

Excerpts from the history of food safety

1. Summary

Just as obtaining and consuming food is part of everyday human life, so have foodborne diseases been occurring regularly throughout history. Most of these sank into oblivion, however, certain events of greater importance, or ones that affected a large number of people or were memorable because of their nature, novelty or long-term effects have been included in source materials preserving our history in written form. There are references to diseases in the holy books that constitute the basis for certain religions (e.g., the Bible or the Quran), as well as detailed food preparation and eating rules aimed at preventing diseases.

Because of the rudimentary nature of scientific knowledge, sometimes it took several centuries until the cause of an epidemic disease could be determined and the measures necessary for prevention could be taken. These diseases were often outbreaks of microbial origin, but toxicoses also occurred frequently, and in many cases they had serious, long-term consequences. This paper mentions several such events, for example, chronic lead poisoning that presumably played a role in the fall of the Roman Empire, or mass diseases accompanied by different syndromes caused by mold toxins.

Unfortunately, this phenomenon was not eliminated by the development of science and technology, so foodborne illnesses still occur and, because of globalization and world trade, they can reach practically any part of the world in a short time. The article also discusses the risks of industrial development and also some of the major food counterfeiting cases that occurred recently and which lead to mass diseases.

2. Introduction

The concept of food safety has become well-known over the past few decades. Unfortunate incidents, scandals and consumer concerns have been in the headlines, and this led to the fact that sometimes we worry when consuming our everyday food, even though, in spite of these random events, it can be said that our foods have never been safer than they are today in the developed countries.

The concept itself may be new, however, diseases and risks related to foods can definitely be traced back to ancient times, one might say that humanity has been faced with foodborne diseases ever since we live on this Earth.

3. Even in ancient times...

Imagine our ancestors who literally had to find food for themselves and their families every day. There are several notions floating around about how the so-called paleolithic diet could have looked like. Modern lifestyle gurus base diets and business enterprises on these assumptions, saying that this diet, presumed by them to be of the Stone Age, is the only healthy one.

However, if we think about it more deeply, the food and lives of our ancestors were not enviable at all. If they managed to get meat then, similarly to predators, it was easier for them to kill weaker, sick animals. Successful hunts were not very frequent, so they consumed large amounts suddenly, but on less

¹ National Food Chain Safety Office

lucky days they presumably had to do with spoiled leftovers. And the effects of poisonous plants and fungi they could test only at the expense of their own health. Their lives, already burdened with thousands of risk were made diverse by eating binges and fasting periods, molds and parasites. It is not a wonder then that, according to available archeological data, their average lifespan was 20 to 30 years.

4. Biblical times

The books considered sacred by humanity, including the Bible, list numerous dietary and hygiene requirements which were obviously included among the mandatory provisions as some kind of summary of many centuries of experience. These rules – e.g., the prohibition of consuming pork, often found to be infected, the separation of pots for meat and dairy foods, the purity and traceability requirements of the raw materials used – helped to maintain the health of believers. However, there are other interesting things in the Bible as well.

There are many people who would like to reveal realistically the secrets of the miracles described therein, that are considered credible. For example, there have been several explanations for the ten plagues of Egypt, which will not be discussed here. However, in the stories of the Exodus from Egypt, we can find references that can be considered as foodborne mass diseases.

4.1. Poisonous quail

An interesting story about the Exodus is the one describing quail poisoning. Participants in the Exodus were fed with manna by the Lord, food was provided for them, but they were discontented and wanted to eat meat. At this time, many quails were brought over them by a wind, birds that were so tired, they fell from the sky, and could be gathered easily. According to the Bible, while the flesh was yet between their teeth, people started to die (Numbers 11:31-33). The question arises, if we accept the event as truth, how is it that consumption of the meat caused almost immediate death. Under no circumstances could it be a destruction caused by a bacterium or a virus, because no matter how rapid its course is, there is a period of latency required for the effect to develop. So what could be the cause? Hunting of migratory quails (*Coturnix coturnix*) had been practiced in the Mediterranean region in historical times. Tired birds, just having crossed the Mediterranean Sea, were captured and destroyed in large amounts. This kind of “hunting” can still be encountered today, even though the meat of the quails sometimes indeed proved to be toxic. When searching for the cause of this, an experience was performed by Dr. Edmont Sergent, director of the Pasteur Institute of Algeria. Quails were fed poisonous hemlock seeds, which were consumed by them without harm. However, dogs who were fed the meat of these quails showed signs of hemlock poi-

soning. Is it possible that this was the explanation for quail poisoning which was also contributed to – according to Greek researchers – by the specific genetic disposition of the Hebrew people [1], [2], [3]?

