"NEWER" OR EMERGING PATHOGENIC MICROORGANISMS IN MEAT AND MEAT PRODUCTS

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INTRODUCTION

Papers dealing with the subject of "newer" pathogens have been published several times the last years (**Doyle, 1985; Buchanan and Palumbo, 1985; Holmberg and Farmer, 1984; Miller and Koburger, 1985; Archer and Young, 1988; Bostock, et al. 1984; Johnston, et al. 1985**). They reflect a phenomenon of increased awareness of consumers, legislators and food technologists for public health problems caused by microorganisms with unfamiliar names. Before describing or only naming a few of these microorganisms, we would like to consider why we call them "newer" or what is the likely reason that they emerge. Then the likely attitudes of the consumer of the future will be looked at, because their eating habits will determine which pathogens will emerge the next decades.

WHY DO PATHOGENS EMERGE ?

1. Changes in eating habits

It is an old postulate that the prevalence of foodborne diseases has something to do with eating habits, but only in the last 15-20 years has this relationship been clarified. We could add that by changing eating habits new problems may be created.

Anisakiasis or herring worm disease in Holland was linked with the consumption of raw fish. This habit also exists in Japan and consequently Anisakiasis occurs also in that country. In most other countries this disease is unknown. After the war, the main animal protein source in Japan was fish, and consequently **Vibrio parahaemolyticus**, a marine microorganism, was one of the most important causes of foodborne diseases. This microorganism emerged some thirty years ago in that country. Later the Japanese started to eat more meat which they imported, like many European countries in those days, from Latin America. From that time on, a steady increase of the number of salmonellosis cases in Japan could be observed and in fact **Salmonella** became an important microorganism in a couple of years. Consumption of raw milk has caused many cases of salmonellosis and campylobacteriosis in Scotland. Mandatory pasteurisation changed the prevalence of these milk-borne diseases dramatically (**Forbes et al. 1986; Sharp et al. 1986**). Tempeh made in Indonesia from fermented soya beans has a good health record. The same type of product made from coconut causes regularly Bongkrek disease, a foodborne illness provoked by toxins produced by **Pseudomonas cocovenenans** in this substrate.

2. Changes in perception, awareness and interest

Having eradicated many traditional infectious diseases and improved as a result our quality of life, our perception of hazards which now represent a threat to us changes. In the developed world we worry about newer hazards which many times only threaten a minority of the population.

Compared to the developing world where the problems are often still as they used to be 50 - 100 years ago in our countries, this may seem strange. It is nevertheless a fact that such increased concern has lead to the emergence of "new hazards" which are often not new or not related to food (e.g. **Listeria monocytogenes** is not new), and relatively unimportant in their effect on overall mortality.

The communication explosion and increased publicity are certainly factors which have influenced the (over)-reaction of consumers, legislators, food industry and the retail chains. We should not be misunderstood here. We do not mean to say that there has not been an increase in the number of foodborne diseases or of the number of microorganisms linked to them or that the economic impact of these diseases is not important. We want to stress that there are certain factors which have influenced their recognition and therefore the increase or its impact may sometimes be more apparent than real.

3. Improvement of detection methods

For certain microorganisms, improved detection methods have lead to their emergence. **Campylobacter** as a cause of diarrheal disease and as a foodborne pathogen was hardly known until the end of the seventies when a good selective method for its isolation was described. Since then, in many countries of the world the number of reported isolations from stools has increased steadily and in some countries campylobacters are now more important than salmonellas. The emergence of viruses as foodborne pathogens is also linked to the availability of detection methods (and also to good epidemiological work).

4. Improved epidemiology

Improved epidemiology is certainly an important factor to be mentioned in relation to the emergence of certain microorganisms or particular strains of them. An example is the emergence of **Listeria monocytogenes** as the cause of outbreaks involving food as a common source (**James et al. 1985; Bille, 1988**). Although this is certainly so we should not let it tempt us to believe that this organism and its presence in sufficient quantities in foods is the sole reason for the emergence of this particular problem (**Cox, 1989**). Epidemiological evidence should be used to point the way for further research, rather than be used as a substitute for etiological evidence.

5. Changes in Food Production (Raw materials)

Large scale production of raw materials or primary food, increases the possibility of creating ecological niches where microorganisms might grow and from there be disseminated. Changes in practices may also introduce possibilities for growth for certain microorganisms which before did not exist, or did not exist to this extent. For instance, a farm with only a few chickens, pigs or cattle cannot, from the ecological point of view, be compared with today's large 'factory farms' where hundreds or thousands or more of the animals are grouped together in close contact with one another.

