EHEC Outbreak Germany 2011 linked to Organic Farming

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Contents

1. Introduction

This story is about an outbreak in early summer 2011 in Northern Germany of a new and uncommon serotype of Escherichia coli O104:H4 with strong hemolytic characteristics and multiple resistances against antibiotics. The serotype infection resulted into almost 4000 patients with acute gastroenteritis or hemorrhagic colitis, 855 cases of a hemolytic uremic syndrome and 53 deaths. The outbreak in this case is most probably connected to organic agricultural management, despite the denial of government agencies and commercial organic organizations.

Those denials ignored systematically the literature on previous outbreaks, clearly linked to organic farming or small scale structured agriculture, based on hard field data and demonstrating a striking persistence of virulent EHEC strains in soil and on plant surfaces.

Previous cases of serious health damage caused by organic farming are reported from the USA: Organic pomegranates from Turkey have caused numerous infection cases on hepatitis A in 2013 (Craft Cynthia, 20141106; FDA, 20130923). A strong evidence regarding a connection between organic farming and EHEC outbreaks is also reported in detail by

As an addendum to this text see the collection of illustration on Escherichia coli genomics and teratology: (Ammann Klaus, 20141109)

For a beginning, it is recommended to study a graph coming from (Bell, 2002), taking into account the possible infection pathways, indirectly also including the food production.

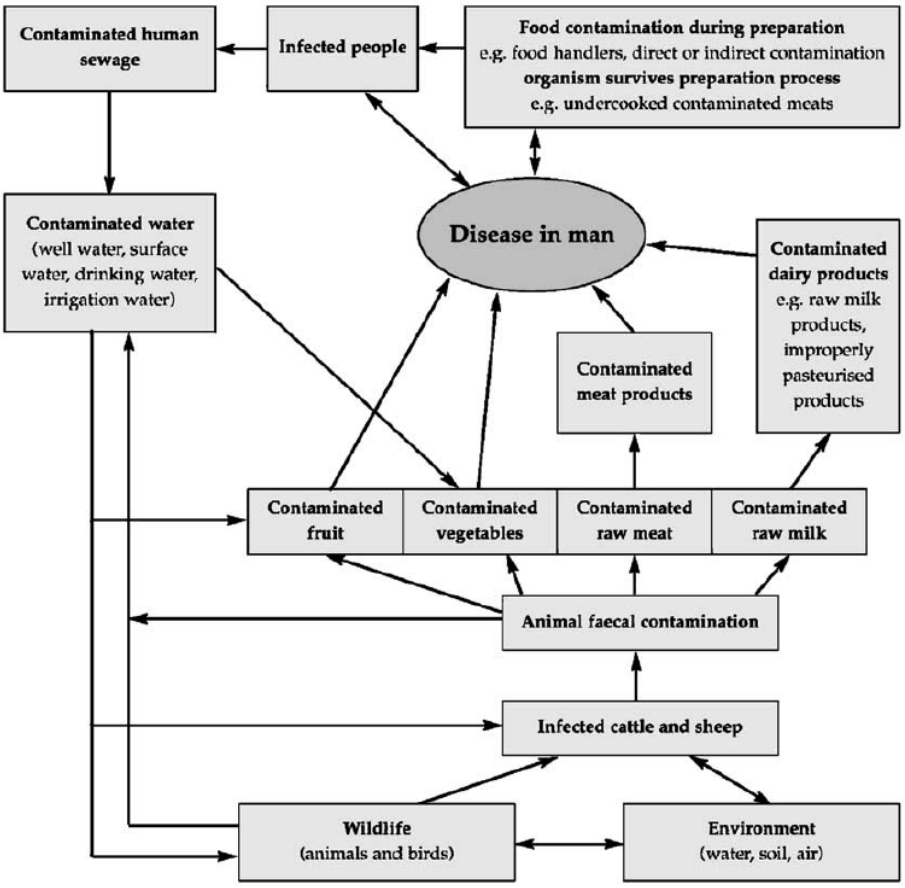

Figure 1 Simplified diagram of the current main routes of transmission of EHEC (fig. 1 from (Bell, 2002)

2. Summary of the German EHEC O104:H7 Outbreak

The first incidence of the latest outbreak of an entero-hemorrhagic Escherichia coli (EHEC) strain in Germany was registered on the first of May 2011 – it took the health authorities by surprise, and it lasted 22 days for them to react properly, although there were plenty of scientific data available as a serious warning about the impact of similar coli strains for many years.

EHEC food-borne illness outbreaks have been described years before in Japan, California, Scotland etc., in most cases causing bloody diarrhea, serious illness including dramatic damage to the kidneys of hundreds, even thousands of patients – and sadly also mortality (51 deaths in a first survey in Germany by July 10, 2011, the final number mounted to 53 deaths). In numerous scientific papers the connection to liquid manure has been established, with hard field data and also with lab inoculation experiments. The problems have been growing over the years with the striking genomic flexibility of the highly infectious germ (50 cells are sufficient to cause illness!). The impact of outbreaks is also exacerbated by the germ's tolerance against stomach acid and with the fact that the new strains have newly acquired virulence, are resistant to antibiotic treatments and show a remarkable persistence on plant surfaces, but also reside inside crops and seeds. They also persist in soil impregnated by infected manure, in the case of EHEC O157:H7 - manure from ruminant carriers - and in the case of O104:H4 exclusively by human carriers. Consequently, the EHEC problems will probably stay with us for at least many years, *until the agricultural systems and daily life hygienic measures behind the sources* will be adapted properly and infections through human faeces can be excluded for good. Even then, the high flexibility of EHEC strains will always be prone for new surprises. Unfortunately, a specific European attitude is working against the clarification of the background of the epidemics: Despite the fact that there are clear relationships to organic farming management systems with previous EHEC-outbreaks, the majority of the public, most of the media and unfortunately also health authorities in Germany (and Europe) are reluctant to dig into the real reasons of the outbreak – namely to clarify with scientific field and laboratory data the interrelationship between the practice of processing liquid manures and agricultural management systems. Only then one could, according to the acquired data, subsequently take appropriate preventive measures. Up to now, this reluctance is based on the ideologically misguided principle of nature being basically benign (also the main reason why organic farming has such a positive image). In the United States researchers, the press and the public were more pragmatic, there is for instance an important body of research which has dealt without prejudice with the relationship of EHEC outbreak and organic farming, as for instance in the outbreak from Minnesota and Wisconsin from 2003, (Mukherjee et al., 2007).

3. Genomics of EHEC

The *science of the EHEC genomics* is fascinating, since *Escherichia coli* as a truly ubiquitous organism can be found in humans (1-2 billion cells per individual), animals, plants and the environment – the overwhelming majority of strains are not only benign but essential for our health. Escherichia coli also has an extraordinary flexibility in its genome (Touchon et al., 2009; Yang et al., 2011). Genomic insight in EHEC strains had an early start in 80ties, when Helge Karch and his colleagues (Karch et al., 1987; Levine, 1987) discovered the details on how those dangerous EHEC strains can adhere to intestinal cells. A further unwelcome discovery was that certain *E. coli* strains produce Shiga-like toxins (STEC, also called Verotoxins VTEC) (Buvens & Pierard, 2012) , causing severe health problems. Another major progress in knowledge is marked by the discovery of a specific *eae* gene locus causing lesions in the intestinal tissues (Jerse et al., 1990). Some years later, the complete DNA sequence of the virulent plasmid of

EHEC strain O157:H7 has been published (Burland et al., 1998) and the main genome of this EHEC strain was also decoded (Perna et al., 2001). This is the strain which caused the notable and serious Californian outbreak, well documented in (California Food Emergency Response Team, 2007) starting in 2003.