4.2. The Rod of Asclepius, or the case of the fiery serpents

There is another interesting event in the fourth book of Moses (Numbers 21:5-9). Israelites (again) started to rebel against the Lord and Moses, and longed for the fleshpots of Egypt. As a punishment, “the Lord sent fiery serpents among the people, and they bit the people; and much people of Israel died”. Moses prayed to the Lord, and he was told the cure: “make thee a fiery serpent, and set it upon a pole: and it shall come to pass, that every one that is bitten, when he looketh upon it, shall live. And Moses made a serpent of brass, and put it upon a pole; and it came to pass, that if a serpent had bitten any man, when he beheld the serpent of brass, he lived.” Several biblical scholars of the opinion that this biblical fiery serpent was not a real poisonous snake, but a very disgusting snake-like parasite, the so-called Guinea worm (*Dracunculus medinensis*), which was endemic in the region [1]. Larvae of the parasite entered the body with the contaminated water consumed, and then an almost one meter long, thin worm develops, which finally comes out of the skin with an extremely painful, burning sensation. It is interesting to note that even today’s medical science can offer no medicine to get rid of the worm other than wrapping the emerging worm around a stick, only a few centimeters per day, taking care not to break it, until finally the whole parasite can be removed [4].

In ancient times, this disease was so common that the sign of the healers was a snake wrapped around a rod. Probably that is why the symbol of medicine is still the rod of Asclepius, the Greek god of healing, which is present in the emblem of many health and healing organizations, including the World Health Organization (WHO) [5].

5. The honey that turned the tide of battle

The famous Greek historian and military leader Xenophon describes an event in which the outcome of a battle was influenced by toxic honey. In 401 BC, a mercenary army of ten thousand was launched to assist Cyrus, a Persian prince, to the throne. The hungry army, returning from a lost battle, was in disarray and they plundered wherever they could. They relished devouring honeycomb found in beehives, after the consumption of which they became incapable of defending themselves because of extreme nausea and vomiting fits. A similar case was reported by historians from 67 BC, when the army of king Mithridates VI was defeated by the great Roman military leader, Pompey. The Roman army, certain of victory, also plundered the beehives of the honey producing area, and consumed a lot of honey. The symptoms

of mass poisoning soon developed, and the soldiers thus weakened were easily dealt with by Mithridates who was thought to be defeated, turning the tide of the battle [1],[6].

The chronicles say nothing about what the toxic substance found in the honey could have been, but there are countless poisonous plants known to science, whose nectar causes toxic symptoms when they end up in the honey, especially when consumed by a weak, starved body in large amounts. Most likely, the cause of the disease was rhododendron honey, which has been known for a long time as mad honey. People who consumed small amounts of the honey, showed strong signs of drunkenness, while those who consumed more, signs of madness. Such poisonings still occur today, especially around the Black Sea, where this honey is also produced on purpose, for its alleged medicinal effects. [7].

6. Lead poisoning and the fall of the Great Roman Empire

The reasons for the fall of the Great Roman Empire, that ruled over a substantial part of the then known world for centuries, have been analyzed by many and explained in different ways. However, it is worth considering the explanation according to which a major role in the fall was played by the chronic lead poisoning of several leaders and citizens of the empire, and the physical and mental degeneration caused, through generations, by this.

Lead as a pliable and non-corrosive metal gained extraordinary popularity in ancient times: various containers, pipes were made of it, and lead pipes were used in a portion of the water network as well. Although some of the lead content may leach from lead pipes, this is usually not sufficient to produce toxic effects. Reasons have to be found elsewhere. Consumers then noticed that certain foods, when stored in lead containers, became particularly tasty. It was a well-known recipe to boil grape must in a lead container, concentrate it, and then add this syrupy liquid ("sapa") to wine to improve its color, flavor and shelf-life. During boiling, a chemical reaction took place between the acetic acid content of the must and the lead, resulting in lead acetate. Because of its sweet taste it is also called lead sugar. 'Sapa' produced according to the original recipe could contain as much as one gram of lead per liter, so even one teaspoon of this liquid could cause lead poisoning. However, considering that lead poisoning is a slowly developing, chronic process, with ill-defined symptoms, more than two thousand years had to pass before the connection between the disease and lead consumption was revealed.