At the same time, however, modern slaughter techniques, developed to be able to slaughter a large number

of animals in a short period of time, have added cross contamination problems. The consumption of undercooked poultry and red meat was all that was needed to cause the emergence of "the **Salmonella** problem" (**van Schothorst, 1986**).

6. Changes in Food Processing Technology

Changes in processing conditions have also been influential in the emergence of some pathogens : shorter fermentation and maturation time for fermented sausages, peeling machines for frankfurters, slicing and vacuum packing, brining methods etc. can be mentioned as examples. The meat industry has certainly been very influential in the reduction of the prevalence of pathogens in meat products, but due to the high output and wide distribution, the consequences of an incidental contamination are more important. The creation of chill chains has been primordial in the prevention of foodborne diseases, on the other hand they could potentially contribute to the emergence of psychrotrophic pathogens.

The use of vacuum or modified atmosphere packaging has significantly increased the shelflife of certain food products. The nature of this technology is such that it limits the multiplication of normally occurring spoilage microorganisms. However, this creates the possibility that other microorganisms might grow but remain undetected due to lack of off-smells or tastes that would normally warn the consumer.

7. Changes in Handling and Preparation practices

As eating habits and their changes may lead to certain food concerns, so may food handling and preparation practices and their changes. Numerous outbreaks have been described with faulty food preparation practices as the causative factor. Often these occur in canteens, hospitals, prisons and small catering establishments. But they also occur during scientific symposia, wedding parties, pleasure cruises, etc. In general, when a large quantity of food has to be prepared in advance, often under inadequate conditions, problems can emerge. In all statistics available, mistakes in food handling and food preparation practices have been described as the most important causative factor (**Bryan, 1988; Davey, 1985; Roberts, 1982; Todd, 1983**).

We should not forget either that household culinary technologies are changing rapidly. Microwave ovens, and the various 'food processors' now available may contribute to undercooking or cross-contamination in the home if not used or cleaned correctly.

8. Demographic changes

a. The state of the population

Changes in the human population which have occurred or are occurring have to be considered. The very young, the very old and ill people are recognised to be more vulnerable than normal healthy persons. More and more people have underlying diseases for which drugs are taken that may influence their resistance to infection. Diseases like

AIDS, cancer and other diseases which affect the immune system influence the susceptibility of a person, but many other factors may be influential such as intake of antiacids and alcohol. In the western world we also have to consider the proportion of old people in the population and their susceptibility. We must take into account too the very young. Apart from being naturally less resistant to infection other problems can emerge due to the 'virgin' nature of the infant gut. Infant botulism (**Long, 1985; Long et al., 1985; Sonnabend, 1985**) has arisen as a problem in some cases due to honey feeding. Not only infants, but also adults in whom the gut flora has been altered due to antibiotic therapy, may be prone to such types of infection where organisms exceptionally grow and/or produce toxin in the gut.

There is no real reason to believe that in future the population will become more resistant. It is more realistic to assume that more people will be at risk, than ever before.

b. Mobility

These days the population is more mobile than ever before. Immigration and migration (tourism) may also affect the emergence of certain diseases previously uncommon in the population. The demand for "ethnic foods" in some communities has given rise to problems.

c. Social conditions

It is beyond the scope of this article to go into the causes and effects of the social plight of human beings except to say that these are many and that social conditions may sometimes change very suddenly due to disasters or war. All these have their effect on the food supply and the emergence of pathogens old and new.

9. Changes in the behaviour of microorganisms

After having discussed some of the factors which may have been influential or which may continue to be influential in the occurrence of foodborne diseases let us touch with a few words on what is known about the behaviour and changes in behaviour of some microorganisms which may cause foodborne diseases (**Archer and Young, 1988**).

Some provoke disease because they multiply in the intestinal tract with or without invading the tissues (**Shigella** type of infection). Others may multiply in the gut and release toxins (**Vibrio cholerae**, some **E.coli**, **C. perfringens**). Others multiply in the food and produce toxins, in this case it is the ingested toxin that provokes the reactions (**Staphylococcus aureus, Bacillus cereus**). Several combinations occur and the exact mechanism or nature of the toxins is not always known.

For several microorganisms the number to be ingested to provoke reactions or to produce toxin in food is assumed to be high (**B. cereus**) for others low **Campylobacter**). Sometimes the minimal disease producing number may also be dependant on the food. **Salmonella** in chocolate or raw minced meat may cause problems in low doses (**Hockin et al., 1989**), in non-fatty foods high doses may be required.

