sealed with nail varnish and stored.

The 50-μl samples following separation for Cyclospora were screened as wet mounts as described elsewhere (38).

For all parasites, appropriate calculations were performed to estimate the number of parasites in the whole of the sample from the number detected in the subsample.
TABLE 2. Results of analysis of samples of fruits and vegetables for Cyclospora oocysts

<table>
<thead>
<tr>
<th>Fruit or vegetable</th>
<th>Number analyzed</th>
<th>Number (%) positive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa sprouts</td>
<td>1</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Dill</td>
<td>2</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Lettuce</td>
<td>13</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Mung bean sprouts</td>
<td>16</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Mushrooms</td>
<td>5</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Parsley</td>
<td>2</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Precut salad mixes</td>
<td>8</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Raspberries</td>
<td>8</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Strawberries</td>
<td>30</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Total</td>
<td>85</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

TABLE 3. Results of analysis of samples of fruits and vegetables for Ascaris eggs and other helminths

<table>
<thead>
<tr>
<th>Fruit or vegetable</th>
<th>Number analyzed</th>
<th>Number (%) positive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa sprouts</td>
<td>13</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Dill</td>
<td>3</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Lettuce</td>
<td>86</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Mung bean sprouts</td>
<td>81</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Mushrooms</td>
<td>32</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Parsley</td>
<td>2</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Precut salad mixes</td>
<td>35</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Raspberries</td>
<td>6</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Strawberries</td>
<td>40</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Total</td>
<td>300</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

Analysis of water samples for Cryptosporidium and Giardia. Ten-liter water samples were collected in plastic carboys. The analytical procedure was based upon draft Method 1622 (1), with modifications to enable analysis for both Cryptosporidium and Giardia.

Before analysis, the sample was shaken thoroughly and a small volume removed for turbidity measurement (Hach turbidimeter 2100A). The analytical technique can be divided into five distinct sections as follows: membrane filtration of sample, elution of material from membrane filter, concentration of eluted material by centrifugation, isolation of parasites from concentrated eluted material by IMS, and screening by microscopy. These five sections are described in brief below.

Membrane filtration. The water sample was pumped through a membrane filter (142-mm Isopore membrane, 2.0-µm pore size; Millipore Corp., Bedford, Mass.) held in a standard 142-mm filter holder under negative pressure. Volume of water filtered was measured.

Elution of material from membrane filter. Following filtration, the membrane filter was washed manually in detergent solution and sonicated as described elsewhere (1).

Concentration of eluted material by centrifugation. The combined membrane filter washings were concentrated by centrifugation.

Isolation of Cryptosporidium and Giardia by IMS. The final pellet was resuspended in 10 ml water and the IMS procedure followed as previously described.

Screening for Cryptosporidium and Giardia. The screening procedure followed was identical to that described above for the fruit and vegetable samples.

Recovery efficiency of techniques used. Seeding experiments were conducted to assess the recovery efficiency of the techniques used. Details of these experiments can be found elsewhere (36–38). In brief, fruit, vegetable, or water samples were seeded with appropriate parasites of known concentration, the described method followed and the recovery efficiency was calculated. Recovery efficiencies from lettuce and strawberries were approximately 42% for Cryptosporidium, 67% for Giardia, and 72% for Ascaris (36). Recovery efficiencies from bean sprouts tended to be more variable and lower (36). Recovery efficiencies of Cyclospora oocysts from mushrooms, lettuce and raspberries were approximately 12% (38). Recovery efficiency of Cyclospora oocysts from bean sprouts was approximately 4% (38). Recovery efficiency from water samples was approximately 43% for Cryptosporidium and 67% for Giardia (37).

Analysis of data. Data were compiled in a spread sheet (Microsoft Excel) and analyzed as appropriate using descriptive statistics (mean, standard deviation), and by construction of contingency tables to test for associations.

RESULTS

Occurrence of parasites in fruits and vegetables. Cyclospora oocysts were not detected on any of the 85 samples examined for this parasite (Table 2), nor were Ascaris or other helminth eggs detected on any of the 300 samples examined for these parasites (Table 3). However, Cryptosporidium oocysts and Giardia cysts were detected on various samples of fruits and vegetables (Table 4).

Of the 475 samples examined for Cryptosporidium oocysts and Giardia cysts, 29 (6%) were found to be positive. No samples were positive for both parasites.