Naturally, the continuous, population-level consumption of lead was not without consequences. Residents were later estimated to have consumed one liter of wine flavored with lead acetate per day on average,

and majority of the leaders, especially the emperors, were heavy drinkers or severe alcoholics, with consumptions even higher. Typical symptoms of lead poisoning include excruciating pain, epileptic seizures, paralyses, mental and physical decline. It is quite possible that the limitation of the capabilities of the ruling class in this way contributed to the fall of the empire [1], [8].

7. A continuous threat: grain mold

Although the identities and the harmful effects of toxins produced by molds came to light only in the second half of the 20th century, history has been accompanied by epidemics caused by moldy grain that resulted in mysterious symptoms and deaths, taking their victims, in particular, during periods of famine with poor yields. Coming back again to biblical stories, according to certain theories, the first of the ten plagues of Egypt, the death of the firstborns, could also be attributed to mycotoxins. Proponents of this theory think that, in accordance with the story of seven lean years and seven fat years, the good harvest was stored in barns where it could become moldy. When the lean years came, the biggest portion was always given the firstborn, held in the highest esteem, so they had a greater chance to fall ill. But this is only a theory or a legend.

However, written records indicate the occurrence, throughout history, of epidemic diseases of which can subsequently be stated safely that they were (also) related to the consumption of mycotoxins found in moldy grain. Europa went through a difficult period between 1315 and 1317. These were cold and wet years, lands could not be tilled because of the constant rain, and however much grain could be harvested, also became moldy. The famine due to the scarcity of food was exacerbated by the fact that toxic grain had to be consumed as well. Thus, it was people with greatly weakened bodies who were exposed to the plague epidemic or Black Death, resulting in the loss of at least 30% of the population [11].

7. 1. St. Anthony's fire

The widespread epidemic in Europe, accompanied by spasms, gangrene and fiery pain, was first mentioned by sources from the 11th century. Similar epidemics occurred regularly in later centuries; several hundreds of outbreaks had been registered, and tens of thousands of people died as a result. Symptoms were triggered by the ergot alkaloid, causing vasoconstriction which, in turn, caused spasms and gangrene accompanied by unbearable pain especially in the extremities, leading to the loss of fingers and limbs. At the time, the disease was called *ignis sacer* (sacred fire), reflecting the burning sensation. A long time had to pass before symptoms were associated with the ergot fungus *Claviceps purpurea*, infecting cereals, and ergot alkaloids produced by it.

The name of St. Anthony's fire also comes from the 11th century. The French town of La Motte was hit by an epidemic of the sacred fire in 1089, in which a nobleman and his son also fell ill. However, after praying to the patron saint of the town, St. Anthony, they successfully recovered. They pledged to found a hospital for those who fell ill in the epidemic, and it was named after St. Anthony. From this time, the disease has been also known as St. Anthony's fire [9].

Unfortunately, we cannot say that this danger is no longer present today. Although major outbreaks are rare (e.g., France 1951, Ethiopia 1978), but infested grain harvest still does occur in more rainy, cooler years. The symptoms of ergotism were also observed in wild animals. The European Food Safety Authority also dealt with the question, requesting measurement data on ergot alkaloids from member states, and formulating a scientific opinion based on the evaluation of these data [10].

7.2. Alimentary Toxic Aleukia

Presumably it was a *Fusarium* toxin, the T-2, that was responsible for the mass disease between 1942 and 1948 in the territory of the Soviet Union, especially around the Caspian Sea, which was diagnosed, based on the symptoms, as ALA (Alimentary Toxic Aleukia), and which was responsible for an estimated death toll of more than 100,000 people.