(Scheutz et al., 2011) point to seven previously reported cases of diarrhea or Hemolytic Uremic Syndrome (HUS) worldwide caused by EAggEC O104:H4: from Germany in 2001, France in 2004, South Korea in 2005, Georgia in 2009 and Finland in 2010. Reliable detection methods have only recently been established (Sidari & Caridi, 2011). It must be seen that EHEC research needs still a boost, although efforts have been multiplied after the German outbreak, and the O104:H7 Genome has been sequenced and published in an unprecedented speed: (Askar M, 2011; Scheutz et al., 2011; Sims & Kim, 2011; Struelens, 2011; Studholme et al., 2011). With amazement, the geneticists discovered, that the new strain O104:H4 not only is well adapted to human gut environment (whereas O157:H7 stems from ruminants), it also causes acute bleeding problems and severe kidney damage, and worse, it is also is remarkably resistant to treatment with antibiotics, leaving as a remedy nothing but the massive exchange of blood, which is of limited effect and mortality is unavoidable (up to today July 10, 2011 51 deaths are counted, the final number of death toll is presently at 53). The special virulence of the new strain is also in the linked with its ability to produce Shiga toxins. Actually, the new strain has adapted so perfectly to new opportunities – genetic engineers could not have done a better job (Rasko et al., 2011). Promptly some incurable opponents of genetic engineering indulge into wild speculations and relate it to GM crops (Ho, 2011), a clear case of malicious polemics. The most recent genomic analysis comes from Tietze et al. (Tietze et al., 2015):

4. The Epidemiology of the latest EHEC O104:H4 outbreak in Germany

Although lead by experienced researchers like Helge Karch, who's research record goes back over many years, the establishment of a proper detection methodology and the completion of the genome analysis only weeks before the outbreak, the hectic search for the sources suffered from mistakes, to mention only the premature ban on cucumbers, which caught the Spanish farmers by surprise. Precautionary measures, based on shaky results, caused damage in the market of roughly half a billion Euros. (BfR-Advise, 20110612; BfR-BVL-RKI-Joint-Declaration, 20110610; BfR-Not-Spanish, 20110601; BfR-Safe, 20110120). When the sprouts (not soybeans) were finally spotted as the most probable source, the dynamics of the spread of the STEC was mainly over. Some small secondary outbreaks in various countries remain a mystery and may occur again, as long as the real reason behind the outbreak is not known. A major infection history has been published by (Frank et al., 2011).

*"**Background:** In this report, we provide a preliminary description of an ongoing large outbreak of gastroenteritis and the hemolytic–uremic syndrome caused by Shiga-toxin–producing Escherichia coli in Germany in May and June 2011.*
***Methods**: We analyzed data from reports in Germany of Shiga-toxin–producing E. coli gastroenteritis and the hemolytic–uremic syndrome and clinical information on patients presenting to Hamburg University Medical Center. An outbreak case was defined as a reported case of the hemolytic–uremic syndrome or of gastroenteritis in a patient infected by Shiga-toxin–producing E. coli, serogroup O104 or serogroup unknown, with an onset of disease on or after May 1, 2011, in Germany.*
***Results:** As of June 18, 2011, a total of 3222 outbreak cases (including 39 deaths) have been reported in Germany, 810 of which (25%) involved the hemolytic–uremic syndrome. The outbreak is centered in northern Germany and peaked around May 21 to 23. Most of the patients in whom the hemolytic–uremic syndrome has developed are adults (89%; median age, 43 years), and women are overrepresented (68%). The estimated*

median incubation period is 8 days, with a median of 5 days from the onset of diarrhea to the development of the hemolytic–uremic syndrome. Among 59 patients infected with the outbreak strain who were prospectively followed at Hamburg University Medical Center, the hemolytic–uremic syndrome developed in 12 (20%), with no significant difference between patients in whom the syndrome developed and those in whom it did not with respect to sex or reported initial symptoms and signs. The outbreak strain was typed as an entero-aggregative Shiga-toxin–producing E. coli O104:H4, producing extended-spectrum beta-lactamase.

***Conclusions**: In this large outbreak of the hemolytic–uremic syndrome, caused by an unusual strain of Shiga-toxin–producing E. coli, cases have occurred predominantly in adults, with a preponderance of cases occurring in women. The hemolytic–uremic syndrome has developed in a quarter of the symptomatic outbreak cases that have been ascertained thus far." From (Frank et al., 2011).*

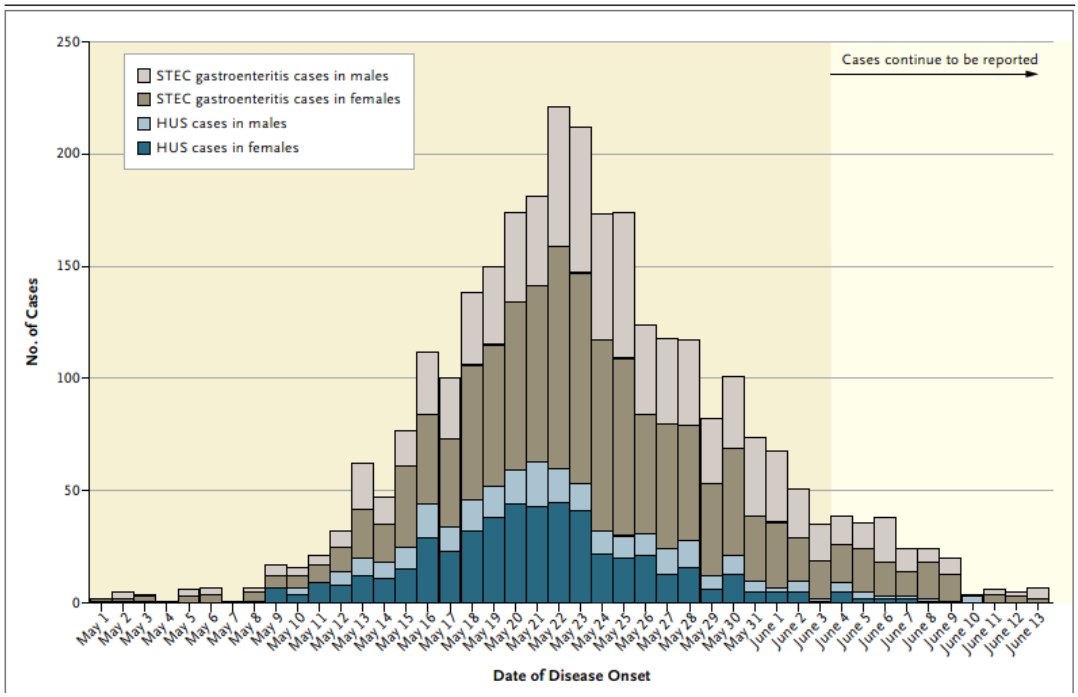

Fig. 1 Epidemiologic Curve of the Outbreak. Shown are the number of cases of the hemolytic–uremic syndrome (HUS) and of Shiga-toxin–producing E. coli (STEC) gastroenteritis, according to sex. Only cases with a known date of onset are included here — 748 of 810 cases of the hemolytic–uremic syndrome and 2166 of 2412 cases of Shiga-toxin–producing E. coli diarrhea. From (Frank et al., 2011)

The final overview of the EHEC-outbreak in Germany 2011 from (Krause et al., 2013).