Of the 19 Cryptosporidium-positive samples, 5 (26%) were in lettuce and 14 (74%) in mung bean sprouts. Of the 10 Giardia-positive samples, 2 (20%) were in dill, 2 (20%) in lettuce, 3 (30%) in mung bean sprouts, 1 (10%) in radish sprouts, and 2 (20%) in strawberries.

TABLE 4. Results of analysis of samples of fruits and vegetables for Cryptosporidium oocysts and Giardia cysts

<table>
<thead>
<tr>
<th>Fruit or vegetable</th>
<th>Number analyzed</th>
<th>Cryptosporidium number (%) positive</th>
<th>Giardia number (%) positive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa sprouts</td>
<td>16</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Dill</td>
<td>7</td>
<td>0 (0)</td>
<td>2 (29)</td>
</tr>
<tr>
<td>Lettuce</td>
<td>125</td>
<td>5 (4)</td>
<td>2 (2)</td>
</tr>
<tr>
<td>Mung bean sprouts</td>
<td>149</td>
<td>14 (9)</td>
<td>3 (2)</td>
</tr>
<tr>
<td>Mushrooms</td>
<td>55</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Parsley</td>
<td>7</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Precut salad mix</td>
<td>38</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Radish sprouts</td>
<td>6</td>
<td>0 (0)</td>
<td>1 (17)</td>
</tr>
<tr>
<td>Raspberries</td>
<td>10</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Strawberries</td>
<td>62</td>
<td>0 (0)</td>
<td>2 (3)</td>
</tr>
<tr>
<td>Total</td>
<td>475</td>
<td>19 (4)</td>
<td>10 (2)</td>
</tr>
</tbody>
</table>

*a No sample was positive simultaneously for Cryptosporidium and Giardia.
Mung bean sprouts were significantly more likely to be contaminated with Cryptosporidium oocysts or Giardia cysts than the other produce ($P < 0.005$).

For both Cryptosporidium and Giardia, concentrations detected were generally low (Table 5), ranging from 1 to 6 oocysts per 100 g produce for Cryptosporidium (mean ± SD = 3.3 ± 1.6 per 100 g produce) and 1 to 8 cysts per 100 g produce for Giardia (mean ± SD = 3.3 ± 2.3 per 100 g produce).

Of the five lettuce samples positive for Cryptosporidium, three were imported (one from Spain, two from Portugal), and two were Norwegian. Of the two lettuce samples positive for Giardia, both were Norwegian. Both the strawberry samples positive for Giardia were imported (from Israel) as were the dill samples (two positive for Giardia), although it was not possible to establish the dill’s country of origin. The 18 sprouting seed samples positive for parasites (17 mung bean sprouts, 1 radish sprout) had all been grown in Norway, but the seeds for both these (which are an integral part of the final crop) had been imported. The mung bean sprout seeds were of Chinese origin, and the radish sprout seed was European in origin.

There were no statistically significant associations between detection of these parasites and whether produce was imported or grown in Norway, even after exclusion of sprouting seeds from the analysis, or when only considering strawberries, lettuce, and dill.

**Occurrence of Cryptosporidium oocysts and Giardia cysts in irrigation and processing water.** In the 11 samples of irrigation water sampled, turbidity measurements varied between 1.4 and 3.0 (mean ± SD = 2.1 ± 0.5), and Cryptosporidium oocysts were detected in 5 (45%) of the samples and Giardia cysts in 2 (18%) of the samples (Table 6). In positive samples, concentrations of parasites detected were low (Table 6). On two occasions all samples taken were negative for both parasites, and on two occasions all samples taken were positive for one or more of the parasites. Some of the lettuces analyzed were grown at the sites irrigated by the irrigation water analyzed, but parasites were not detected in these lettuces.

Insufficient data were collected to investigate any association between turbidity and occurrence of parasites.

Among the three water samples associated with bean sprout production that were analyzed, parasites were not detected in the single precontact water sample. In the two samples of postcontact irrigation water, a single Cryptosporidium oocyst was detected in one 10-liter sample, and a single Giardia cyst was detected in the other 10-liter sample.

**DISCUSSION**

During a relatively extensive search of fruit and vegetables within Norway, parasitic contamination was found to be low. Helminth eggs were not detected on any of the produce analyzed for these parasites, nor were Cyclospora oocysts. However, both Cryptosporidium oocysts and Giardia cysts were detected on various vegetable and fruit produce, although percentage of produce positive was low for both parasites. No attempt was made to assess viability, infectivity, or strain/isolate of parasite. While both Cryptosporidium and Giardia have been detected on fruits and vegetables in surveys in less prosperous tropical or semitropical countries (11, 28, 30), to our knowledge this is the first time that these parasites have been detected on fruits and vegetables in a highly developed, wealthy country, without there being an outbreak situation.