The disease has an unusual course and is serious. Following the ingestion of the toxic grain, first general and gastrointestinal symptoms occur (headache, sore throat, nausea, vomiting, diarrhea), then the symptoms lessen, or might even disappear, even if consumption of the grain is continued. Meanwhile, the bone marrow and cells of the immune system are insidiously destroyed by the T-2 toxin. The result is the severe, often fatal disease of a body rendered incapable of defending itself, with ulcers of the gastrointestinal tract, pulmonary hemorrhage and other symptoms [12].

Similar outbreaks have occurred previously, for example, according to records, in 1913 and 1932, but in all likelihood, there had been such diseases earlier and in other countries as well. Even today, the danger has not passed. *Fusarium* infection of cereals, as a function of the weather, still happens every year to a greater or lesser degree, and it is only due to the abundance of food, strict food safety regulations, and the attention of farmers and the authorities that our country's population is currently not at risk for acute illness. However, in other, less fortunate parts of the world, such outbreaks are still detected today [13].

The topic of mycotoxicosis is extremely diverse, and has to be given top priority both from an agricultural as well as veterinary and human health aspects.

8. Epidemics caused by microorganisms

There have been countless epidemics throughout history that were caused by microorganisms. According to WHO information, there are already more than two hundred known microbes (bacteria, viruses, parasites) that can cause foodborne or waterborne diseases. Think of cholera, tuberculosis that can spread with milk, botulism, different parasitoses and zoonoses. Until the discovery of microorganisms, the nature of these diseases had remained in obscurity for a long time, the cause and way of spreading of the diseases and epidemics were not known, and neither were possibilities for prevention, so in many cases they were attributed to bad air („miasma theory”) or intentional poisonings.

Diseases caused by microorganisms still present a burning issue today; WHO estimates that, even in developed countries, they affect up to one third of the population. Members of the food chain, as well as the general public must assume a role in the prevention and in reducing the number of outbreaks, and this can be achieved by scientifically sound, conscious government support [14]. Of the countless outbreaks, two interesting examples are presented.

8.1. Cholera epidemic, London, 1854

Cholera reared its head in London several times, because of overpopulation, crowdedness and poor sanitary conditions. It was subsequently estimated that cholera claimed 54,000 to 62,000 victims between 1848 and 1849, and the 1853-54 epidemic was responsible for the deaths of 31,000 Londoners. In 1854, the epidemic reached the Soho district at the center of the capital, and suddenly, within days, it resulted in a large number of deaths in a given area. A doctor, John Snow, did not accept the miasma theory, but – with no knowledge of the existence of the cholera bacterium – found the common factor, revealed the source of the outbreak, and thus laid the foundation for preventive hygienic measures and epidemiological investigations. In order to do so, he visited and questioned the patients and their environments. Diseases were recorded on a map, and they were concentrated in the area of a water withdrawal place – a public water well. In the immediate vicinity of the well, there was a pit latrine type pit for collecting wastewater and feces (a “cesspool”), which was characteristic of the London of the day. The investigation was also helped by exception, for example, in a monastery that was close to the water withdrawal well, nobody fell ill. It turned out that the monks only consumed their homemade beer, and never drank water. Once he considered his suspicions well founded, he convinced the city administration to remove the pump from the well, as a consequence of which no one else fell ill [15]. This was the first case where the fecal-oral method of spreading of an epidemic was demonstrated by someone with scientific credibility, i.e., that fecal contaminations in the mouth can cause illnesses.

8.2. *E. coli* epidemic, Germany, 2011

It was announced by Germany at the end of July 2011, that the most serious food epidemic of the century, caused by *Enterohaemorrhagic E. coli* (EHEC O104 H4) can be considered over. Over three months, confirmed illnesses of almost five thousand people were caused by the bacterium, nearly one thousand of whom developed the life-threatening hemolytic uremic syndrome (HUS), associated with internal bleeding and kidney failure, and more than fifty people died. From a professional point of view, the episode had several interesting aspects. First, this strain of *E. coli* had been extremely rare both in Europe and in the rest of the world, had caused no outbreaks, and virtually disappeared after the episode. The severity of the illnesses and the incidence of complications was extraordinary. Because of the above, the possibility of bioterrorism was raised on several occasions, but this was ultimately not confirmed. The investigation of the outbreak revealed that it was mainly women who fell ill, for which no explanation had been found for a long time. Finally, after a long epidemiological inquiry, it was found that the disease was spread by way of fenugreek seed sprouts that were used in salads and sandwiches, which were consumed by men less frequently.