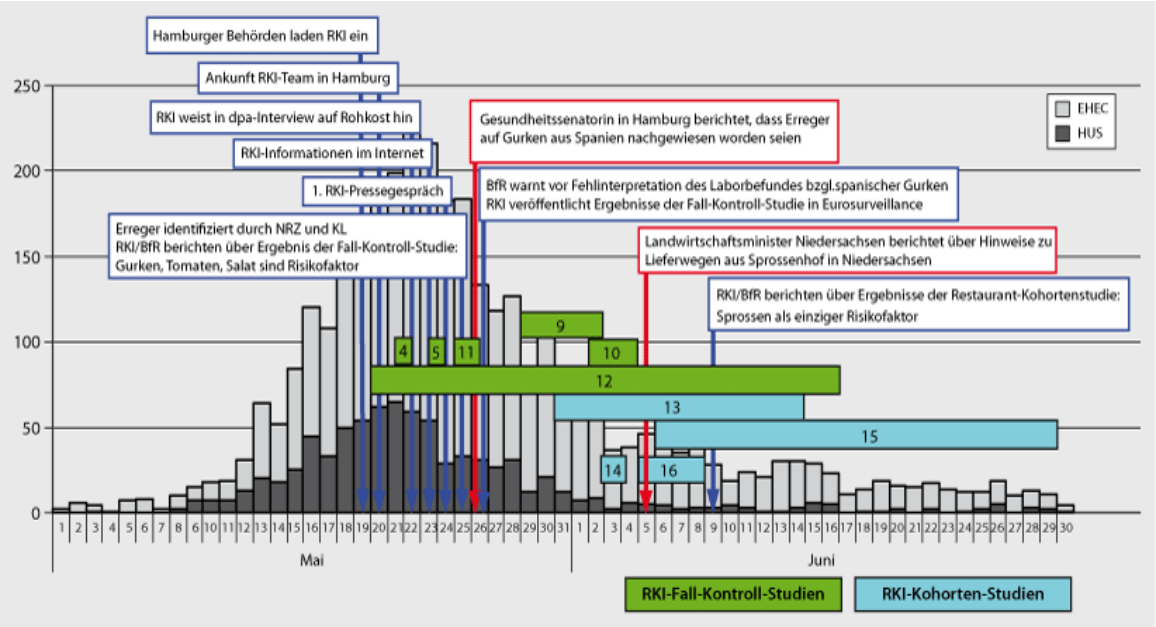

Fig. 2 Epidemiologische Studien des RKI (Zahlen entsprechen den in Tab. 1 aufgeführten Studien), sowie wichtige behördliche Mitteilungen im zeitlichen Ablauf vor dem Hintergrund der epidemiologischen Kurve (Anzahl übermittelter Fälle nach Symptombeginn) Status 2013. From (Krause et al., 2013)

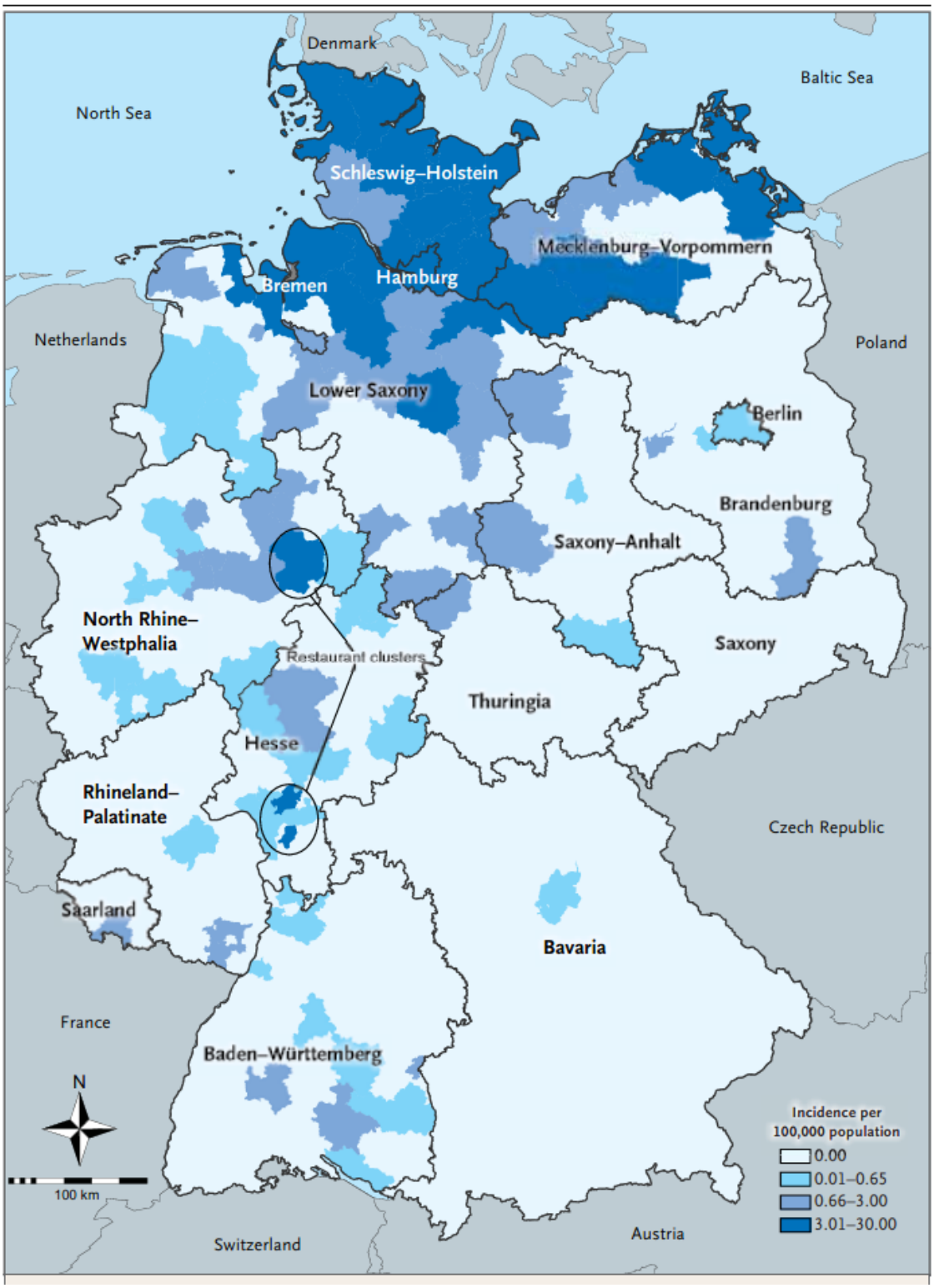

Fig. 3 Incidence of the Hemolytic–Uremic Syndrome According to County in Germany. The incidence shown is per 100,000 population. A total of 810 cases have been detected so far in this outbreak. Cases are attributed to a particular county if that county was the probable site of infection. From (Frank et al., 2011).