Sometimes specific factors which help them to colonize the intestinal track

(adhesins) are needed to provoke disease. Other virulence factors may exist, the role of which is not always well known (haemolysin for instance) (**Parry and Rooke, 1985; Levine, 1987; Sussman, 1985**).

We can cite as an example the current emergence of **S. enteritidis** Pt4 in Britain. This organism has become adapted to laying hens and has as a result found its way into eggs. In the last three years cases of salmonellosis due to this organism have increased rapidly (**PHLS, 1989.**)

Some of these factors are chromosomally defined, others are determined by plasmids. When these factors are on plasmids they may be transferred from one species to to another thereby changing the behaviour of sometimes otherwise innocuous microorganisms (**Klipstein and Engert, 1975, 1976; Guarino et al. 1987**).

We should underline here, that as a consequence, it is not the names of microorganisms that are important, but their behaviour. In explaining the etiology of foodborne diseases, behaviour in terms of competitiveness and conditions necessary for growth or toxin production (e.g. a_w, pH, nutrients, redox potential, temperature) are the determining parameters rather than the position of a microbe in any taxonomic scheme. For example, **B. cereus** is considered to be a mesophile but psychrothrophic strains exist. Even certain strains of **Clostridium botulinum**-B may grow and produce toxin at refrigeration temperatures.

In describing a few microorganisms of recent concern, we should bear in mind that others which are not yet known, may emerge because our habits and behaviour change, or that existing organisms may change their behaviour due to transfer of plasmids or due to a natural selection process in new ecological niches.

"NEWER" FOOD-BORNE PATHOGENS

E.coli.

The newest microorganism of concern carries one of the oldest names in microbiology, i.e. **Escherichia coli**. One particular serotype (**0157:H7**) has been recognised as the causative organism in outbreaks of haemorrhagic colitis and the more serious hemolytic uremic syndrome (**Riley et al., 1983; Griffin et al., 1988; Carter et al., 1987; Neill et al., 1985; Kinney et al., 1988**). Outbreaks have been linked to the consumption of raw or undercooked ground beef or hamburgers (**Waters, 1989**). These strains produce a toxin similar to those produced by shigellas, the ability to produce this toxin seems to be phage-encoded. All the available evidence leads to the conclusion that only a low number of these microorganisms is necessary to produce disease. However, why the microorganism emerged is not yet clear. It may be that just the seriousness of the disease and good epidemiological investigations have lead to the recognition that this microorganism may lead to disease through the consumption of certain foods. Another factor may have been a changing preference from **well done** to **rare** or **medium rare** meat and barbecuing. Outbreaks have also been linked to the consumption of raw milk.

Listeria monocytogenes.

Another important pathogen which may cause serious disease is

Listeria monocytogenes. Although many years back, consumption of sausages was suspected to be responsible for cases of Listeriosis and a few epidemiological investigations have linked Listeriosis with the consumption of frankfurters and some other meat products (**Schwarz et al., 1988**), most studies have revealed no clear evidence that meat and meat products have caused Listeriosis. This does not mean that under the appropriate set of conditions this may not happen exceptionally. However, knowing the frequency with which **L. monocytogenes** can be found in meat and meat products and the still very low frequence of Listeriosis has lead several expert groups to the conclusion that Listeria is considered not to be a hazard for people who do not belong to the high risk group (**WHO, 1988**). In some of the epidemiological studies, the normal predisposing factors were not found in some patients (**Bille, 1988**). This may mean that they were either not recognised, or that there are still other factors which play a role in the etiology of this disease.

The major contentious point concerning this organism is the relative importance of the factors which may have brought about the emergence of this pathogen.

Listeria may have emerged as foodborne pathogen due to increased shelflife of certain foods at refrigeration temperatures, increase in the use of refrigerated temperatures during storage or to change in processing practices. The best investigated outbreak, the one linked to a certain type of cheese in Switzerland (**Bille 1988**), gives reasons to state that changed practices (longer shelflife) and changed processing conditions (use of pasteurised milk instead of raw milk) did contributed to the growth of this microorganism and its emergence. One important characteristic of this microorganism is its growth at refrigerated temperatures, another is its ubiquitous presence in the general environment, in wet environments of factories and, very importantly, in domestic environments (**Cox et al., 1989; Weis and Seeliger 1971**). Even so, there are aspects of the epidemiology of listeriosis which lead us to believe that its ingestion in sufficient quantities by sensitive persons is not the only factor involved in its causation.