This outbreak prompted a rethinking of the safety of consuming raw plant-based foods, and highlighted the importance of prudent, responsible communication. Namely, because of the disclosure of a not solid enough laboratory result (contamination of Spanish cucumbers) resulted in extraordinary losses in the fruit and vegetable trade of Spain [16], [17].

9. The risks of industrial development

The industrial revolution of the 19th century did not leave food science untouched either. The invention of pasteurization meant greater food safety than before, and it had great merits in the fight against tuberculosis, which was considered an endemic, among other things. And the technology for the preparation of canned foods was a great help in feeding armies and expeditions, because previously soldiers could rely only on salted, dried foods. However, until these technologies reached their current level of safety, a lot of bitter experience was accumulated from the occasional mistakes. Canned foods that have not undergone proper thermal treatment can still cause botulism today, and it was not any different in the past either.

Already in the Napoleonic times, canned foods were prepared, which completed the supply of the army. The developer of the technology was Nicholas Appert (1749-1841), a Parisian confectioner, who was decorated for his invention. The technology of heat treatment was developed empirically, even though its microbiological bases were not yet known. Appert won an award for his discovery, however, he could only publish his results in 1810, because up to that

time – because of the Napoleonic Wars – the technology helping to feed the army was considered a military secret [18]. Shipment of the products was largely restricted by the fact that Appert was only willing to prepare canned food in glass containers. However, his discovery was soon developed further and preparation of canned foods in metal containers started, which made supplying of armies and travelers more simple.

The five years' worth of food supply of one of the most famous and most expensive expeditions was put together by businessman named Stephan Goldner – in haste under time pressure – of canned foods produced by him. It was because in 1845, Sir John Franklin set sail on his last voyage to explore the Northwest Passage, appearing in the dreams of many, which would have made shipping between the Atlantic and Pacific Oceans possible. The expedition never returned. Years later, the dead bodies of a few members of the team were found, together with several cans, which were clearly spoiled. Although it was logical to assume that they became sick because of the faulty cans, the examination of the bodies led to a surprising discovery. The lead concentrations in their bodies were more than one hundred times higher than the normal level, and the lead probably came from the alloy used for sealing the cans. The mental instability caused by lead poisoning and spoiled foods certainly contributed to the downfall of the expedition [19].

It should be noted that, due to the tin alloy mixed with lead used for closing the cylinders of the cans, the risk of lead leaching still existed later (and may still exist), which was tried to be eliminated by the internal lacquer coating of the cans. It goes to show that nothing is perfect that there are concerns today regarding the compound called Bisphenol A, found in the lacquer coating of the cans...

10. Modern times, new threats

With the spreading of industrial development, and pursuing larger and larger profits, new problems came to the fore. Of these, the penetration of the food chain by environmental pollution stands out, and the mass emergence of never before seen diseases. One of the often-mentioned examples of this is the so-called Minimata disease.

Minimata was a small Japanese village, whose inhabitants lived mainly from fishing. At the beginning of the 20th century, in 1908, a fertilizer plant was established by the Japanese Nitrogen Company (Nippon Chisso), whose production grew continuously. The waste produced during the technology, containing organic mercury compounds, was released into the water of the bay. Fishermen were first faced with the destruction of the fish population, however, serious human and animal diseases were soon brought to light as well. The symptoms of mercury poisoning manifested in spasms, loss of consciousness and

coma, and in many cases led to death. Since organic mercury compounds can cross the blood-brain barrier and the placenta, primarily neurological disorders and fetal malformations occurred. This case is also instructive from the point of view how corporate interests could hinder substantive investigation and measures, as well as compensation of the thousands of victims for a long time (decades) [20].

11. Food counterfeiting on a large scale

Food counterfeiting is probably as old as trade itself, there were, are and, presumably, will be unscrupulous people who want to get rich, not caring about other people's lives, health and interests. All advanced civilizations have fought against this phenomenon with drastic measures and guilty parties paid with their property or lives – if they were found out. In the old days, such cases were usually of local importance. However, the level of technological development of the 20th century and widespread global trade established the foundation for large volume marketing of counterfeit products.