English: Epidemiological studies of the RKI (Figures relate to the studies mentioned in Tab.1.), including important official messages on the chronology derived from the background of epidemiological data (number of communicated cases after begin of symptoms) Status 2013. From (Krause et al., 2013)

5. The search for products as a source of EHEC

In a first phase, due to an incomplete form launched by German authorities asking for vegetables excluding sprouts, the search concentrated on cucumbers, tomatoes, spinach and lettuce with only doubtful results, resulting in to premature warnings against Spanish cucumbers which had to be withdrawn later (BfR-Not-Spanish, 20110601), after having caused major commercial damage [1]. There is a political debate going on [2] about the re-compensation on the level of the EU. There might be a connection between Egyptian Fenugreek organic sprouts and the outbreak in Northern Germany, and indirectly they might be the source of the dangerous Escherichia coli-strain O104:H7: (Buchholz et al., 2011; King et al., 2012). But more detailed reading reveals that indeed the Egyptian fenugreek meals in specific restaurants were the 100% - source of the infections, but tests showed that the original seed packages were clean, no EHEC traces were found.

Buchholz, U., Bernard, H., Werber, D., Böhmer, M. M., Remschmidt, C., Wilking, H., Deleré, Y., an der Heiden, M., Adlhoch, C., Dreesman, J., Ehlers, J., Ethelberg, S., Faber, M., Frank, C., Fricke, G., Greiner, M., Höhle, M., Ivarsson, S., Jark, U., Kirchner, M., Koch, J., Krause, G., Luber, P., Rosner, B., Stark, K., & Kühne, M. (2011). German Outbreak of Escherichia coli O104:H4 Associated with Sprouts. *New England Journal of Medicine, 365*(19), pp. 1763-1770. http://www.nejm.org/doi/full/10.1056/NEJMoa1106482 AND http://www.ask-force.org/web/Escherichia/Buchholz-German-Outbreak-O104-H4-Sprouts-20111110.pdf

"The case–control study included 26 case subjects with the hemolytic–uremic syndrome and 81 control subjects. The outbreak of illness was associated with sprout consumption in univariable analysis (matched odds ratio, 5.8; 95% confidence interval [CI], 1.2 to 29) and with sprout and cucumber consumption in multivariable analysis. Among case subjects, 25% reported having eaten sprouts, and 88% reported having eaten cucumbers. The recipe-based study among 10 groups of visitors to restaurant K included 152 persons, among whom bloody diarrhea or diarrhea confirmed to be associated with Shiga-toxin–producing E. coli developed in 31 (20%). Visitors who were served sprouts were significantly more likely to become ill (relative risk, 14.2; 95% CI, 2.6 to ∞). Sprout consumption explained 100% of cases. Trace-back investigation of sprouts from the distributor that supplied restaurant K led to producer A. All 41 case clusters with known trading connections could be explained by producer A. ***The outbreak strain could not be identified on seeds from the implicated lot****."*

But screening of Fenugreek sprout sources from Egypt were also negative. The most plausible source is the fact that the watering of the Fenugreek sprouts was done with sources from the organic farming section of the company. Further investigations were not deemed necessary of the responsible researchers, despite of the authors demand at the Robert Koch Institute – most probably for political reasons.

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[1] Tons of Vegetables lost ftp://ask-force.org/www/ask-force.org/web/Escherichia/Tons-Vegetables-Trash-20110711.pdf

[2] Debate Spain-Germany ftp://ask-force.org/www/ask-force.org/web/Escherichia/Germany-Spain-Cucumber-Talks-20110608.pdf

6. Links between organic Farming and EHEC Outbreaks clearly documented

The reasons of the outbreaks go back to agricultural management, clear links to organic farming are obvious, despite denials from the organic industry:

Contrary to the systematic search on the background during and after the Californian outbreak (Kuhnert et al., 2005), the European specialist community is only hesitantly digging into the reasons behind the outbreak. Also the European press does not really do proper research on the case, since it might reach the tricky realms of attacking organic farming and negligent practice to sterilize manure with fermentation – knowing that 65° are not sufficient to kill the germs efficiently (a method still used by many organic farmers).

6.1. Comparison of agricultural management systems related to EHEC outbreaks

"Microbiological analyses of fruits and vegetables produced by farms in Minnesota and Wisconsin were conducted to determine coliform and Escherichia coli counts and the prevalence of E. coli, Salmonella, and E. coli O157:H7. During the 2003 and 2004 harvest seasons, 14 organic farms (certified by accredited organic agencies), 30 semi-organic farms (used organic practices but not certified), and 19 conventional farms were sampled to analyze 2,029 pre-harvest produce samples (473 organic, 911 semi-organic, and 645 conventional). Produce varieties included mainly lettuces, leafy greens, cabbages, broccoli, peppers, tomatoes, zucchini, summer squash, cucumber, and berries. Semi-organic and organic farms provided the majority of leafy greens and lettuces. Produce samples from the three farm types had average coliform counts of 1.5 to 2.4 log most probable number per g. Conventional produce had either significantly lower or similar coliform populations compared with the semi-organic and organic produce. None of the produce samples collected during the 2 years of this study were contaminated with Salmonella or E. coli O157:H7. E. coli contamination was detected in 8% of the samples, and leafy greens, lettuces, and cabbages had significantly higher E. coli prevalence than did all the other produce types in both years for the three farm types. ***The prevalence of E. coli contamination by produce type was not significantly different between the three farm types during these 2 years, with the exception of organic leafy greens, in which E. coli prevalence was one-third that of semi-organic leafy greens in 2003. These results indicate that the pre-harvest microbiological quality of produce from the three types of farms was very similar during these two seasons and that produce type appears to be more likely than farm type to influence E. coli contamination***