No known cases of infection were associated with contaminated produce throughout the survey period. This may have been because the level of contamination was below the human infectious dose, because the parasites were nonviable or noninfectious to humans, or because, if infection occurred, it was not always identified and/or not associated with specific product consumption.

Although some of the produce from which the parasites were detected was imported, some was grown locally (within Norway), indicating that parasitic contamination of foodstuffs should not only be considered to be of exogenous origin. Indeed, irrigation water was also found to contain both these parasites, demonstrating the potential for one possible route for contamination of produce grown in Nor-
way, although parasites were not detected in lettuces grown in fields irrigated by this water. However, it should be noted that unusually high and prolonged rainfall during this period meant that irrigation requirements were minimal. Previous survey of water sources in Norway has also revealed contamination with *Cryptosporidium* oocysts and *Giardia* cysts (37).

Other potential routes of contamination (e.g., via fertilization procedures, contaminated environments during handling, transport and storage, or direct contamination from individuals involved in the production and processing of products) were not investigated.

Despite the strong association between mung bean sprouts and contamination with these parasites, none of the documented outbreaks of foodborne cryptosporidiosis and giardiasis have been associated with this product (39). However, consumption of sprouting seeds has been implicated in various outbreaks of illness including salmonellosis and *E. coli* O157 infection (33, 41) in the United Kingdom, the United States, Finland, Sweden, Denmark, Holland, Canada, and Japan. In most of these outbreaks of illness, the sprout type associated has been alfalfa, although soy, cress, mustard, radish, and mung bean have also been implicated. In particular, consumption of mung bean sprouts has been associated with a *Salmonella* Saint-Paul outbreak in the United Kingdom in 1988 involving 143 cases (29) and an outbreak of salmonellosis in California in 2000 involving 45 cases (33). In our survey, none of the samples of alfalfa sprouts was found to be positive for parasites, but *Giardia* was detected in one sample of radish sprouts. Radish sprouts were associated with two large outbreaks of *E. coli* O157 infection in Japan in 1996 and 1997 (25, 41). In the first of these, over 9,000 people (mostly school children) were affected and 11 died.

It has been suggested that contaminated seed has been the source of most, if not all, sprout-associated disease outbreaks (4), with seed contamination occurring at the farm, seed processor, or sprouting facility. Seed is apparently frequently grown, milled, and stored in conditions where contamination can occur readily (4). Contamination with pathogenic bacteria may be very low, but conditions and processes during sprouting are ideal for amplifying numbers of *Salmonella* and *E. coli* and also for spreading the infective agent throughout the entire production lot. However, for pathogens such as *Cryptosporidium* and *Giardia* that do not amplify outside their hosts, the risks of adverse public health consequences are considered similar for sprouts to those for other products, or, indeed, less due to the extensive washing used during sprout production (4). Our survey, however, indicates that sprouts are more likely to be contaminated than other fresh produce, and the limited examination of rinse and prerinse water also indicates that seeds, which in this survey were imported, are likely to be the source of contamination. This is presumably due to the seeds themselves being an integral component of the final produce.

The possible routes for seed contamination are described in full elsewhere (4), but the primary reason for seed contamination appears to be that the seeds are treated as a raw agricultural product rather than a food product. Indeed most seed grown is used for agricultural purposes rather than sprouting, and the decision is often not made until postharvesting. Further difficulties may arise from scarification procedures to alter germination characteristics that may make subsequent pathogen removal difficult, and complicated processing, shipping, and selling practices that may involve mixing of multiple lots of seeds of different origins.

In conclusion, although the extent of occurrence and the concentrations of parasites detected on contaminated fruits and vegetables were low, in Norway the potential exists for acquisition of *Cryptosporidium* and/or *Giardia* infection from consumption of contaminated produce. The most important contaminated product was mung bean sprouts, but lettuce, dill, radish sprouts, and strawberries were also found to be contaminated. Contaminated produce may have been grown within Norway or been imported. These findings may have important implications for those concerned with global food safety and indicate the need for further investigation in this area.

**ACKNOWLEDGMENTS**

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