One could fill volumes with the countless sad and outrageous stories, but we will only mention two examples to illustrate what the consequences of human irresponsibility and greed could be.

11.1. Toxic oil syndrome (TOS)

In May 1981, more and more children were admitted to the Madrid children's hospital, with unusual symptoms. In the acute stage, atypical pneumonia, pulmonary edema, skin lesions, fever and abdominal pain occurred. Those who survived were also faced, after roughly two months, with neurological symptoms, severe muscle pain, spasms, memory loss, and abnormal thickening and hardening of their skin in the subchronic/chronic stage. These symptoms were not characteristic of any then known disease, so the possible cause was found by questioning the patients and performing an epidemiological investigation. The trail led to five-liter, unmarked packages of olive oil. Laboratory analysis revealed that it was not olive oil, but industrial rapeseed oil denatured with 2% aniline, the aniline content of which the counterfeiters tried to remove, to "bleach" it. However, during the process, even more toxic aniline derivatives were produced, and one or more of these was the cause of the illnesses. During the episode, more than 20,000 illnesses were registered, and 1,663 people died. The cause of the illnesses was determined and eliminated within a few months, but legal proceedings took much longer. Several oil merchants were arrested, but sentencing took place only in 1989. Representatives of the victims sued for compensation which was awarded to them by the Supreme Court only in 2002 (!) [1], [21].

11.2. Melamine

In November 2008 – after a long period of secrecy – China's health authorities informed the public that 294,000 babies fell ill with kidney stones, 51,900 of them required hospitalization, and six of them died. Determining the cause of the disease was facilitated by the fact that a year earlier, in the United States and Canada, similar symptoms were observed in cats and dogs who were fed by their owners with food from the same source. It had already been revealed then that a protein source from China was mixed in the food by the producer, and that triazine derivatives, melamine and cyanuric acid in particular, were detected by chemical analysis. During food and feed inspections, the presence of melamine was detected in formula, powdered milk and milk-containing products (yogurt, biscuits, sweets, coffee drink), which had obviously been prepared using milk contaminated with melamine. It is known that the protein content of foods is still primarily determined using the Kjeldahl method, the principle of which is determination of the nitrogen content of the concentrate and then calculation the amount of protein from this value. If high nitrogen content triazines are added to a protein-containing product, then the protein content calculated after digestion will be much higher than the actual protein content of the mixture, so the product can be sold at a higher price. Due to the export, melamine contamination was observed in almost every country in the world where it could be analyzed and detected at all. This is how an originally local counterfeiting became a worldwide food scandal, with a number of lessons [22], [23].

12. Conclusions, recommendations

Coming back to the Bible, the Book of Ecclesiastes (1.9) shares the following experience with us: ***"The thing that hath been, it is that which shall be; and that which is done is that which shall be done: and there is no new thing under the sun."*** Indeed, we must prepare ourselves that there will be counterfeiters and swindlers in the future as well, new technologies with downsides and victims will be discovered, mistakes will be committed because of ignorance, negligence or malicious intent. There will be new scientific discoveries and harmful properties of some of the currently used and approved ingredients will be realized. However, what is still new in our current era, is the extent of the threat. In addition to the beneficial effects of mass production, world trade and globalization, the theoretical possibility of a food catastrophe on a global scale appears. We are faced with new challenges such as risks due to environmental pollution and climate change, or food terrorism, the possibility to cause harm on purpose. One should also not forget that part of our planet is still hobbled by wars, hunger, terrorism and epidemics, the far-reaching effects of which, that can even affect us, are difficult to estimate in advance.

The relatively good food safety situation of the western world – including Hungary – is a cause for optimism, but not for complacency. The strict system of food control has to be maintained, and potential new risks have to be monitored constantly. This has to be completed in a good international cooperation, because experience shows that whichever strand of a more significant food-related event is in our hands, it cannot be followed to the end within the confines of the country, the fabric that consists of the strands can extend to other continents. We have to be prepared routinely for emergency situations, and so losses due to hastiness and panic can be avoided. “Hope for the best, prepare for the worst”. This way, in the future we can probably avoid negative food safety episodes of historical significance.

13. Literature

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