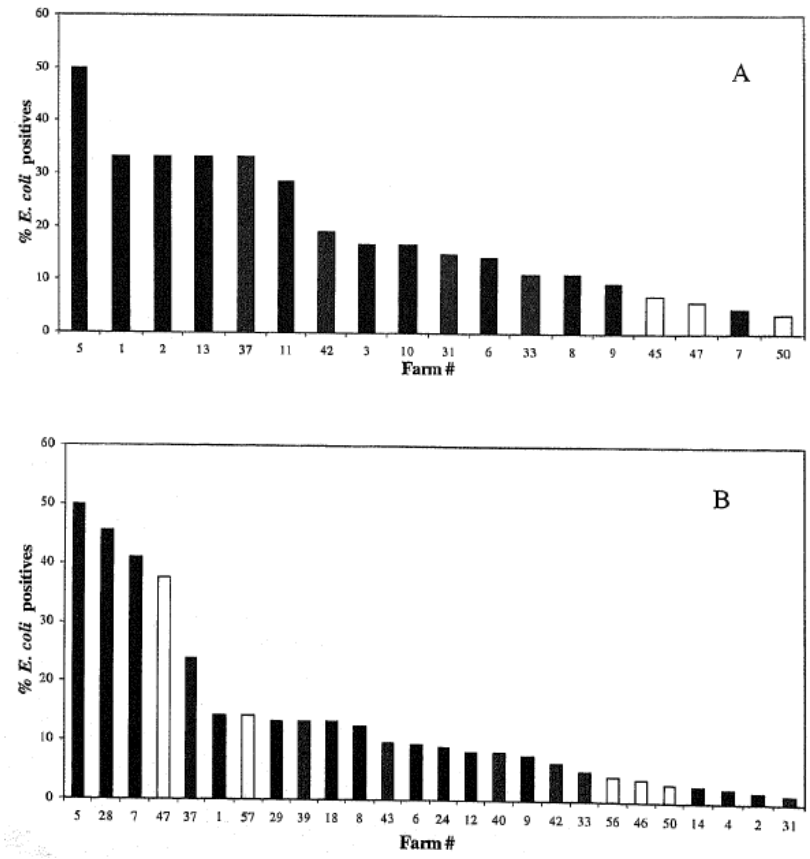

FIGURE 1. *Prevalence of* E. coli *on semiorganic (■), organic (▩), and conventional (□) farms from which at least one contaminated sample was collected in 2003 (A) and 2004 (B).*

Fig. 2 Number of farms from which at least one contaminated sample was collected in 2003 (A) and 2004 (B).

Cited from (Mukherjee et al., 2007):

"In Minnesota, organic and semi-organic produce collected from the southeastern (SE) part of the state were at a significantly greater risk of E. coli contamination (OR=3.45, 95% CI=1.8–35.2, P=0.008), compared to those collected from farms located in the southern (S) regions of the state. ***In Wisconsin, organic and semi-organic produce collected from the southern (S) cluster of farms were at approximately 3-times greater risk of E. coli contamination (OR=2.67, 95% CI=1.3–9.4, P=0.004), compared to those grown in the northern (N) cluster of farms."***

According to (Mukherjee et al., 2007) the results show that the contamination risk can be reduced by composting manure before use, this might explain the difference: Conventional farmers tend to not composting manure, whereas organic farmers use to compost manure.

The **ultimate proof of a link to organic farming** comes from a publication of Lisa King et al.: (King et al., 2012):

King, L. A., Nogareda, F., Weill, F. X., Mariani-Kurkdjian, P., Loukiadis, E., Gault, G., Jourdan-DaSilva, N., Bingen, E., Mace, M., Thevenot, D.,

Ong, N., Castor, C., Noel, H., Van Cauteren, D., Charron, M., Vaillant, V., Aldabe, B., Goulet, V., Delmas, G., Couturier, E., Le Strat, Y., Combe, C., Delmas, Y., Terrier, F., Vendrely, B., Rolland, P., & de Valk, H. (2012). Outbreak of Shiga Toxin-Producing Escherichia coli O104:H4 Associated With Organic Fenugreek Sprouts, France, June 2011. *Clinical Infectious Diseases, 54*(11), pp. 1588-1594. <Go to ISI>://WOS:000304048400011 AND http://www.ask-force.org/web/Escherichia/King-Outbreak-Shiga-Escherichia-Fenugreek-2012.pdf

"Comparison of microbiologic and epidemiologic results from the French and German outbreaks enabled confirmation of a common strain of STEC O104:H4 and food vehicle in the 2 outbreaks. **Based on these results, a European level traceback exercise identified a producer in Egypt and a batch of 15 000 kg of organic fenugreek seeds common to both outbreaks.** The batch of fenugreek seeds had been imported into Europe by a German importer in 2009 [11]. The identification of a common producer and a single batch of fenugreek seeds supports the epidemiologic evidence implicating them as the source of both outbreaks." From (King et al., 2012)

See the *clear connection to organic farming* from a paper of King et al. (King et al., 2012): with samples from France:

The summary:

Background. *On 22 June 2011, 8 patients with hemolytic uremic syndrome (HUS) or bloody diarrhea were reported in France. All 8 were attendees of a community center event on 8 June near Bordeaux. Three Escherichia coli cases were confirmed by isolation of Shiga toxin–producing E. coli O104:H4 stx2 aggR producing a cefotaximase (CTX-M) b-lactamase (STEC O104:H4); the same rare serotype caused the outbreak in Germany in May–July 2011. An investigation was initiated to describe the outbreak, identify the vehicle for infection, and guide control measures.*

Methods. *We conducted a retrospective cohort study among all adults attending the event, including food handlers. A standardized questionnaire was administered to participants. A case was an attendee who developed HUS or diarrhea between 8 and 24 June. Cases were confirmed by isolation of STEC O104:H4 or O104 serology. Relative risks (RRs) and 95% confidence intervals (CIs) by exposure were calculated using a Poisson regression model.*

Results. *Twenty-four cases were identified (14% attack rate). Of these, 18 (75%) were women, 22 (92%) were adults, 7 (29%) developed HUS, 5 (21%) developed bloody diarrhea, and 12 (50%) developed diarrhea. Ten (42%) cases were confirmed. Fenugreek was the only sprout type with an independent association to illness (RR, 5.1; 95% CI, 2.3–11.1) in multivariable analysis.*

Conclusions. This investigation identified a point-source STEC O104:H4 outbreak associated with consumption of fenugreek sprouts. Comparison of results from French and German STEC O104:H4 outbreak investigations enabled identification of a common food vehicle, fenugreek sprouts, and resulted in implementation of Europe-wide control measures in July 2011. *From (King et al., 2012)*

The epidemiologic curve in France

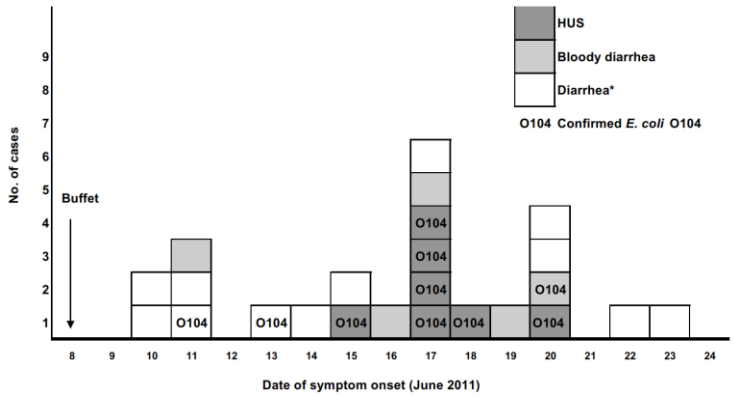

Fig. 3 Epidemiologic curve of the Shiga toxin–producing Escherichia coli O104:H4 outbreak, France, June 2011 (n 5 24). *Diarrhea defined as $3 loose stool samples per day or for at least 2 days' duration. HUS, hemolytic uremic syndrome. From (King et al., 2012)