Campylobacter jejuni

Campylobacter jejuni has now worldwide been recognised as a causative organism of diarrheas. Food and especially undercooked poultry and unpasteurised milk (**Taylor et al. 1982**) have been implicated in outbreaks. The minimal infective dose seems to be quite low, the microorganism can be invasive but also it can produce two or more toxins, one of which is related to cholera toxin. Its prevalence in poultry and of poultry meat has been well established. These bacteria are quite sensitive to drying which explains their low incidence on carcass meat. For this reason these meats are not a major source of human infection. The microorganism does not grow at temperatures below 30°C and consequently growth does not occur in foods unless they are mishandled. They are killed by normal cooking procedures.

Yersinia enterocolitica

Yersinia enterocolitica is not a new pathogen, it has been recognised as

the causative agent of enterocolitis with or without diarrhea for several decades. Foodborne outbreaks have been reported since the early 1970's and eating raw pork has been incriminated in several epidemiological studies. Not all strains are pathogenic, virulence may be plasmid mediated. It is a psychrotroph and may as such become more important in the future. It produces a heat stable enterotoxin but it seems that this is not produced at temperatures above 25°C.

Vibrio vulnificus

Another emerging pathogen that should be mentioned is **Vibrio vulnificus**. Like **Vibrio parahaemoliticus** its occurrence is mainly linked to raw sea food but the disease is much more serious. We mention this microorganism because it underlines again, that certain strains of well known microorganisms may go undetected for a long time as pathogens: **Vibrio cholerae** was recognised as a pathogen already more than hundred years ago. The reason for the emergence of this organism is its pathogenicity in persons with cirrhosis of the liver or other disease states, where levels of iron are high in the serum (**Tacket et al., 1984**).

Aeromonas hydrophila

Aeromonas hydrophila is an extremely common microorganism which can be found in fresh water and other wet environments and is frequently isolated from human stools. They may perhaps cause diarrhea but feeding studies have been unsuccessful in provoking illness. This species produces a enterotoxin which is similar to cholera toxin. An important characteristic is the ability of the organism to grow at refrigeration temperatures in foods as well as in water.

PREDICTING THE FUTURE

Habits and changing habits have been underlined as the major driving force in the emergence of pathogenic organisms. Our industry is driven by consumer forces which dictate the needs of the future and the development of products. It is thus essential to try to predict the future needs and habits of consumers, in order to predict the behaviour of the organisms of the future.

Studies of the consumer of the future carried out in Germany, Australia and the United States all lead to the same kind of conclusions. There will be more leisure time, and more money will be spent to obtain pleasure foods. But convenience, health aspects, freshness, etc. will also increase in importance. More variety, ethnic foods, fermented oriental foods, more daring combinations, etc. will be demanded by the consumer of the future.

Out of home eating will increase but not only fast food restaurants, also speciality restaurants will increase in number. In many of these places the meals will not be completely prepared at the spot. Many dishes will already be totally or partly pre-prepared ("assembled meals"). But also the consumer himself will take up cooking as one means of filling its leisure time. Slogans like "champagne, lobster and company" are used to describe experimenting with cooking by the amateur. The same cook may however grab the next day for a health food with a low calorie intake or for a snack food because he has no time to prepare a meal. He may

therefore want to have available in his refrigerator quite a variety of food which he can take whenever his mood asks for a specific item. Normally a home refrigerator is not designed for a "first in-first out" type of management, and too long storage can be a consequence. Moreover, he wants "freshness" , "naturalness", but at the same time the food should be convenient and have a long shelflife. This may also create some hazards because some of these wishes of the consumers are contradictory to safety and the wishes may change all the time. These demands will create opportunities for inventive food producers but we doubt whether they, even large or small, would know all the hazards the new formulations could lead to. But even if they knew the handling of such foods by the consumers would not be easy to predict.

CONCLUSION

Based on these considerations, we expect that in future some well known microorganisms will cause more problems than they do at the moment or that new microorganisms will emerge because we created the right set of conditions for their emergence.

To prevent this, the food industry, retailers and everyone handling food professionally should continue to question whether changes in processing, distribution conditions, changes in formulation, changes in packaging, etc. may not create hazards. We use specifically the word hazard here because this kind of hazard anticipation is an integral part of the **Hazard Analysis Critical Control Point** concept which is and should be pushed by governments and food professionals alike, as one of the means to increase consumer protection. At the same time honest information of food handlers, cooks and consumers will be one of the most important action programs because their habits will continue to be responsible for many of the cases or outbreaks of food poisoning (ICMSF 1988). We used specifically the word "information" and not the word "education", the word normally used in this context. Information should be balanced, it should contain all the elements which allows the consumer to make up his mind, to choose the eating habits which suits him most, considering however at the same time the hazards which they may involve. In this way, the consumer can join the professionals to prevent old and 'newer' foodborne diseases.

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