An earlier study from 2004 focusses on EHEC incidences and a GIS-supported study of the geographical distribution in Sweden: (Kistemann Thomas et al., 2004):

"This article describes the spatial and temporal distribution of verotoxin-producing Escherichia coli among humans (EHEC) and cattle (VTEC) in Sweden, in order to evaluate relationships between the incidence of EHEC in humans, prevalence of VTEC O157 in livestock and agricultural structure by an ecological study. The spatial patterns of the distribution of human infections were described and compared with spatial patterns of occurrence in cattle, using a Geographic Information System (GIS). The findings implicate a concentration of human infection and cattle prevalence in the southwest of Sweden. The use of probability mapping confirmed unusual patterns of infection rates. The comparison of human and cattle infection indicated a spatial and statistical association. The correlation between variables of the agricultural structure and human EHEC incidence was high, indicating a significant statistical association of cattle and farm density with human infection. The explained variation of a multiple linear regression model was 0 56." From (Kistemann Thomas et al., 2004)

From the conclusions:

*"**From our results it appeared that local conditions seem to have a high impact on the routes of EHEC transmission in Sweden.** This putative hypothesis includes close contact to (infected) cattle, due to an agricultural environment, including picnicking next to grazing cattle, pasturing cattle or disposal of manure close to where people swim and possibly the consumption of local food (meat, milk or manured vegetables), as has been reported in other studies [9, 21, 36]. This may explain the observed spatial coincidence of human EHEC and livestock VTEC infection patterns and agricultural structure. **It is not the nationwide distribution of industrially processed food, as reported for many outbreaks worldwide, e.g. the United States [37], but predominantly the spatial contiguousness to farms and cattle and different opportunities for contact with faecal contamination that seem to be important for EHEC transmission in Sweden.**" From (Kistemann Thomas et al., 2004)*

6.2. Political resistance against the connection of EHEC and organic farming.

It is amazing to see, how reluctant the European public, the media and even government agencies are to dig into the difficult question on the relationship of the latest German outbreak with organic farming and maybe other management methods. The press echo was only minimal, since in the view of the European public organic farming cannot do any evil (Maxeiner & Miersch, 20110909). In the same NOVO arguments magazine, well known for its independent views, you can find an extensive, detailed documentation: (Keckl Georg, 20110928), the publication also mentions numerous details of the regulatory process, giving another ultimate proof that the German EHEC outbreak can be correlated to organic farming:

"The suspected involuntary main propagator of the EHEC bacteria, the organic vegan gardener community of Lower Saxony, campaigned against the terrible glitch in the internet with international organic certificates, which should prove the organic quality of its imported seeds. "Traceability" and "transparency" are the key arguments in favor of organic quality. How much "bio" could the clover seed from the very distant Egypt really be? For the exported fenugreek seeds in Egypt, the chain of evidence leading to the tracing the EHEC contaminated sprouts is virtually unknown. And Egypt denies still vehemently that Egyptian products were contaminated with EHEC. Actually, in this case the organic organizations must ask themselves, what is the quality of their certificates, if they cannot even find the exporter in Egypt with the beautiful name "Organic Green" when their warehouse does not even carry a company sign (Focus 28, 2011) and the producer company cannot even be named properly? Despite the risk of a bad press, it would be important to investigate where the batch of fenugreek seeds has really grown, irrigation and fertilization should be considered carefully in order to prevent any repetition." From

. Schulz et al (Schulz, C. et al., 2014) have analyzed the 2011 outbreak in the German TV and can statistically (still below significance) suggest that related to the diarrhea symptoms the TV press reports ran parallel, but the whole report is playing down in a strange way to include in the survey the importance of grave hemorrhagic incidences and the connected numerous casualties. Therefore the conclusions of the TV report are questionable: The German TV is ironically accused of exaggerating the outbreak case – the contrary is true, because they avoided making clear statements of the deadly hemolytic threat (mentioned only once and by the side), and also by meticulously avoiding in the report to mention the organic farming connection.

The official declaration from the European Organization for organic farming from June 8, 2011, basically repeated on June 16 of the world organization of organic farming IFOAM is defensive (Organic World et al., 2011). It ignores a rich scientific literature and is therefore not very helpful:

*"**Further, the IFOAM EU Group underlines that it is neither appropriate nor responsible to use the present outbreak of enterohemorrhagic Escherichia coli (EHEC) to blame any farming method. EHEC is not a problem of a specific production system and any farming methods can potentially be affected.** The IFOAM EU Group appreciates that policy makers have been communicating carefully in this regard so far."* [3]

The Research Institute of Organic Agriculture (FIBL) supported IFOAM in the denial on June 22 and published another defensive report (Niggli & Forster, 2011), explicitly not dealing with the latest EHEC outbreak in Germany, an exclusion which is only mentioned in the preface, the report title therefore clearly misleading. Even so, dealing with the previous outbreaks, the authors completely miss a bulk of scientific publications confirming the link between the application of liquid manure and the presence of EHEC since years. The authors cite correctly (Wiessner et al., 2009), demonstrating that after simple tap water rinsing the lettuce, *there is no significant difference between organic and mineral* fertilizing. But they miss the scientific discussion in the Wiessner paper, which points to some serious possible risks related to organic farming, calling for more research and better management.

"However, Enterobacteriaceae count as well as count of coliform bacteria provide no serious information concerning the human health risk of food, and are rather used as an indicator for a potential faecal contamination. Specific information about faecal contamination linked with a risk for human health can only be delineated by E. coli (O157:H7) and Salmonella counts. These bacteria are proven to be possible sources for foodborne diseases. In our study, in 2 out of 4 trials low numbers of E. coli were detected in lettuce regardless of the fertilizer type applied. Our findings are in agreement with the results reported by (Johannessen et al., 2005; Johannessen et al., 2004) who neither observed any correlation between the occurrence of E. coli in lettuce and the type of fertilizer used. However, (McMahon & Wilson, 2001) did not detect E. coli in organic fertilized lettuce at all." From (Wiessner et al., 2009)

It is correct to cite data that grain feeding of cattle show a higher infection risk with EHEC, because they select for more acid tolerant EHEC which might pose a higher risk for human infection, but by citing this paper (with correct results) the authors miss two crucial points: Grain fed cattle is only to a very small degree related to management with manure and the latest, much more mortal outbreaks in Germany 2011 are clearly coming from a human reservoir – not from cattle (Wieler et al., 2011).

[3] http://www.organic-world.net/35.html?&tx_ttnews%5Btt_news%5D=526&cHash=d6ac61edd80878c8f7994ff2c6381189

Indeed, the European comments miss (systematically or by ignorance?) a bulk of papers outside Europe with *EHEC outbreaks of the O157:H7 strain which has been clearly correlated to organic farming*: (Mukherjee et al., 2006), details see above in chapter 6.1.

The latest news from EFSA June 29, 2011 [4] are again avoiding to dig into the real reasons of the outbreak:
EFSA recommends cooking of the sprouts and still insists the problems will be solved by just tracing back the sprouts or other vegetables in suspicion, but in fact they still underestimate the situation: As long as the REAL source and the real REASON of the infection is not traced back over the whole production line *including* agricultural production systems, EHEC dynamics will continue to surprise governments and agencies. The strategy of tracing back the source seems to be insufficient, even according to the EFSA report itself:

"The tracing back is progressing and has thus far shown that fenugreek seeds imported from Egypt either in 2009 and/or 2010 are implicated in both outbreaks. There is still much uncertainty about whether this is truly the common cause of all the infections as there are currently no positive bacteriological results. In particular, the 2009 lot appears to be implicated in the outbreak in France and the 2010 has been considered to be implicated in the German outbreak. Furthermore, this link does not explain the most recent case in Sweden, currently under investigation and in which, thus far, no consumption of sprouts has been implicated."

Heidi Wichmann-Schauer et al. (Wichmann-Schauer Heidi et al., 2012) come to a prudent judgement about the infection source: They approve that Fenu-Greek sprouts have been spotted as a possible Infection source, they do not know "where and how the seeds came into contact with the pathogen leading to the outbreak."

"For expeditious and effective investigation into foodborne outbreaks, a close collaboration between Public health, veterinary public health and food safety authorities is needed. During the EHEC O104:H4 outbreak in May-July 2011 in Germany tremendous efforts were made by all parties involved to identify the contaminated food vehicle and the source of the outbreak. Laboratory analyses of more than 8.000 food and environmental samples and detailed trace back and trace forward investigations into the supply chains were conducted. Finally, one of the largest foodborne outbreaks in recent time was successfully clarified. ***It is thought that the EHEC outbreak was caused by fenugreek seeds imported from Egypt which were subsequently used to produce sprouts by a horticultural farm in Lower Saxony as well as by private individuals in Germany and France. Where and how the seeds came into contact with the pathogen lead ing to the outbreak could not be determined, however."*** *(Wichmann-Schauer Heidi et al., 2012)*

It is frustrating to see that new publications and critical views about the handling of the EHEC crisis coming from social sciences again do *not* deal with a holistic picture of the crisis, namely INCLUDING the agricultural elements during the production of the suspected produce (here the Egyptian sprouts). The review of Franziska Engels (Engels, 2014) deals in a highly critical way with the internal handling and chaos of researchers and institutes being on high pressure of coming out with detailed decisions, but no word about agriculture.

The same reductionist syndrome with the extensive publication of Emily van de Venter et al. (van de Venter et al., 2015). Lots of helpful hints for future analytical efforts of the responsible labs on coming earlier with final judgement, but again a clearly reductionist view of laboratory-oriented scientists, with a blatant blindness of looking at the agricultural production side of the case.

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[4] http://www.efsa.europa.eu/en/press/news/110629a.htm

The latest disclaimer regarding the Egyptian organic origin of the German EHEC is coming from officials of the Egyptian Administration[5]. There is some logic in those contrasting statements, since an infection can stem from a very few and local events, disappearing quickly again, consequently they do not show up again in later analysis.

The head of Egypt's Central Administration of Agricultural Quarantine, Ali Suleiman, said claims by the European Food Safety Authority (EFSA) that Egyptian fenugreek seeds exported in 2009 and 2010 may have been implicated in the outbreak were ***"completely untrue."***

"The presence of this bacteria in Egypt has not been proven at all, and it has not been recorded,"
He said the Egyptian company that exported the seeds in 2009 has stressed in a letter that it had exported the fenugreek to Holland and not to Germany, Britain or France. "

Sadly, it is obvious that blaming Egypt for dirty seeds is very popular in many European countries and does not need verification.

But there are exceptions with a more critical judgement coming from Heidi Wichmann et al.

Thanks go to David Tribe for his comments, and for his numerous blog contributions related to EHEC, a rich source of information: http://gmopundit.blogspot.com/.

After some years of debate forth and back, today the situation does not need further debate: there is also in the case of European EHEC-outbreaks a clear connection with organic farming practices.

Proper science needs time, but by now there are two facts verified in an undeniable way: Escherichia coli is a quickly and heavily mutating organism and has changed dramatically to the worse its teratology, and scientists and regulators should well be aware of this situation.

6.3. Survival of E.coli strains in Soil and on the agricultural products and problem solutions

Another problem arises from the survival of E. coli in soil and on the products, results coming from the O154:H7 strain:

Survival of EHEC (O157:H7) is enhanced when those coliforms reach the soil (tilled or not) as runoff from stored manure or when manure is applied directly to fields, if rainfall or irrigation provides the mechanism for dispersion (Gagliardi & Karns, 2000). They also can survive on roots for months on various environmental conditions (Gagliardi & Karns, 2002). Dozens of papers are clearly relating the presence in soil of those highly virulent coliforms with contaminated liquid manure or sewage water, the persistence for many months, if not years has been monitored with hard field data, including also a

[5] http://www.expatica.com/de/news/german-news/egypt-denies-its-seeds-caused-ecoli-outbreak_160185.html

comprehensive summary of previous scientific results by (Islam, Doyle, et al., 2004; Islam et al., 2005; Islam, Morgan, et al., 2004).

From (Islam et al., 2005):

"E. coli O157:H7 survived for atleast154 days in all the amended soil samples on which carrots or onions were grown (Figs. 1 and 2). However, in soil samples from carrot fields where poultry manure compost PM-5 and dairy cattle manure compost 338 were applied, survival was up to 196 days."

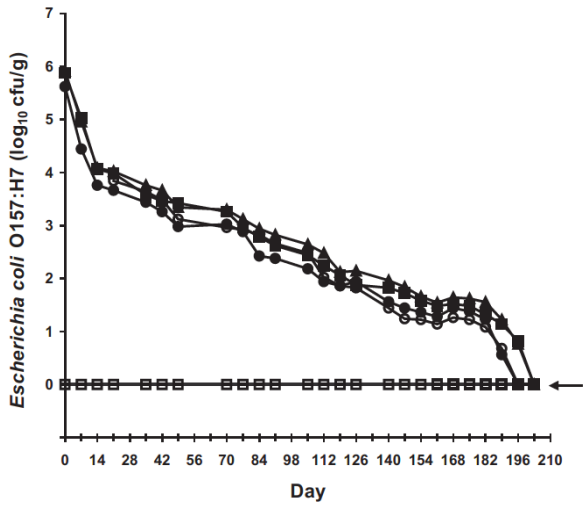

Fig. 4 see caption below from fig. 1 of publications

Fig. 1. Survival of *E. coli* O157:H7 in inoculated compost-amended or inoculated water-irrigated soil samples from fields used for growing carrots. Treatments included: no compost (□), poultry manure compost (■), dairy cattle manure compost (▲), alkaline-stabilized dairy cattle manure compost (●), and contaminated irrigation water (○). Contaminated irrigation water was applied at 3 weeks after seeds were planted. Arrow (←) indicates not detectable by enrichment culture.

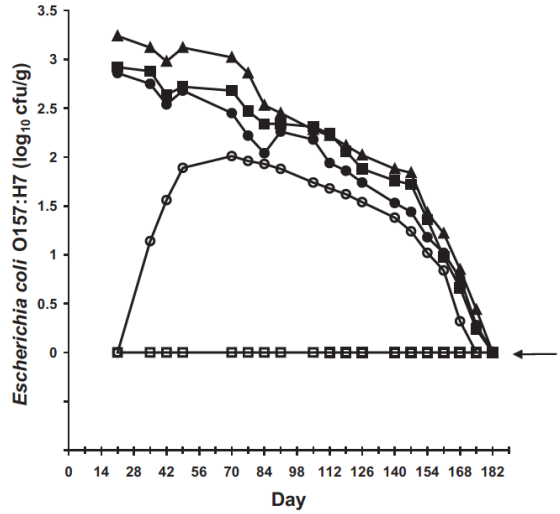

Fig. 5 see Fig. 3 caption of the publication below

Fig. 3. *E. coli* O157:H7 counts on carrots grown in fields containing inoculated compost-amended or inoculated water-irrigated soil. Treatments included: no compost (□), poultry manure compost (■), dairy cattle manure compost (▲), alkaline-stabilized dairy cattle manure compost (●) and contaminated irrigation water (○). Carrots were harvestable at day 126. Contaminated irrigation water was applied at 3 weeks after seeds were planted. Arrow (←) indicates not detectable by enrichment culture.

Survival of pathogenic *E. coli* O157:H7 has been also studied by (Patel et al., 2010) with varying results according to experimental conditions and more persistently (for a few weeks) in the root systems of spinach, ca. a week on the leaf surface, among many other factors influencing the survival time the authors point to the competition with non-pathogenic epiphytic microbes, preventing a longer survival period of pathogenic coliforms. Overall, their conclusions are clear: Microbial contamination of produce may occur anytime during the primary production, harvesting and processing and packing stages.

Because there is no 'kill-step' during packing of raw produce, identifying source of pre-harvest contamination of fresh produce is necessary to control food-borne illness.

Recent research from tropical environments show that the problem is less dramatic, but still existing: Internalization of *E. coli* O157:H7 and S. Typhimurium in cabbage leaf tissues at harvest seems to be limited to the worst-case situation, i.e., when highly contaminated manure is introduced into the soil at the time of transplantation of cabbage seedlings. Among many other field experimental data it is worthwhile to cite (Nyberg et al., 2010) from the abstract:

"The results showed that the inactivation of E. coli O157:H7 and Salmonella Typhimurium varied depending on the manure type used and its carbon content. The longest inactivation time occurred in samples amended with poultry manure, in which both E. coli O157:H7 and Salmonella Typhimurium were detected up to day 90 with the spread plate method. The most rapid inactivation for both pathogens occurred in soil amended with urine. However, low amounts of culturable E. coli O157:H7 and Salmonella Typhimurium were detected by enrichment throughout the study period (180 days), regardless of manure type."

An option to fight the infections in organic soils is offered by (Yossa et al., 2010): Essential oils could reduce in the soil the number of virulent coliforms, but the question about side effects is justified and would need to be tested.

Recently, a purely epidemiological study has been published by Katherine Heiman et al (Heiman Katherine E. et al., 2015), which does not consider agronomical factors at all, and consequently missing the whole literature cited above. Survival in soil of E. coli is not mentioned, and worse, the new very pathogenic strain *E. coli* O104:H4 is not mentioned at all, although there are several outbreaks already documented outside Germany (2001, 2011): In France (2011), (Poudelet, 2012), (King et al., 2012), (Jourdan-da Silva et al., 2012), in the Czech Republic (imported from Germany (Marejkova et al., 2012), Poland (Bilinski et al., 2012), Norway 2006, Georgia USA (2009) infections of travel to Germany, (Beutin et al., 2012), (Alexander et al., 2012), The Netherlands (Kuijper et al., 2011) and Sweden (Kistemann Thomas et al., 2004), and more from regions out of Europe, see citations in

The conclusions: The new type of pathogenic *E. coli* O104:H4 needs to be studied intensively in its teratology (symptoms in Hamburg patients also show disturbing negative effects on brain activity), but in order to get a deeper understanding about the German outbreak we also urgently need European field studies comparing agricultural management systems as the one from (Kistemann Thomas et al., 2004). A good beginning for the development of a rapid detection method of numerous pathogenic E.coli-strains has been published by Tzschoppe (Tzschoppe et al., 2012). Also a validation of treatment strategies has been approved by a large group of authors (Menne et al., 2012). Another multi-author study dealing with therapeutic measures comes from Kielstein (Kielstein et al., 2012).

All options for sterilizing fresh produce of vegetables that may come direct or indirect contact with manure should be studied, including ozone[6].

A recent study cuts through the Gordian Knot and offers an efficient solution by genetically engineer the exposed agricultural products: (Schulz, S. et al., 2015)

Schulz, S., Stephan, A., Hahn, S., Bortesi, L., Jarczowski, F., Bettmann, U., Paschke, A.-K., Tusé, D., Stahl, C. H., Giritch, A., & Gleba, Y. (2015). Broad and efficient control of major foodborne pathogenic strains of Escherichia coli by mixtures of plant-produced colicins. *Proceedings of the National Academy of Sciences*, pp. http://www.pnas.org/content/early/2015/09/02/1513311112.abstract AND http://www.ask-force.org/web/Escherichia/Schulz-Broad-efficient-control-Ecoli-colicins-2015.pdf AND http://www.ask-force.org/web/Escherichia/Schulz-Broad-efficient-control-Ecoli-colicins-supplements-2015.pdf

Enterohemorrhagic Escherichia coli (EHEC) is one of the leading causes of bacterial enteric infections worldwide, causing ~100,000 illnesses, 3,000 hospitalizations, and 90 deaths annually in the United States alone. These illnesses have been linked to consumption of contaminated animal products and vegetables. Currently, other than thermal inactivation, there are no effective methods to eliminate pathogenic bacteria in food. Colicins are nonantibiotic antimicrobial proteins, produced by E. coli strains that kill or inhibit the growth of other E. coli strains. Several colicins are highly effective against key EHEC strains. Here we demonstrate very high levels of colicin expression (up to 3 g/kg of fresh biomass) in tobacco and edible plants (spinach and leafy beets) at costs that will allow commercialization. Among the colicins examined, plant-expressed colicin M had the broadest antimicrobial activity against EHEC and complemented the potency of other colicins. A mixture of colicin M and colicin E7 showed very high activity against all major EHEC strains, as defined by the US Department of Agriculture/Food and Drug Administration. Treatments with low (less than 10 mg colicins per L) concentrations reduced the pathogenic bacterial load in broth culture by 2 to over 6 logs depending on the strain. ***In experiments using meats spiked with E. coli O157:H7, colicins efficiently reduced the population of the pathogen by at least 2 logs. Plant-produced colicins could be effectively used for the broad control of pathogenic E. coli in both plant- and animal-based food products and, in the United States, colicins could be approved using the generally recognized as safe (GRAS) regulatory approval pathway.*** *From (Schulz, S. et al., 2015)*

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[6] http://www.anseros.de/?gclid=CNGYq6uZ36kCFdAn3wodlgr4aw

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